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Xamid Abduramanov

khamidabduramonov@gmail.com

Research institute Family and Gender

Lutfullo Ibragimov

Samarkand State University named after Sharof Rashidov

Bobomurod Rabiye

Andijan State University

Sherzod Dusnaye

Research institute Family and Gender

Olimjon Sherxolov

Samarkand pedagogical Institute

Bekzod Musaye

Samarkand pedagogical Institute

Muazzam Sabirova

Alfraganus University

Nazar Esanov

Termez State University

Kuvonchoy Pulatova

Urgench State University

Gulmira Maxmudova

Samarkand State University named after Sharof Rashidov

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STATISTICAL MODELING AND FORECASTING OF KEY DEMOGRAPHIC TRENDS IN UZBEKISTAN

***1. Xamid Abduramanov**

Professor of research institute "Family and Gender", Tashkent, Uzbekistan

<https://orcid.org/0009-0008-5822-4222>

khamidabduramonov@gmail.com

2. Lutfullo Ibragimov

Professor of Samarkand State University, Samarkand, Uzbekistan

<https://orcid.org/0000-0002-1524-8469>

E-mail: ibragimovlutfullo@gmail.com

3. Bobomurod Rabiye

PhD (Sociology). Andijan State University, 129 University Str., Andijan Region, Uzbekistan.

<https://orcid.org/0009-0009-8741-0953>

r.bobomurod.rp@gmail.com

4. Sherzod Dusnaye

Associate professor of research institute "Family and Gender", Tashkent, Uzbekistan

sherzod01.85@mail.ru

5. Olimjon Sherxolov

Associate professor of Samarkand pedagogical Institute, Samarkand city, Uzbekistan.

<https://orcid.org/0009-0002-7718-8737>

osherxolov@gmail.com

6. Bekzod Musayev

Associate professor of Samarkand pedagogical Institute, Samarkand city, Uzbekistan.

<https://orcid.org/0000-0001-6258-6340>

bekzodmusayev85@gmail.com

7. Muazzam Sabirova

Associate professor of Alfraganus university, Tashkent city, Uzbekistan.

<https://orcid.org/0000-0003-2250-3824>

mua1993.10@mail.ru

8. Nazar Esanov

Associate professor of Termez State University, Termez, Uzbekistan

<https://orcid.org/0009-0008-5926-4365>

esanovn@mail.ru

9. Kuvonchoy Pulatova

PhD student of Urgench State Pedagogical Institute, Urgench, Uzbekistan

<https://orcid.org/0009-0002-5988-9142>

quvonchoy_polatova@urspi.uz

10. Gulmira Maxmudova

PhD student of Samarkand State University, Samarkand, Uzbekistan

<https://orcid.org/0009-0004-9977-6630>

otayorovagulmera@gmail.com

ABSTRACT.

The imperative of ensuring demographic security in the Republic of Uzbekistan has emerged as one of the most critical scientific and practical priorities in contemporary socio-economic discourse. This complex task is encumbered by substantial organizational and methodological challenges, largely stemming from adverse trends within the nation's demographic landscape. Addressing these challenges is not merely a prerequisite for sustainable socio-economic development, but also a cornerstone for safeguarding national stability and maintaining Uzbekistan's strategic relevance within the global geopolitical arena. In this context, it becomes essential to undertake a thorough and systematic investigation into the multifaceted dimensions of demographic security, identify the underlying determinants, and devise actionable solutions to mitigate associated risks.

This article presents an empirical study aimed at advancing the understanding of demographic security in Uzbekistan. Specifically, it establishes threshold values for 23 key demographic security indicators, along with corresponding risk-level criteria and contextualized metrics. The research further delineates the distinctive characteristics of population reproduction patterns in the country. A comprehensive statistical evaluation of demographic dynamics, informed by diverse socio-economic variables, has been conducted. Using multifactorial analysis, the study also offers an economic interpretation of demographic evolution. An econometric model identifying the determinants influencing demographic trends has been developed, accompanied by regionalized forecasts of Uzbekistan's population trajectory up to the year 2030. In addition, the study offers scientifically grounded proposals and practical policy recommendations to address current demographic challenges and promote long-term resilience.

KEY WORDS. *Population, demographic security, multifactor analysis, econometric models, socio-economic, risk, demographic policy.*

INTROCDUCTION. Demographic processes such as the increase in population size and mobility, as well as the increase in the proportion of elderly people, are having an impact on the socio-economic development of countries of varying degrees of development. In particular, according to United Nations (UN) statistics, “by the end of the next decade, the world population will reach approximately 8.5 billion people, and by the middle of the 21st century, it will reach 9.7 billion”. Moreover, by 2037, Central and South Asia will become the most populous regions” [10]. In this day, targeted measures to regulate and manage demographic processes are being implemented on a large scale in country.

The development of demographic processes in the world due to various factors requires targeted scientific research to find scientific solutions to a number of emerging socio-economic problems. In particular, it is important to analyze demographic processes and their statistical assessment, as well as to develop statistical forecasts of their future state. Special attention is paid to scientific researches aimed at assessing process of population reproduction, increasing the share of working-age people, reducing mortality among the working-age population, extending life expectancy, obtaining a demographic dividend, and reducing the volume of irrational migration. In

essence, addressing the intricate interplay of demographic trends and socio-economic challenges requires methodical, evidence-based approaches. By prioritizing analytical precision and future-oriented planning, the global community—and countries like Uzbekistan in particular—can leverage demographic research to inform policy, secure developmental gains, and foster a more balanced and resilient society.

LITERATURE ANALYSIS AND METHODS. Many scientists have focused their attention on research related to demographic problems, population regeneration, and factors affecting population development. A lot of scientific research has been carried out in foreign countries, especially on birth and death rates, population migration, improving population demography, and its statistical and econometric study. In particular, scientific research has been carried out by foreign scientists includes E. Rosset [1], A. Sovi [3], R. Kuchinsky [2], E. Tera [4], D. Valentey, I. Kalinyuk [5], L. Chuyko, T. Domenik [9], L. Michel, K. Irina [8], K. Nivel, A. Akani [11], A. Ravinsankar, Sh. Mziya [12], G. Bakhmetova, L. Ivankova, G. Safarova [2]. These scientists theoretically studied the processes of population reproduction and its characteristics, forms and types, and emergence. They focused on the practical assessment of factors affecting population renewal, modeling demographic processes at the regional level based on factor analysis, and improving mechanisms for regulating and managing the processes of population demographic formation.

The development of population demography in Uzbekistan—including analyses of reproductive dynamics, patterns of natural population growth, migration-related challenges, and the demographic risks influencing the country's socio-economic trajectory—has been comprehensively addressed in scholarly works by a number of prominent national researchers. Their studies encompass economic and statistical inquiries as well as advanced econometric modeling of demographic processes. Significant contributors in this field include M.K. Karaxonov, I.R. Mullajanov, R.A. Ubaydullayeva, O.B. Ata-Mirzayev, K.Kh. Abdurakhmonov, S.S. Gulyomov, B.K. Goyibnazarov, B.Kh. Umurzakov, A.A. Qayumov, A.S. Soliyev, L.P. Maksakova, M.R. Buriyeva, Z.N. Tojiyeva, Kh.Kh. Abduramanov, B.B. Usmonov, A.D. Abdurakhmonov, T.M. Akhmedov, D.M. Karimova, F.K. Komilova, D.V. Rasulova and H. Mamadaliyeva, whose collective efforts have significantly contributed to the understanding and interpretation of Uzbekistan's demographic transformation [13].

RESEARCH METHODS. The study is based on secondary statistical data published by the National Statistics Committee of the Republic of Uzbekistan. The research employed systematic analysis, absolute, relative, and average measures, grouping, analysis of time series, synthesis, comprehensive assessment, logical and comparative analysis, correlation and regression analysis, statistical tables and graphical methods, economic-mathematical modelling, index methods, and demographic forecasting. These methods were used to analyse key demographic indicators, identify their trends and interrelationships, and develop forecasts of demographic changes in Uzbekistan.

