SOCIO-DEMOGRAPHIC SCENARIOS FOR POST-WAR RECOVERY OF UKRAINE

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Petrukha N. M., Petrukha S. V., Velykyi Y. O., Yakymchuk A. V. Socio-Demographic Scenarios for Post-War Recovery of Ukraine

The relevance of the article is justified by the significant need to develop a comprehensive demographic strategy for post-war Ukraine, which is facing unprecedented challenges – population loss, a migration crisis, declining birth rates, and an aging society. In this regard, the aim of the article is to develop potential socio-demographic scenarios for Ukraine's development in the post-war period, taking into account the consequences of the armed aggression of the russian federation, changes in the population structure, migration trends, birth and death rates, as well as the formulation of policies for restoring human potential as a key component of the sustainable development of the State. The methodological basis of the research included the dialectical method, a systemic approach, methods of abstraction and generalization, scenario analysis methods, structural-factor modeling, statistical forecasting, moving average analysis, and regression analysis. The novelty of the article lies in the scenario approach to assessing the socio-demographic prospects of post-war recovery in Ukraine, which is based on a combination of quantitative forecasting, analysis of migration dynamics, and a systemic view of demographic revival policy. The article analyzes population size, birth rates, mortality rates, and migration processes. Three scenarios for Ukraine's demographic development by 2050 have been proposed: optimistic, baseline, and pessimistic. The optimistic scenario anticipates population stabilization through the mass return of emigrants, support for birth rates, and active State policy. The baseline scenario reflects a gradual decrease in population under conditions of partial success of the regulatory measures implemented by the State. The pessimistic scenario illustrates a deep demographic crisis amid ongoing negative trends. The growth rates of the population in Ukraine have been analyzed, both with and without taking into account migration, indicating the decisive influence of migration processes on demographics. The distribution of Ukrainian refugees across EU countries following the full-scale invasion by russia is presented, enabling an assessment of repatriation potential. The strategic importance of human capital for Ukraine's sustainable development is emphasized. It is substantiated that without reforms in the social sphere, employment policy, and healthcare, post-war demographic recovery in Ukraine will be a highly complicated process. A comparative analysis of the gender-age structure of the population in 2000, 2025, and 2050 has been conducted, confirming the trend towards aging, a decline in birth rates, and losses among the youth. The role of State policy in shaping Ukraine's demographic future is demonstrated. The necessity to create demographic infrastructure is outlined: reintegration centers, housing policies, and healthcare systems. The prospects for applying incentives to return the population to the de-occupied regions of Ukraine are described. It is concluded that a comprehensive approach to post-war demographic recovery is necessary as a foundation for sustainable development in Ukraine amid a migration crisis.

Keywords: demographic recovery, scenario analysis, post-war Ukraine, migration, migration crisis, birth rate, human capital, demographic policy.

Fig.: 9. Tabl.: 1. Formulae: 5. Bibl.: 35.

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Петруха Н. М., Петруха С. В., Великий Є. О., Якимчук А. В. Соціально-демографічні сценарії повоєнного відновлення України

Актуальність статті обґрунтовується значною потребою у формуванні комплексної демографічної стратегії для повоєнної України, що зіштовхується з безпрецедентними викликами – втрата населення, міграційна криза, зниження народжуваності та старіння суспільства. З огляду на це, мета статті полягає в розробці можливих соціально-демографічних сценаріїв розвитку України в повоєнний період з урахуванням наслідків збройної агресії рф, змін у структурі населення, міграційних тенденцій, рівня народжуваності та смертності, а також формування політики відновлення людського потенціалу як ключової складової стійкого розвитку держави. Методологічною основою дослідження стали діалектичний метод, системний підхід, прийоми абстрагування й узагальнення, методи сценарного аналізу, структурно-факторне моделювання, статистичне прогнозування, аналіз ковзного середнього та регресійний аналіз. Новизна статті полягає у сценарному підході до оцінки соціально-демографічних перспектив повоєнного відновлення України, що ґрунтується на поєднанні кількісного прогнозування, аналізу міграційної динаміки та системного бачення політики демографічного відродження. Проаналізовано чисельність населення, динаміку народжуваності, смертності та міграційних процесів. Запропоновано три сценарії демографічного розвитку України до 2050 року: оптимістичний, базовий і песимістичний.