RESULTS. In recent years, terms that appear to be related to the concept of “demographic security” have been increasingly used both in scientific literature and

in public speeches by scientists from different countries of the world. Also, a number of countries (for example, Belarus, Kazakhstan, etc.) are implementing systemic measures aimed at developing and adopting regulatory legal acts to ensure the security of demographic processes.

The category of demographic security is the degree to which a country's development is protected from internal and external demographic threats to the extent that it ensures the preservation of the state's geopolitical, economic, and ethnic status. In the principles of demographic security include:

1. The first place should be given to the person, his interests, the needs to ensure his personal safety and the safety of his family.

2. Any demographic impact should be carefully designed and studied, and implemented only for good purposes.

3. Demographic impact is the sovereign right of every state, every people, and every family, is carried out based on strict consideration of the potential resources of this country.

4. The political leadership of states, political parties, and international organizations is facing a demographic crisis and intentional, overt and covert actions that lead to the extinction of any people belonging to modern humanity are legally responsible. The effectiveness of implementing the above principles is clearly demonstrated through the aspects of demographic security that may be specific to each country in terms of their composition and forms of manifestation.

For example, among the real demographic risks that are relevant for a number of developed countries today, the following can be included. The key issues include: escalating depopulation trends; a birth rate insufficient to sustain natural population replacement; a rising incidence of disease and mortality; declining life expectancy; the worsening overall health condition of the populace; a weakening of the family as a foundational social institution; disordered internal migration patterns; and a growing prevalence of undocumented or clandestine migration. Ensuring demographic security is a long-term task, as it cannot be achieved without changing existing trends, without changing them, it is impossible to simply stabilize the situation and begin to increase the level of protection of society from demographic risks.

In addition to modern measures to optimize the situation in the population sector, the country needs to implement scientifically based and it is also worth highlighting the problem of the lack of an effective concept. From this point of view, a simple and exemplary example can be given. According to the historical experience of many countries, demographic security is necessary, but it comes at a high cost. Ensuring it requires large amounts of financial resources. In this regard, it is necessary to objectively talk about the problem of financial constraints in implementing the concept of demographic security in Uzbekistan [6].

Despite the favorable conditions for raw material and energy resources prices on the world market in recent years, Uzbekistan still does not have sufficient financial resources to improve the living standards of its citizens and reverse the negative impact of demographic processes. The successful implementation of the

concept of demographic security must rely on continuous and intensive work aimed at improving the parameters of the population situation [7].

The persistent absence of a structured and proactive demographic policy in Uzbekistan poses significant obstacles to national stability and sustainable development. To confront emerging demographic risks and secure long-term socio-economic resilience, it is imperative that the country adopt a strategic and scientifically informed approach to population governance.

During the 90s of the last century demographic policy measures in Uzbekistan were implemented superficially (if they were implemented at all) and did not meet the requirements of the time. Due to the severe economic situation, the state had almost no opportunity to regulate demographic processes. In recent years, the situation has begun to change for the better, namely, assistance to young families (especially in terms of purchasing housing), a radical improvement of the healthcare system, a rational migration policy, and a number of other positive measures are being implemented.

Understanding different options for quantitatively assessing the level of demographic security allows us to distinguish two independent directions. The first of these is related to the using of one main indicator of the demographic situation. Its strength lies in the level of development achieved by the selected indicator, of various administrative-territorial units according to time and it is determined by a unique feature that allows for very precise identification of the state of affairs, even in terms of their mutual positioning in space. Based on the analyses we conducted in the study, we can say that, in this process, a single definition can be achieved by dividing the indicator into subjective parts that are important in a certain direction of the demographic development of society.

For example, it is reasonable to consider the net population growth (decrease) or population replacement rate as one of the main factors, because these indicators provide a more general idea of the results of generational renewal. Indeed, the difficulty of this chosen method lies in the fact that the descriptions used in each case consist of non-repeating fragments, and not only does it not reflect the real situation as a result of demographic changes over time and space, but rather, it is exacerbated by the fact that individual aspects and aspects that are capable of being transformed are not sufficiently taken into account.

Calculating an integral indicator of the level of demographic security eliminates the problem of using separate descriptions in most cases. However, at present, practical progress in this area of improving population statistics is being achieved very slowly. The literatures almost never contains recommendations and methodologies for combining multiple indicators used to reflect one or another aspect of demographic security. This is mainly due to the fact that, It is not yet clear which parameters of the demographic situation should be included in the integral assessment of the type of national security under consideration. Establishing a system of demographic security indicators, in which the structural and systematic nature of the information using and it is necessary to rely on some conceptual ideas and views that imply the interdependence of these indicators.

In our opinion, demographic security indicators can be divided into 3 structural components:

1. Indicators of the level of individual aspects of demographic security.
2. Indicators of the speed and direction of change in the level of individual aspects of demographic security.
3. Indicators of losses due to changes in the level of individual aspects of demographic security.

It is known that any shifts in the levels, directions, and rates of change of individual aspects of demographic security are particularly it has certain consequences that require statistical assessment, which is considered relevant from the point of view of developing and justifying measures to reduce current and future social losses.

The demographic situation can be assessed based on the threshold values of demographic indicators (Tables 1 and 2). Table from 1 shows that the study selected 23 indicators characterizing demographic security and divided their threshold values into “pre-crisis” and “crisis” levels. It is worth noting that the developed approach to assessing the demographic situation is considered universal and can be applied to all administrative-territorial structures of the Republic of Uzbekistan. Table from 2 shows, the study assessed the demographic situation in the Republic of Uzbekistan based on the threshold values of demographic security indicators. According to it, 23 indicators were identified as having varying levels of risk across 4 demographic indicators. Table 3 shows that the migration growth rate in our country is at a pre-crisis level. The main reason for this is the migration decline inherent in the population of Uzbekistan. According to statistics informations, the migration reduction coefficient was 2.7 in 2000, 1.5 in 2010, and 0.4 per mille in 2023.

Table 1. Threshold values of demographic security indicators

№	Indicator naming	Threshold values					
		IO1	IO2	IO3	I1	I2	I3
1.	Coefficient of natural growth of the population, ‰	2,00	0,67	-0,67	-2,00	-3,60	-5,20
2.	Net coefficient of reproduction rate population, units	0,900	0,830	0,760	0,690	0,606	0,522
3.	Coefficient of total fertility rate, ‰	15,5	14,7	12,8	11,5	9,9	8,3
4.	Special coefficient of birth rate, ‰	45,00	41,67	38,33	35,00	31,00	27,00
5.	Birth accumulation coefficient, unit	2,10	1,90	1,70	1,50	1,26	1,02
6.	Coefficient of overall mortality rate, ‰	10,0	12,0	14,0	16,0	18,4	20,8
7.	Mortality rate of the working-age population, per 100,000 working-age population	300	400	500	600	720	840
8.	Life expectancy at birth of the total population, age	72	70	68	66	63,6	61,2
9.	Male life expectancy at birth, age	70	68	66	64	61,6	59,2
10.	Life expectancy at birth for women, age	74	72	70	68	65,6	63,2
11.	The coefficient of migration growth, ‰	0	-5	-10	-15	-21	-27
12.	Percentage of people under working age in the total population, %	22,0	20,6	19,3	18,0	16,4	14,8
13.	The proportion of working-age people in the total population, %	58,0	55,0	52,0	49,0	45,4	41,8
14.	The number of people under working age per 1,000 working-age population	330	310	290	270	246	222
15.	The number of people over working age per 1,000 working-age population	350	400	450	500	560	620
16.	The number of people unable to work per 1,000 people of working age	680	710	740	770	806	842
17.	Population aging coefficient (percentage of the total population aged 65 and over), %	6,0	8,0	10,0	12,0	14,4	16,8
18.	Population incidence of dangerous diseases of the circulatory system, per 100,000 population	3500	5000	6500	8000	9800	11600
19.	Population incidence of dangerous tumor diseases, per 100,000 population	1000	1333	1667	2000	2400	2800
20.	Population incidence of active tuberculosis, per 100,000 population	500	833	1167	1500	1900	2300
21.	Prevalence of HIV and AIDS among the population, per 100,000 population	500	833	1167	1500	1900	2300
22.	Prevalence of viral hepatitis among the population, per 100,000 population	250	300	350	400	460	520
23.	The infant mortality rate, ‰	12,0	14,0	16,0	18,0	20,4	22,8

*IO1 - the first case before the crisis, *IO2 - the second situation before the crisis, *IO3 - the third situation before the crisis, *I1 - crisis is the first situation, *I2 - crisis is the second situation, *I3 - crisis is the third situation.