Оптимістичний сценарій передбачає стабілізацію населення за рахунок масового повернення емігрантів, підтримки народжуваності та активної державної політики. Базовий сценарій відображає поступове зниження чисельності населення в умовах часткового успіху, вжитих державою регуляторних заходів. Песимістичний сценарій ілюструє глибоку демографічну кризу при збереженні негативних тенденцій. Проаналізовано темпи приросту населення в Україні з урахуванням і без урахування міграції, що вказують на вирішальний вплив міграційних процесів на демографію. Наведено розподіл українських біженців за країнами ЄС після повномасштабного вторгнення рф, що дає змогу оцінити потенціал репатріації. Підкреслено стратегічне значення людського капіталу для сталого розвитку України. Обґрунтовано, що без реформ у соціальній сфері, політиці зайнятості та охороні здоров'я повоєнне демографічне відновлення в Україні буде дуже ускладненим процесом. Здійснено порівняльний аналіз статево-вікової структури населення у 2000, 2025 та 2050 роках, що підтверджує тенденцію до старіння, зниження народжуваності та втрат серед молоді. Показано роль державної політики у формуванні демографічного майбутнього України. Розкрито необхідність створення демографічної інфраструктури: центрів реінтеграції, житлової політики, системи охорони здоров'я. Описано перспективи застосування стимулів для повернення населення в деокуповані регіони України. Зроблено висновок про необхідність цілісного підходу до післявоєнного демографічного відновлення як бази для сталого розвитку України в умовах міграційної кризи.

Ключові слова: демографічне відновлення, сценарний аналіз, повоєнна Україна, міграція, міграційна криза, народжуваність, людський капітал, демографічна політика.

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The study of socio-demographic dynamics in a post-war environment is of significant importance for national recovery and future stability. Wars inevitably cause deep and multifaceted damage to the structure of a nation's population, leading to complex and often irreversible changes. For Ukraine, the ongoing full-scale invasion by the russian federation has caused unprecedented demographic issues, including mass forced displacement, a sharp decline in birth rates, increased mortality, and accelerated population aging. Without a clear understanding of the demographic situation, efforts to restore infrastructure and the economy may fail due to an unbalanced population structure or insufficient human resources.

Based on the above, a key issue is the profound uncertainty surrounding Ukraine's demographic future in the post-war era. There is a significant need today to develop comprehensive, scenario-based forecasts that consider various potential trajectories of demographic change. The present research aims to compose and analyze different socio-demographic scenarios – optimistic, baseline, and pessimistic – by integrating key demographic components with socio-economic factors. Such a structure is important for substantiating strategic decisions related to repatriation, social support, economic recovery, and human capital development in the context of a migration crisis.

The *aim of the article* is to develop possible social-demographic scenarios for the development of Ukraine in the post-war period, taking into account the consequences of the armed aggression by the russian federation, changes in the population structure, migration trends, birth and death rates, as well as the formation of a policy for the restoration of human potential as a key component of the sustainable development of the State.

The *novelty of the article* lies in the scenario-based approach to assessing the social-demographic prospects of post-war recovery in Ukraine, which is based on a combination of quantitative forecasting, analysis of migration dynamics, and a systemic view of demographic revival policy.

Research methods. The article employs dialectical methods, a systemic approach, techniques of abstraction and generalization, methods of scenario analysis, structural-factor modeling, statistical forecasting, moving average analysis, and regression analysis. The information base of the research was formed by the works of domestic and foreign scholars, materials from State statistics, data from the World Bank, international analytical agencies, and experts.

A significant contribution to the study of the socio-demographic development of Ukraine in the context of transforming economic policy, modernizing social policy, and the management system of State finances, considering social triggers in the post-war recovery process of Ukraine from the consequences of the russian-Ukrainian war was made by the Ukrainian scholars such as E. Libanova, S. Pyrozhkov, O. Makarova, O. Hladun, V. Chernychenko, D. Shushpanov, T. Zayats, O. Poznyak, S. Rybak, K. Pavliuk, V. Blyzniuk, O. Stepanova, N. Andriiv, S. Melnyk, D. Konovalenko, M. Tripak, M. Oliievska, N. Kukina, D. Plakhotnyi, O. Mukhin, O. Tsyupa, V. Shlyakhetko, N. Alekseienko,

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O. Zelenko, V. Klochkovska, I. Novikova, E. Zabarna, T. Vasylytsiv, and others [1–35].

The Western school also extensively studies the issues of long-term and short-term strategic planning concerning the role of social policy in economic development processes, including development based on inclusion, accessibility, resilience, and the socialization of public finances. These aspects are discussed in the works of E. Darling, A. Fair, K. Abi, H. Uluorta, P. Bloom, G. Cazelli, J. Vallen, G. Wunsch, and others. Despite the comprehensive theoretical analysis of the subject, questions regarding the scale and pace of the return of Ukrainian emigrants and internally displaced persons remain unresolved, which will significantly influence the restoration of labor potential in post-war Ukraine. The effectiveness of State policy in stimulating birth rates amid economic instability and psychologically traumatized population remains uncertain.

The full-scale invasion of Ukraine by the russian federation has led to profound socio-demographic consequences that will affect our country for decades to come. Forced displacement is one of the defining demographic outcomes of the war. Millions of Ukrainians have been displaced within the country, while others have sought refuge abroad, primarily in the European Union Member States. According to international estimates, Ukraine is currently the leader in the number of displaced persons in the world. All of this creates sharp demographic imbalances between regions: some Western regions are experiencing significant population growth, while large parts of the East and South have become almost uninhabited. At the same time, Ukrainian refugees abroad often face uncertainty regarding legal status, employment, and access to education, complicating prospects for their return and reintegration.

Emigration tendencies have also intensified due to the war, especially among the working-age adult population and families with children. Many of them have settled abroad for permanent residence, creating a growing and active Ukrainian diaspora. At the same time, the longer displaced Ukrainians remain outside the country, the lower the likelihood of their return. This poses long-term challenges for the recovery of both the economy and the population, particularly in sectors that are already suffering from labor shortages. The war has also altered the age and gender structure of Ukraine's population. A significant portion of emigrants consists of women and children, as men of conscription age are prohibited from leaving the country. Meanwhile, within the country, some men have already been mobilized into the Ukrainian Armed Forces, among whom a certain share have died or sustained serious injuries, further reducing the male population of working and reproductive age. This imbalance complicates the future recovery of the population of Ukraine and affects family structure and birth rates.

Together, these socio-demographic shifts establish serious challenges for the post-war recovery of Ukraine. The loss of population due to death, emigration, and declining birth rates weakens Ukraine's future economic and social potential. Reconstruction will require not only physical infrastructure but also targeted demographic policies to encourage repatriation, support family growth, and integrate displaced populations.

The *Fig. 1* shows a dynamic series of changes in the population of Ukraine, birth rates, and mortality rates from 2001 to 2023. A clear trend of decreasing population is observed: from over 49 million persons in 2001 to less than 38 million in 2023. This decline has particularly accelerated since the beginning of 2022, associated with the full-scale war, mass emigration, and an increase in mortality.

The birth rate in Ukraine grew until 2012, when it peaked at 11.4 per 1,000 persons; however, it has since been steadily declining. In 2023, this indicator was only 5.6, which is critically low. This trend indicates a deep demographic crisis that complicates the natural recovery of the population.

Conversely, the mortality rate remained consistently high throughout this period, increasing in crisis years, particularly in 2022, when it reached 17.1. In 2023, mortality slightly decreased to 13.1 but still exceeds the birth rate by more than two times. These data indicate a serious demographic imbalance that requires urgent reassessment of social and migration policies as a basis for post-war recovery scenarios in Ukraine.