Table 2. Values of demographic security indicators in the Republic of Uzbekistan

№	Indikatorning nomlanishi	Years							
		2000	2005	2010	2015	2020	2021	2022	2023
1.	Coefficient of natural growth of the population, ‰	15,8	14,9	17,2	18,6	19,5	20,9	21,4	21,7
2.	Net coefficient of reproduction rate population, units	1,224	1,082	1,106	1,212	1,217	1,513	1,558	1,645
3.	Coefficient of total fertility rate, ‰	20,6	19,6	21,2	22,5	23,8	25,2	25,4	26,4
4.	Special coefficient of birth rate, ‰	82,684	73,570	77,116	84,573	93,392	99,727	100,481	103,932
5.	Birth accumulation coefficient, unit	2,585	2,361	2,342	2,491	2,904	3,173	3,265	3,445
6.	Coefficient of overall mortality rate, ‰	5,5	5,4	4,8	4,9	5,1	5,0	4,8	4,7
7.	Mortality rate of the working-age population, per 100,000 working-age population	276,2	260,9	222,1	226,7	212,0	215,5	207,7	
8.	Life expectancy at birth of the total population, age	70,8	71,8	73,0	73,6	73,4	73,8	74,5	74,7
9.	Male life expectancy at birth, age	68,4	69,6	70,6	71,2	71,2	71,7	72,5	72,5
10.	Life expectancy at birth for women, age	73,2	74,1	75,1	76,0	75,5	75,8	76,6	76,9
11.	The coefficient of migration growth, ‰	-2,7	-3,9	-1,5	-1,0	0,3	-0,5	-0,2	-0,4
12.	Percentage of people under working age in the total population, %	39,7	35,0	31,3	30,0	30,9	31,4	31,7	32,0
13.	The proportion of working-age people in the total population, %	53,0	57,9	61,1	61,0	58,3	57,6	56,8	56,4
14.	The number of people under working age per 1,000 working-age population	751	605	511	492	531	545	559	568
15.	The number of people over working age per 1,000 working-age population	137	122	125	148	185	192	202	206
16.	The number of people unable to work per 1,000 people of working age	888	726	636	640	716	738	761	774
17.	Population aging coefficient (percentage of the total population aged 65 and over), %	4,2	4,5	4,1	4,1	4,9	5,1	5,4	5,6
18.	Population incidence of dangerous diseases of the circulatory system, per 100,000 population	1209,0	1451,6	1630,2	2330,9	2851,0	3384,7	3539,3	
19.	Population incidence of dangerous tumor diseases, per 100,000 population	71,6	66,7	67,4	67,7	64,4	73,3	76,6	
20.	Population incidence of active tuberculosis, per 100,000 population	65,5	76,0	60,9	46,9	31,8	34,8	36,4	
21.	Prevalence of HIV and AIDS among the population, per 100,000 population		7,0	12,3	14,0	9,1	9,4	9,9	
22.	Prevalence of viral hepatitis among the population, per 100,000 population	234,7	115,8	127,6	82,3	33,6	22,6	23,7	
23.	The infant mortality rate, ‰	18,9	14,9	11,0	11,4	9,4	9,2	8,7	8,5

The age structure of the population directly affects all demographic indicators. For example, from the analysis in our study, we can say that, if the proportion of young people in the total population is relatively high, the number of marriages and births in the population increases. In turn, demographic phenomena are also having an impact on the age structure of the population.

A decrease in the birth rate, an increase in the proportion of elderly people in the population, that is, it causes an acceleration of the demographic aging of the population. Throughout the period under review, the share of the working-age population prevailed, however, there has been a steady decline in the last two to three years. According to the analysis, Uzbekistan has entered a pre-crisis zone since 2021 due to a decrease in the share of the working-age population.

At present, demographic dynamics in Uzbekistan and globally are marked by a steadily increasing proportion of elderly individuals within the total population, signifying an unmistakable trend toward population aging. This demographic shift, while reflective of improved healthcare and life expectancy, presents critical socio-economic implications. As underscored in demographic literature, notably by Bloom et al. (2010) and Harper (2014), the transition to an aging society significantly heightens fiscal pressures on the state, particularly in sustaining pension systems and healthcare infrastructure.

With the aging of the population, the dependency ratio increases, placing an intensified burden on the working-age population to support a growing cohort of retirees. This demographic imbalance challenges the long-term viability of pay-as-you-go pension schemes and necessitates urgent reforms in social protection policies. Moreover, the increasing demand for age-related social services—ranging from healthcare to assisted living—places additional stress on national budgets and calls for a strategic reallocation of resources.

Critically, the literature also warns against viewing aging solely as a burden. Instead, it advocates for adaptive policy innovations that include promoting active aging, increasing retirement age in line with life expectancy, and leveraging the potential of the “silver economy”, in this context, Uzbekistan must reimagine its welfare and labor policies to balance economic sustainability with the dignified inclusion of its aging population.

Table 3. Demographic risk indicators and their risk levels in the Republic of Uzbekistan

№	The naming of indicator	Risk level
1.	The coefficient of migration growth, ‰	The first case before the crisis
2.	Share of people of working age in the total population, %	The second case before the crisis
3.	The number of people unable to work per 1000 people of working age.	The third case before the crisis
4.	Population incidence of circulatory system diseases, 100 000 aholiga	The first case before the crisis

In the economic studying of the age structure of the population, the demographic pressure indicator, which gives an idea of how many children and elderly people there are per 100 working-age people, is of practical importance. If the number of disabled people per 1,000 working-age population exceeds 680, the country is in a crisis, and if it exceeds 770, it enters in the crisis zone. We can observe that in the Republic of Uzbekistan, for every 1,000 able-bodied population, there are 716 people unable to work in 2020, 738 in 2021, and 774 in 2023. In conclusion, we can say that since 2020, we can see that Uzbekistan has entered the pre-crisis zone.

The poor health of the population (physical, mental, and social) in Uzbekistan inevitably leads to a high mortality rate. First of all, circulatory diseases, injuries and poisonings, newly emerging diseases, and respiratory diseases are the main causes of death among the population of the republic. According to analyzes, the incidence of circulatory system diseases among the population of Uzbekistan has moved into the “pre-crisis” zone since 2022.

DISCUSSION. Accurate and high-quality statistical data are the foundation for the development of current and future socio-economic sectors of society.

Analysis of the demographic situation is a prerequisite for the preparation of conceptual program documents defining the demographic policy strategy. With the help of the analysis, the priority and most urgent demographic problems that need to be solved are identified and priority tasks for solving the problems are set.

This process allows us to compare current changes in demographic parameters with the level of progress prior to the implementation of population policy.

On its basis, it will be possible to assess the effectiveness of demographic policy and make necessary changes to its implementation in response to changes in the demographic situation. The current state of demography in Uzbekistan. The institutional units involved in the analysis and study of demographic processes in Uzbekistan and making relevant decisions in this regard can be divided into 5 categories.

1. Government agencies that make decisions on demographic policy.
2. National statistical bodies and agencies that monitor demographic processes.
3. Academic and research institutions.
4. Civil society organizations.
5. International, non-governmental, non-profit organizations, etc.

Government agencies that adopt decisions (documents) related to demographic policy and demographic processes include the Administration of the President of the Republic of Uzbekistan, the Cabinet of Ministers, the Statistical Agency under the President of the Republic of Uzbekistan, the Ministry of Economy and Finance, the Ministry of Poverty Reduction and Employment, the Ministry of Health, the Ministry of Internal Affairs, the Ministry of Justice, and other agencies. These can also include local government bodies (regional and district khokimiyats) that carry out demographic policy in their regions.

Aimed at implementing the identified measures and preventing future problems in the implementation of other tasks, the listed ministries and departments, state authorities are engaged in analyzing demographic situations in accordance with the established procedure and making decisions based on the results depending on the situation.

In addition, some of them also carry out relevant demographic forecasts in their areas. The agencies involved in the formation of demographic indicators and analysis at various levels include the Statistical Agency under the President of the Republic of Uzbekistan and other organizations monitoring demographic processes. In recent years, the role and importance of the institution of the neighborhood and family in our country has been increasing. It is the neighborhood that remains the primary source of demographic data and the initial geographical point for monitoring.

A wide array of international, non-governmental, non-profit, and public institutions are actively contributing to the advancement of demographic research and analysis in Uzbekistan. Significantly, global organizations such as the United Nations Population Fund (UNFPA), UNICEF, the United Nations Development Programme (UNDP), and the World Bank are at the forefront of conducting in-depth demographic assessments, policy analysis, and capacity-building initiatives aimed at informing evidence-based decision-making in population-related areas.

Simultaneously, a growing ecosystem of non-governmental, non-profit entities, independent media outlets, and digital influencers—including data-centric bloggers and civil society platforms—have emerged as influential actors in shaping public discourse and disseminating demographic insights. These diverse voices contribute to enhancing demographic literacy and advocating for population-sensitive governance frameworks.

Literature underscores the centrality of comprehensive, high-quality demographic data in guiding socio-economic reforms. As noted in international development scholarship (e.g., Bloom et al., 2003; Lutz & KC, 2011), accurate demographic information is a cornerstone for optimizing public service delivery, managing age-related transitions, and aligning education, healthcare, and labor policies with evolving population structures. In the context of Uzbekistan, such data is indispensable for reforming the social sector, ensuring equitable resource allocation, and anticipating long-term challenges such as aging, migration, and urbanization.

The main problem in Uzbekistan in analyzing and studying demographic processes is the lack of sufficient data, that is, the lack of data on all indicators of demographic processes, the lack of census activities in this regard during the years of independence, that is, it has not been conducted for more than 30 years (only 2 countries in the world have not conducted a census for such a long period of time: Somalia and Uzbekistan) and the lack of fully open and transparent sources of information, this can be attributed to the fact that access to information is limited,

such as “free access to information”. As a result, the current situation reduces the ability to analyze the impact of demographic processes on socio-economic development in the country.

Another problem is the lack of a single agency or institute in Uzbekistan that would implement a unified demographic policy. It is worth noting that the functions and tasks related to the analysis and study of demographic conditions in the country are contained in the regulations of several ministries and departments, and there is no single coordinating organization.

Also, the institutional and legal framework for analyzing and studying demographic processes in Uzbekistan is insufficient. This is due to the insufficient knowledge of government bodies, including local government bodies, that make decisions on demographic policy, in analyzing and concluding demographic processes, and the lack of experienced and qualified scientific and pedagogical personnel in the field.

Based on the above analysis and problems, it is advisable to carry out the following work, namely:

- to conduct statistical analysis of demographic processes in order to fully create the possibility of statistical analysis of the impact of demographic processes on socio-economic trends in the country, and creating the openness and transparency of primary data considered necessary for the studying and the possibility of “free access to information”;

- to establish a single agency in Uzbekistan to conduct or coordinate demographic and family policy or assign this task to existing appropriate organizations;

- to creation of institutional and legal frameworks for statistical analysis and study of demographic processes by this agency, developing methods for analyzing demographic processes based on international experience and improve the system for delivering them to relevant government bodies;

- to increase the number of institutions conducting scientific and practical research and academic activities related to demographic policy, supporting existing ones, expanding the scope of scientific research in this area, as well as to establish demography-related courses and training in specialties in higher education institutions;

- to ensuring regular (at least once every ten years) population censuses in order to create the possibility of a full-fledged statistical assessment of demographic processes;

- to introduce a mechanism for compiling forecasts of demographic growth and demographic composition changes and their full use in regional and sectoral programs;

- to this end, it is advisable to create a demographic database, strengthen the capacity of personnel in the field of demographic forecasting, and create a functional basis for demographic forecasting;

to take into account the enormous potential of population registers, creating opportunities to use the register in maintaining demographic statistics, etc.

Therefore, to create multivariate statistical forecasts of the main trends in the demographic processes of the population. The forecast parameters of the demographic development of the Republic of Uzbekistan were carried out using the “cohort-component” (age shifting) method. According to forecasts, by 2030, the population of our country is expected to reach 41.3 million people (Table 4).

Table 4. Forecast indicator of the population of the Republic of Uzbekistan (people)

Years	Total	Including:			
		Men	Women	City	Village
2023	36 431 517	18 335 621	18 095 896	18 543 642	17 887 875
2024	37 143 326	18 696 261	18 447 065	18 905 953	18 237 373
2025	37 894 545	19 075 994	18 818 551	19 288 323	18 606 222
2026	38 687 261	19 475 991	19 211 270	19 730 504	18 956 757
2027	39 523 633	19 897 437	19 626 196	20 157 052	19 366 581
2028	40 405 802	20 341 581	20 064 221	20 647 365	19 758 437
2029	41 336 342	20 809 668	20 526 674	21 122 871	20 213 471
2030	42 317 507	21 302 846	21 014 661	21 624 246	20 693 261
Growth in 2030 compared to 2023, %	116,2	116,2	116,1	116,6	115,7

As can be seen from eable 4, in 2023–2030, the population of the Republic of Uzbekistan will increase from 36,431.5 thousand in 2023 by 5,886.0 thousand people or 16.2%, to 42,317.5 thousand people in 2030. Although the average annual growth rate in the years under study was 1.7%, it was observed that by 2023 this indicator will reach 2.0%, and by 2030 it will increase by 0.4% to 2.4% (Table 5).

Table 5. Forecast parameters for average annual population growth (%)

Year	Total	Including:	
		Men	Women
2023	2,0	2,0	2.0
2024	2,0	2,0	1.9
2025	2,0	2,0	2.0
2026	2,1	2,1	2.1
2027	2,2	2,2	2.2
2028	2,2	2,2	2.2
2029	2,3	2,3	2.3
2030	2,4	2,4	2.4

Projections on the sex composition of the population show that the number of men will increase by 16.2 percent, reaching 21,302.8 thousand people in 2030, the number of women increased by 16.1 percent to 21,014.7 thousand people, in this

process, the average annual growth rate of the number of women and men was the same as the average annual growth rate of the republic's population which was 2.2% (Table 5).

The projections also show that the ratio of women to men in the population will be 49.7 percent and 50.3 percent, respectively, in 2030, with the ratio remaining unchanged in 2023. In addition it is worth noting that, based on the country's population projections by place of residence, the population of the republic living in urban areas will increase by 16.6% from 18,543.6 thousand people in 2023 to 21,624.2 thousand people by 2030 while the population living in rural areas will increase by 15.7% to 20,693.3 thousand people in 2023-2030.