The *Fig. 2* illustrates the dynamics of the population of Ukraine from 2001 to 2023, as well as the 3-year moving average. In 2001, the population of Ukraine was 49.1 million persons, and by 2020, the decline was relatively smooth, with figures remaining within the range of 44–48 million persons.

In 2001, the population of Ukraine was 49.1 million persons, and by 2020, the decline was relatively smooth, with figures remaining within the range of 44–48 million persons.

Starting from 2021, the rate of population decline sharply increased. A particularly noticeable drop occurred in 2022 and 2023 – down to 41.0 million and 37.7 million persons, respectively. This corresponds to the period of russia's full-scale invasion of Ukraine, mass emigration, and losses among the civilian population. The trend line and moving average emphasize a persistent trend towards a decreasing population, which has both social and economic consequences. A polynomial model demonstrates that even before the war began, the population of Ukraine was gradually declining, and the full-scale war merely accelerated these processes. The coefficient of determination (R^2 = 0.7943) indicates a high correspondence between the trend line and the actual data.

The *Fig. 3* shows the population growth rates in Ukraine from 2010 to 2023, considering and excluding migration. It is clear that even without taking migration processes into account, the dynamics are negative – the figures decrease every year, reaching –1.02% in 2021 and –0.75% in 2023. Considering migration, the trend is even more negative: in 2022, the growth was critically –14.76%, indicating a substantial loss of population due to emigration during the full-scale war.

In 2023, the rate, considering migration, improved significantly but remained very low at –1.55%. This may indicate a partial return of Ukrainians or a decrease in the pace of emigration. Overall, it can be stated that migration processes play a key role in shaping the demographic situation in Ukraine.
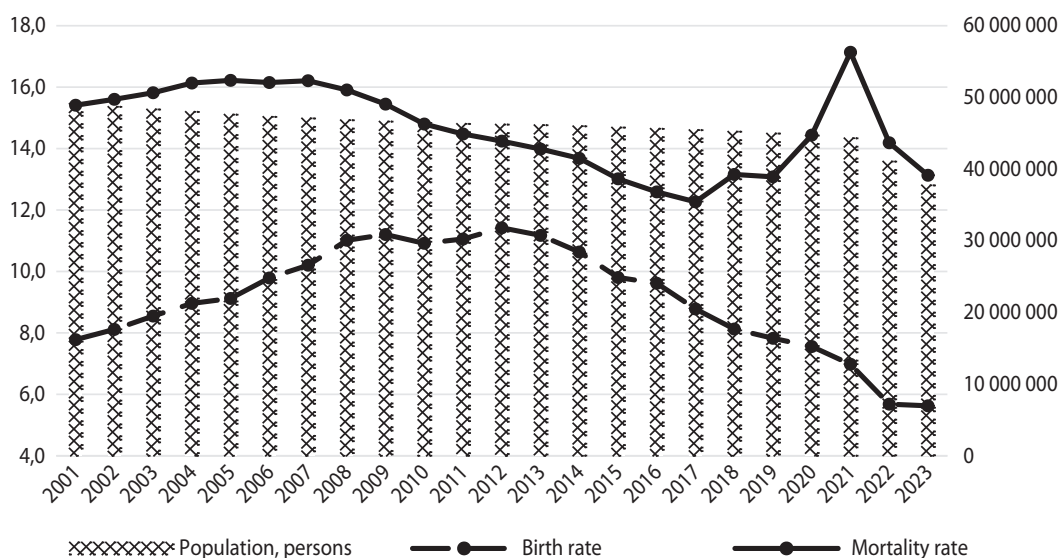
Fig. 1. Dynamic series of the population in Ukraine from 2001 to 2023, persons

Source: composed on the basis of [9].