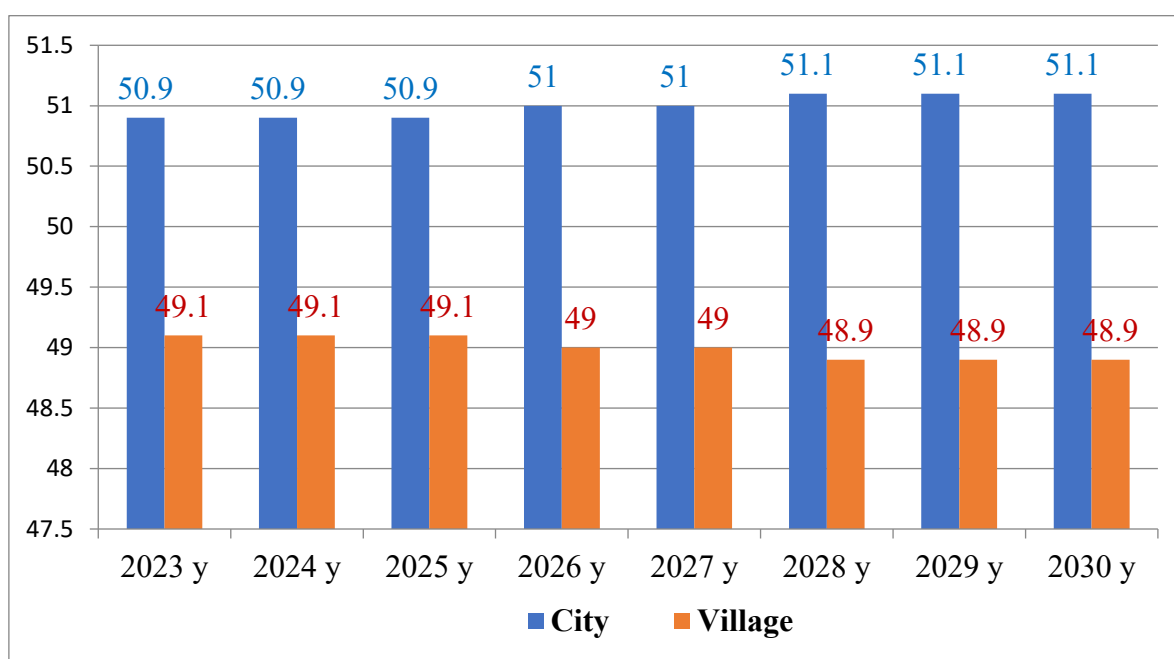


Figure 1. Forecast parameters of population change in urban and rural areas of the republic of Uzbekistan (%)

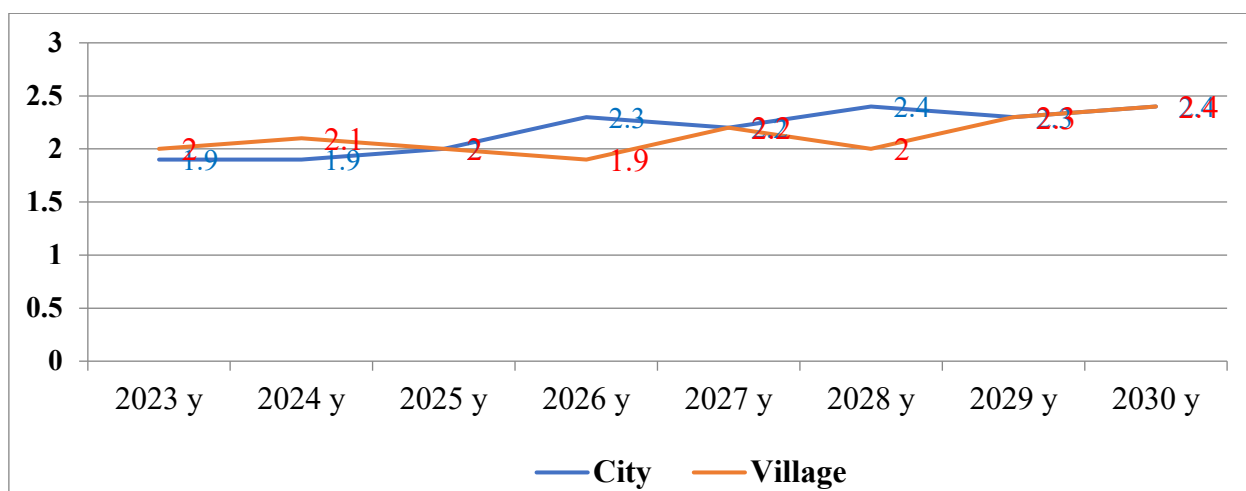


Figure 2. Forecast parameters for average annual population growth by place of residence

The forecast parameters for the average annual population growth by place of residence are expected to increase by 0.4 units in 2030, from 2.0 percent in 2023 to 2.4 percent in urban and rural areas (Figure 2). However, in 2026 and 2028, the trend of mutual equality in average annual growth will disappear, and the average annual growth rates of the urban population will be higher than those of the rural population. According to future population growth forecasts in the Republic of Uzbekistan, overall population growth will steadily decrease in 2023–2030. The total population growth is expected to reach 981,165 people in 2030 an increase of 265,956 people, or 37.2% compared to 2023.

Table 6. Future population growth dynamics, people

Year	Total population	Population growth (decrease)		
		general	natural	mechanic
2023	36 431 517	715 209	746 921	-31 712
2024	37 143 326	711 809	745 603	-33 794
2025	37 894 545	751 219	786 614	-35 395
2026	38 687 261	792 716	829 393	-36 677
2027	39 523 633	836 372	874 010	-37 638
2028	40 405 802	882 169	920 607	-38 438
2029	41 336 342	930 540	969 619	-39 079
2030	42 317 507	981 165	1 020 725	-39 560
2030 compared to 2023	(+/-)	5 885 990	265 956	273 804
	%	16,2	37,2	36,7

From the analysis, it can be said that the natural increase in the population will decrease in line with the overall growth and will reach 1,020,725 people in year 2030, a decrease of 273,804 people or 36.7% compared to 2023. The forecast made during the study expects the rate of population migration, one of the trends that directly affects the overall population growth, to increase in years 2023-2030. This

situation contributes to the fact that the overall population growth rate in the years under analysis has been gradually decreasing.

The projections show that the mechanical population decline in 2030 is 7,848 people, or 24.7 percent, higher than in 2023 (Table 6). Forecasts show that the share of people aged 0-14 in the total population will increase by 0.2 units in 2023-2030, reaching 30.4 percent in 2030. Also, this indicator will increase by 0.5 units during 2023-2028 to 30.7 percent, but will decrease by 0.3 units in 2028-2030. From this, it follows that the share of the population aged 0-14 in the total population will not grow steadily during 2023-2030.

Table 7. Forecast indicators of the share of certain age groups in the total population (%)

Indicators	2023	2024	2025	2026	2027	2028	2029	2030
Percentage of 0-14 year olds	30,2	30,3	30,4	30,6	30,7	30,7	30,6	30,4
Percentage of people aged 15-49	51,4	51,1	50,7	50,2	49,9	49,6	49,4	49,3
Percentage of people aged 50 and over	18,4	18,7	18,9	19,2	19,4	19,7	20,0	20,3

At the same time, forecasts show that the share of people aged 15-49 in the total population will decrease by 2.1 units in 2023-2030, reaching 49.3 percent in 2030. Table 7 shows that the share of people aged 50 and over in the total population will increase by 1.9 units in 2030 compared to 2023, reaching 20.3 percent. If we draw a brief conclusion from the table, the share of people aged 15-49 is decreasing due to the increase in the share of people aged 0-14 and people aged 50 and older in the population, this, in turn, will also lead to a decrease in the proportion of the working-age population.

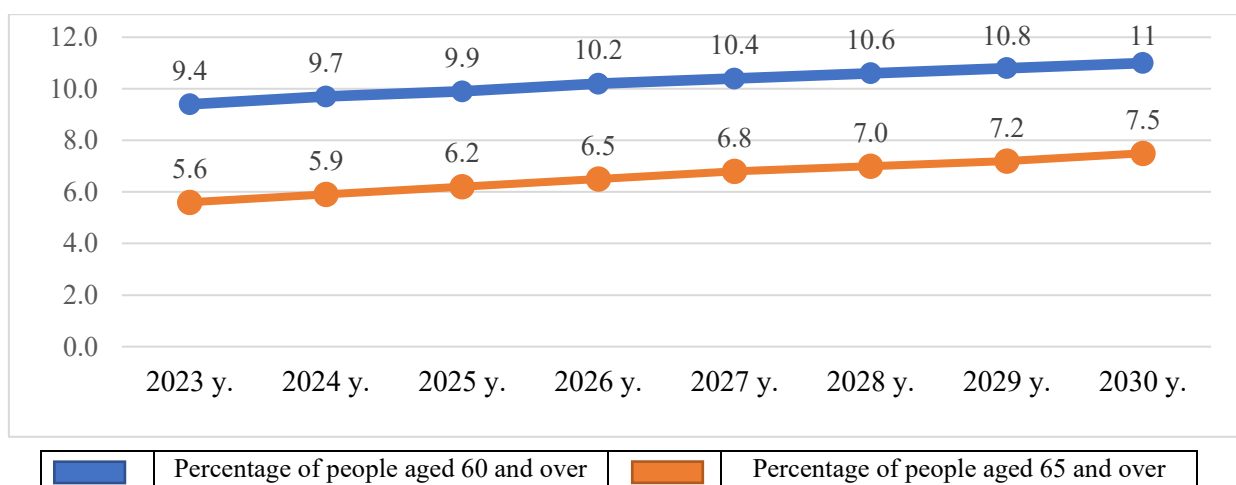


Figure 3. Forecast indicators of the share of the total population aged 60 and over and 65 and over (%)

The age-sex pyramid resembles real pyramids because as people get older, the number of people in their age group decreases and the length of the pyramid's bars shortens. The ideal age structure of a population, where birth and death rates remain constant over many years, resembles an almost equilateral triangle with straight sides. However this is not the case, as both the number of births and the number of deaths usually fluctuate dramatically [2]. An age-sex pyramid of the population of the Republic of Uzbekistan for the future (2023 and 2030) has been constructed (Figure 4).

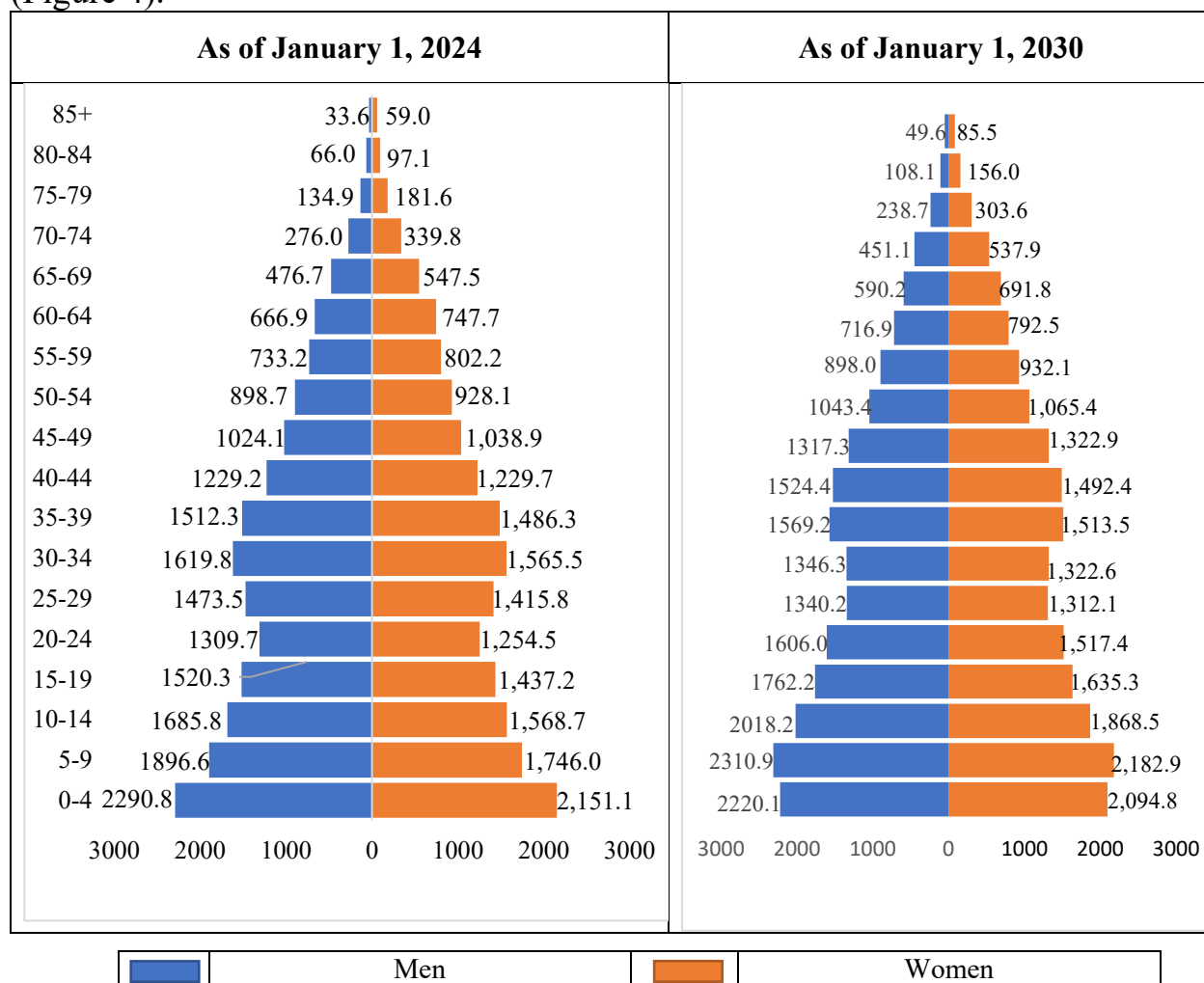


Figure 4. Future age-sex pyramid of the population of the Republic of Uzbekistan, (thousand people)

As can be seen from Figure 4, the age-sex pyramid of the population of the Republic of Uzbekistan in 2024 took its shape. That is, in this year's age-sex structure of the population, the number of men and women in the 0-4, 5-9, 10-14, and 30-34 age groups was high. The highest share of the working-age population was among men and women in the 25-29 and 30-34 age groups, while this share decreased in the 55-59 age group.

Table 8. Future fertility rates in the Republic of Uzbekistan

Years	Number of births, people	Birth rate, per thousand	Total fertility rate
2023	923 268	25,4	3,308
2024	958298	25,8	3,315
2025	985258	26,0	3,378
2026	1021344	26,4	3,415
2027	1071090	27,1	3,587
2028	1123281	27,8	3,637
2029	1178086	28,5	3,760
2030	1235671	29,2	3,880

As can be seen from the data in the table above, the number of births in the Republic of Uzbekistan in 2023–2030 is expected to decrease from 923,268 in 2023 to 312,403, or 33.8 percent, and by 2030 it is expected to reach 1,235,671. Also, if the birth rate in 2023 is 25.4 per thousand, the total birth rate will be 3.308. According to the forecast results, by 2030, the birth rate is expected to be 29.2 per thousand, and the total fertility rate is expected to be 3.880. According to the results of the analysis, it can be predicted that the birth rate will change over the years as follows: 25.8 per thousand in 2024, 26.0 per thousand in 2025, 26.4 per thousand in 2026, 27.1 per thousand in 2027, 27.8 per thousand in 2028, 28.5 per thousand in 2029, and 29.2 per thousand in 2030.

Table 9. Prospective mortality rates in the Republic of Uzbekistan

Years	The number of dead		Infant mortality	
	Number, people	coefficient, per mille	Number, people	coefficient, per mille
2023	176 347	4,8	8320	9,0
2024	178 288	4,8	8568	8,9
2025	181 894	4,8	8814	8,9
2026	181 830	4,7	9059	8,8
2027	185 761	4,7	9302	8,7
2028	185 867	4,6	9547	8,7
2029	190 147	4,6	9792	8,6
2030	194 661	4,6	10037	8,6

As can be seen from the data in Table 9, while 176,347 deaths were observed in the Republic of Uzbekistan in 2023, it is expected that by 2030 this number will increase by 11.3%, or 19,789 more deaths will be recorded. The mortality rate is expected to be 4.8 per thousand in 2023 and 4.6 per thousand by 2030. Infant mortality under the age of 1 will increase from 8,320 to 1,717 in 2023, or 20.6 percent, reaching 10,037 in 2030. The infant mortality rate will drop to 9.0 per thousand in 2023 and 8.6 per thousand in 2030. According to the results of the analysis, it is possible to predict that the infant mortality rate will change over the years as follows: 8.9 per thousand in 2024, 8.9 per thousand in 2025, 8.8 per thousand in 2026, 8.7 per thousand in 2027, 8.7 per thousand in 2028, 8.6 per

thousand in 2029, and 8.6 per thousand by 2030. According to forecasts, life expectancy at birth in Uzbekistan is expected to increase steadily (Table 10).