$$y = -0.0161x^2 + 0.0792x + 47.962$$
$$R^2 = 0.7943$$
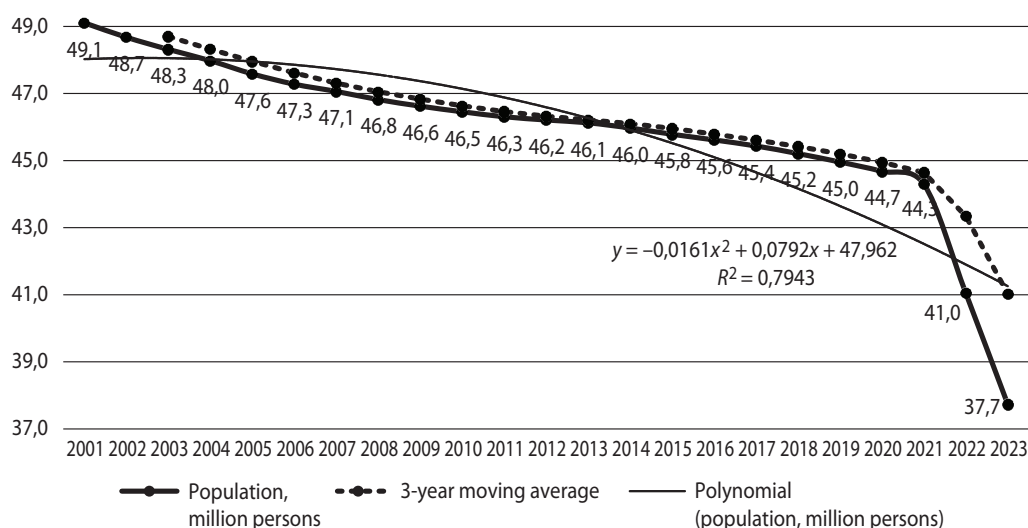
Fig. 2. Dynamics of the population of Ukraine from 2001 to 2023 with a 3-year moving average (smoothing coefficient – 3)
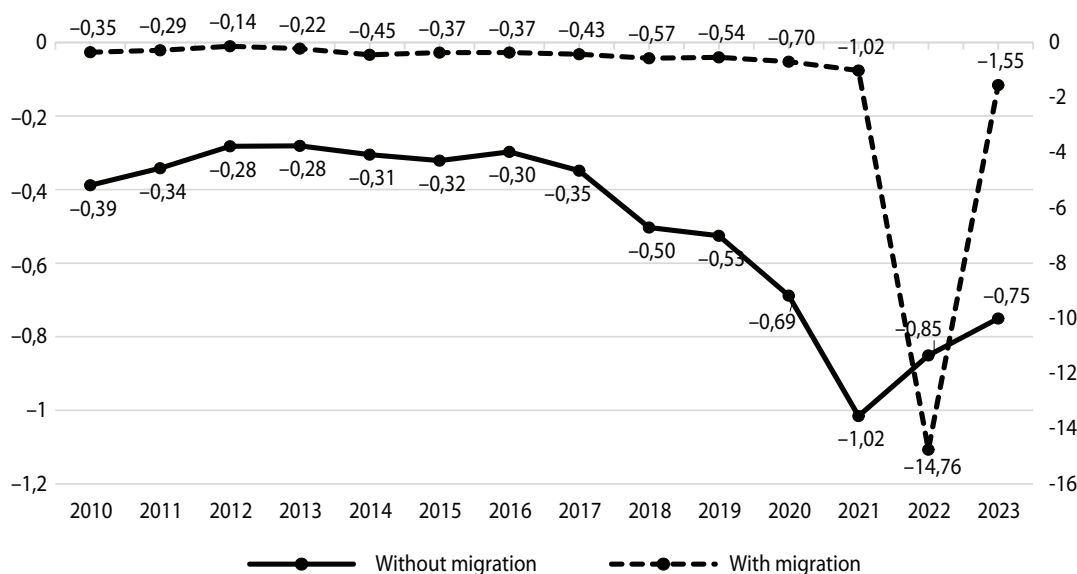
Source: composed on the basis of [9].