Table 10. Life expectancy at birth, age

Regions	Years								Changes in 2030 compared to 2023 (+,-)
	2023	2024	2025	2026	2027	2028	2029	2030	
Republic of Uzbekistan	74,7	74,8	74,8	75,0	75,1	75,2	75,3	76,3	1,6
Republic of Karakalpakstan	73,2	73,3	73,4	73,6	73,8	73,9	74,0	74,2	1,0
<i>regions:</i>									
Andijan	73,5	73,6	73,7	73,8	73,9	74,0	74,1	74,2	0,7
Bukhara	76,2	76,4	76,5	76,6	76,7	76,9	77,0	77,2	1,0
Jizzakh	75,4	75,5	75,6	75,9	76,3	76,5	76,6	76,8	1,4
Kashkadarya	75,5	75,6	75,6	75,7	75,9	76,0	76,1	76,1	0,6
Navoi	75,4	75,5	75,6	75,7	75,8	76,0	76,1	76,2	0,8
Namangan	74,1	74,2	74,3	74,4	74,5	74,6	74,7	74,8	0,7
Samarkand	74,7	74,8	74,9	75,1	75,3	75,4	75,5	75,7	1,0
Surkhandarya	74,7	74,7	74,8	74,9	75,1	75,2	75,3	75,4	0,7
Syrdarya	72,1	72,1	72,2	72,3	72,5	72,6	72,7	72,8	0,7
Tashkent	74,0	74,1	74,1	74,3	74,4	74,5	74,6	74,7	0,7
Fergana	75,4	75,5	75,5	75,7	75,8	75,9	76,0	76,1	0,7
Khorezm	74,1	74,2	74,2	74,3	74,4	74,5	74,7	74,8	0,7
Tashkent city	75,5	75,5	75,6	75,7	75,9	76,1	76,2	76,4	0,9

Life expectancy at birth will be 74.7 years in 2023, 75.0 years in 2026, and 76.3 years in 2030. During the forecast years, life expectancy at birth for men will increase from 72.6 to 75.0 years, and for women from 76.7 to 77.4 years. Also, during the forecast period, an increase of 1 year and above was observed in the Jizzakh, Bukhara, and Samarkand regions, as well as the Republic of Karakalpakstan. In our scientific work, we forecast demographic processes in our country, taking into account the need to determine their future prospects, not limited to their current state and dynamics.

Forecasting allows you to obtain statistical information about what changes will occur in the composition of the permanent population in the future, and what factors will influence it. Taking these aspects into account, in our scientific work, we can construct an econometric model of the permanent population of our country based on independent variables affecting it. The following variables were defined as independent variables in constructing the econometric model of the constant population size (U), namely:

X1 – birth rate (per 1,000 population);

X2 is the mortality rate (per 1,000 population).

In our research, we used a correlation matrix to see the relationship between the dependent and independent variables presented. Essentially, a correlation matrix consists of correlation coefficients (R, r) that indicate the relationship between the dependent and independent variables. The correlation matrix results show that there is a relationship between the permanent population size and the birth and death rates. In this case, there is a strong linear relationship between the permanent population size and the birth rate. This indicates that an increase in the birth rate affects the increase in the permanent population size. The population size is inversely related to the mortality rate, which means that a decrease in the mortality rate leads to an increase in the population size. It was found that there is a moderate linear relationship between the mortality and birth rates.

Table 11. Correlational linkage matrix

	The number of permanent residents (Y)	Birth rate (X ₁)	Mortality rate (X ₂)
The number of permanent residents (Y)	1	-	-
Birth rate (X ₁)	0,82	1	-
Mortality rate (X ₂)	-0,69	-0,57	1

The correlation matrix presented above showed that there is a relationship between the constant population size and the birth and death rates. Determining the quantitative impact of the above independent variables on the permanent population requires the construction of an econometric model. The results of the correlation matrix show that it is possible to construct an econometric model of the constant population based on birth and death rates. This can be explained by the lack of a strong linear relationship between the two independent variables. In our scientific work, it is appropriate to construct an econometric model (1) with the functional form given below, taking into account the dynamics of population change, namely:

$$\ln(y_t) = \beta_0 + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + u \quad (3.1)$$

The semi-logarithmic model assumes that the resulting variable is a constant population, which is positive, and the population growth is exponential. Therefore, the semi-logarithmic model fully reflects the trends in permanent population change. The coefficients of the econometric model are estimated using the least squares method. The using of this method is to minimize the forecast errors determined based on the model. The econometric model of the permanent population was built mainly on the basis of the important factors affecting it. It was found that the actual statistical value of the student's test, which tests the statistical significance of the parameters of the econometric model, is higher than the tabular value ($F\text{-real} > F\text{-table}$). This indicates that the parameters of the constructed model are statistically significant. At the same time, we can see that the derivative of the parameters of the econometric model has the expected value.

Specifically, it states that an increase in the birth rate (X_1) leads to an increase in the permanent population (Y), while an increase in the death rate (X_2) in turn leads to a decrease in the permanent population (Y). In addition, it was found that the calculated values of Fisher's exact test, which checks the quality of the model, were greater than the critical value. This showed that the combined effect of the independent variables in the econometric model on our outcome factor was statistically significant and that the constructed model was statistically adequate. We check the residuals from the constructed econometric model against the Durbin-Watson autocorrelation residuals. In this case, the statistical value of the Durbin-Watson criterion equal to 1.93 indicates that there is no autocorrelation in the residuals. The coefficient of determination of the constructed model is 0.75, indicating that the independent variables in the model represent our resulting factor by 75%.

Table 12. Results of the econometric model of the permanent population

Changeable	Coefficient	Standard errors	t-Statistics	R-value
X1	0,04	0,01	4,52	0,00
X2	-0,16	0,06	-2,67	0,01
C	10,22	0,47	21,94	0,00
R ²	0,75	Average connection		10,27
Flattened - R ²	0,73	Standard deviation of the dependent variable		0,12
S.E regression	0,06	Akaike Information criterion		-2,66
The sum of the squares of the constant values	0,07	Shvarts - criteria		-2,51
Logarithmic probability	33,55	Hanan Quyin-criteria		-2,62
F-statistic	30,51	DW-Durbin-Watson statistics		1,93
Problem (F-statistic)	0,00			

The results of statistical tests of the developed model show that the model can be used. According to the developed model, it was found that an increase in the birth rate by one unit leads to an increase in the average annual population by 4%. An increase in the death rate by one unit can lead to an average decrease in the permanent population by 16.0%.

$$\ln(y_t) = 10,22 + 0,04 \cdot x_1 - 0,16 \cdot x_2 \quad (3.2)$$

(21,94) (4,52) (-2,67)

According to the developed econometric model, forecast values of birth and death rates are needed to forecast the permanent population size for the coming years. Therefore, trend models were created to determine the values of these

variables in subsequent periods. A trend model with a polynomial functional form was developed to determine the forecast values of the fertility rate for the coming years. The coefficient of determination of the constructed trend model is $R^2 = 0.89$, indicating that the model is 89% close to the real process. In addition, the trend model is growing, and the model revealed that the fertility rate will increase in 2023–2030 (Figure 5).

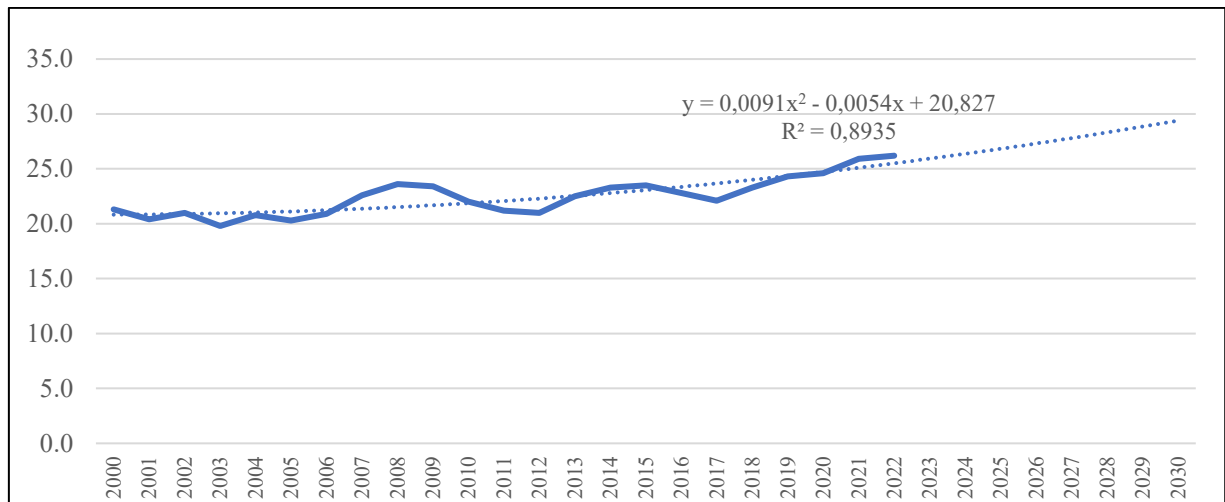


Figure 5. Birth rate trend in the Republic of Uzbekistan, per 1000 population

A logarithmic model was used to determine the mortality rate forecast values for the following years. It was found that the coefficient of determination of the logarithmic trend model was 0.83. This indicates that the constructed trend model is 83.0% close to the real process. According to the results of the developed trend model, the mortality rate will have a tendency to decrease at a low rate. Therefore, it is predicted that the mortality rate will decrease in 2023–2030 and will reach 4.7 per thousand in 2030 (Figure 6).

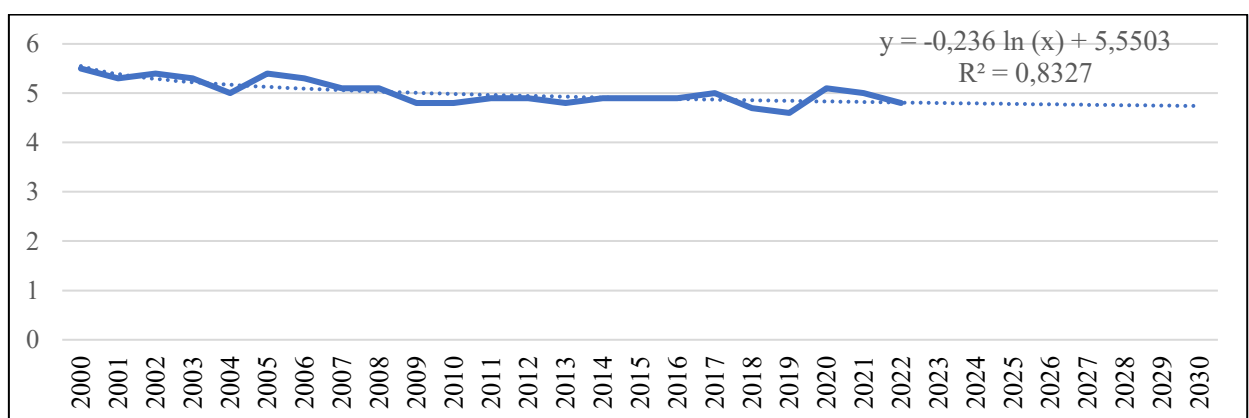


Figure 6. Death rate trend in the Republic of Uzbekistan, per 1000 population

According to the forecast, an increase in the birth rate and a decrease in the death rate of the population will, in turn, affect the permanent population size

according to the model (2) in the years 2023–2030. According to model (2), it was determined that the number of permanent residents in our country will increase in the years 2023–2030. In particular, by 2030, the number of permanent residents is expected to reach 42,317.5 thousand people.

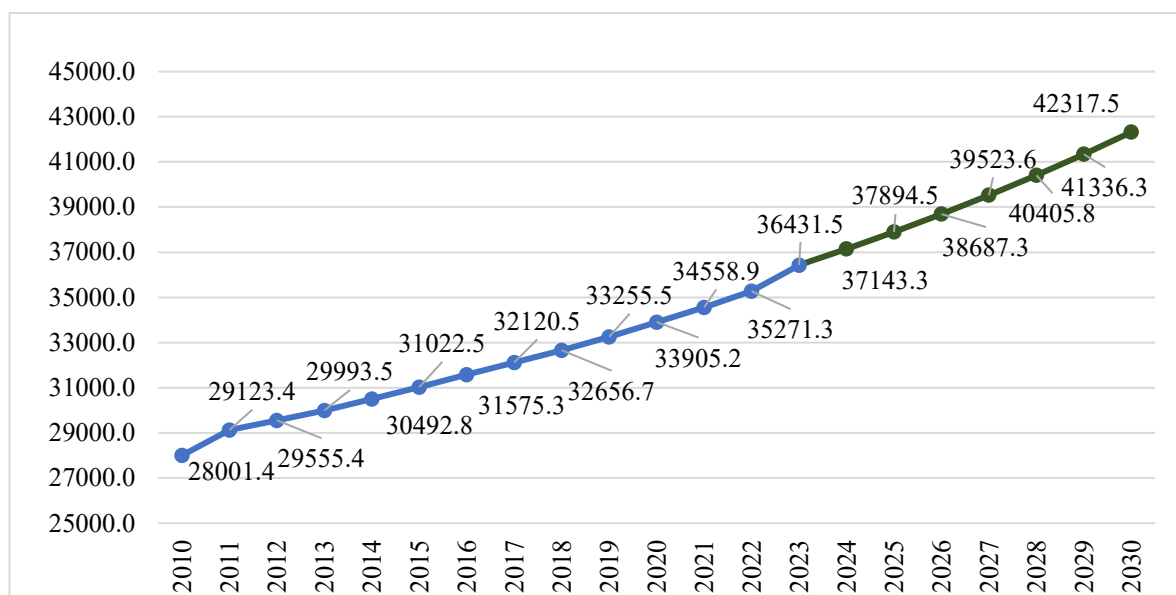


Figure 7. Forecast values of the permanent population of Uzbekistan for 2023–2030, (thousand people)

Based on the forecast data from the study, we can say that: the birth rate in country will be 29.4 per thousand in 2030 and the mortality rate is 4.7 per thousand, so the natural increase is expected to be 24.7 per thousand. As a result, the permanent population of our country is projected to reach 42,317.5 thousand people in 2030, which is 1.2 times higher than the value in 2022.

CONCLUSION. The goals of statistical forecasting include: determination of the near and distant future prospects of the object under study based on the analysis of real processes; a compiled forecast and evaluating the decisions made in terms of their consequences in the forecast period, and making optimal decisions and forward-looking plans. Statistical analysis of the demographic situation of the country and regions and the cluster analysis method was used to identify cities and districts with high socio-economic potential in terms of population demographics.

According to the forecast made in the scientific research, the population of Uzbekistan will reach 41.4 million people by 2030 or an increase of 14.8% compared to 2022. Based on our scientific research, by 2030 (information 2030), the birth rate in Uzbekistan will be 20.9 per thousand, the total fertility rate (the number of children per woman of reproductive age) is 3,080, the mortality rate is 5.2 per thousand, the infant mortality rate is 11.6 per thousand, we can conclude that life expectancy at birth is expected to reach 76.3 years.

Demographic development, primarily the population aged 3-18, determines the requirements for the development of the preschool, secondary, vocational and

higher education system. From the point of view of achieving demographic stability, first of all, it is necessary to ensure the implementation of the parameters for covering the population with preschool, school, secondary specialized, vocational and higher education, planned for the period until 2030 (in special programs).

According to demographic forecasts, the following positive demographic changes will occur in the number and composition of our country's population in the near future: increase in the total fertility rate, increase in natural growth, increase in life expectancy at birth, etc. The negative aspect is that the increasing proportion of older people will lead to increased demographic pressure on the working population.

This situation requires the country to take into account the demographic factor when developing socio-economic development programs. It is manifested in achieving demographic stability, increasing the standard and quality of life of the population, and increasing life expectancy.

Funding

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Data Availability Statement

The data analysed in this study were obtained from official statistical data published by the National Statistics Committee of the Republic of Uzbekistan. The data are publicly available through the official website of the National Statistics Committee at <https://stat.uz/en/>

Ethics Approval

Not applicable. This study was based exclusively on secondary statistical data and did not involve human participants or primary data collection.

Consent to Participate

Not applicable, as no human participants were involved in the study.

Consent for Publication

Not applicable.

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