As of 2025, the total population of Ukraine is 38.980.380 people. In particular, youth (under 15 years old) represents 13.69% of the population, or 5.33 million persons, while the share of the working-age population (mainly 15–64 years) reaches 67.33%, corresponding to 26.24 million persons. Elderly citizens (65+ years) account for almost one-fifth of the population – 18.97%, or 7.39 million persons. In contrast, the population growth rate in 2025 is 2.96%, which is a positive signal after a long period of decline. The gender ratio is 0.87 (that is, there are 87 men for every 100 women), while among the working-age population, the ratio is slightly higher at 0.96. The demographic dependency ratio is 48.5%, which means that for every 100 working-age individuals, there are nearly 49 children and elderly people [11].

The *Fig. 4* compares the gender-age structure of the population of Ukraine in key years of its history: 2000 and 2025. The left side of the Fig. 4 illustrates the population structure at the beginning of the millennium, demonstrating the consequences of the profound demographic crisis of the 1990s, caused by the collapse of the Soviet Union and economic decline. The gender-age structure of Ukraine's population in 2000 already indicated the beginning of demographic aging, with a narrowed base due to low birth rates, but with relatively wide middle-age groups.

The right side of Fig. 4 reflects the gender-age structure of Ukraine's population in 2025, which is particularly indicative as it shows the consequences of the full-scale invasion by the russian federation. The diagram shows signifi-

Fig. 3. Population growth rates in Ukraine from 2010 to 2023, taking into account migration and without it, %
Source: composed on the basis of [10].

cant «gaps» in the age groups of 0–4 and 20–30 years, which are a direct result of falling birth rates and mass emigration, especially among young women and families.

In general, both graphs in the Fig. 4 illustrate the relentless decline and aging of the Ukrainian population, which is one of the greatest threats to post-war recovery. The comparison of the years 2000 and 2025 enables us to assess not only the scale of the disaster caused by the war but also its acceleration, rendering the demographic issue crucial for strategic planning and the development of policies for the recovery of Ukraine's human capital.

The *Fig. 5* presents the forecast of the gender-age structure of Ukraine's population for 2050, demonstrating the consequences of long-term demographic trends. Its shape resembles an urn, which is a classic indicator of deep demographic aging. Unlike the pyramid, where a wide base indicates a young population, here we see a significant narrowing in the lower age groups (0–24 years) due to persistently low birth rates, which are only exacerbating due to the war and emigration. In contrast, the widest part of the pyramid is in the age groups of 60–75 years, indicating a high proportion of the elderly population.

Such a structure indicates a critical demographic burden on the working-age population. Essentially, a small number of young people in the future will be forced to provide for a significantly larger cohort of retirees, which threatens the stability of the pension system and social security. This forecast demonstrates that without radical changes in demographic policy, particularly in the areas of encouraging birth rates and returning migrants, Ukraine will face serious challenges for its sustainable development and economic viability.

Fig. 6 shows the distribution of registered Ukrainian refugees in key European countries as of April 2025. The majority of refugees have found shelter in Germany, as confirmed by the highest number – over 1.2 million persons (1.217.680 individuals). This indicates that Germany is the main center of attraction for Ukrainians, likely due to its strong economy and effective support programs. The countries following Germany, such as the Great Britain (254.580 persons) and Spain (239.670 persons), accept significantly fewer refugees, creating a considerable asymmetry in their distribution.

The data in Fig. 6 is crucial for modeling post-war recovery scenarios for Ukraine. A large concentration of Ukrainians in one country, particularly in Germany, can both simplify and complicate their return process. On one hand, it allows efforts to be concentrated on collaborating with one country to develop repatriation programs; on the other hand, it creates the risk that this large group may integrate and not return, which would significantly impact Ukraine's human capital.

Among the indicators characterizing the socio-demographic scenarios of post-war recovery in Ukraine is the birth rate relative to GDP per capita (*Fig. 7*).

Thus, the regression model is defined by the following equation (1):

$$y = -4E - 05x + 11.98, \qquad (1)$$

where y – birth rate in Ukraine; x – GDP per capita, UAH.

The correlation coefficient in this model: $R = -0.962$, which indicates a strong linear relationship between GDP per capita and the birth rate in Ukraine. The coefficient of determination $R^2 = 0.927$ indicates that 92.7% of the fluctuations in the birth rate are due to changes in GDP per capita, while the remaining 7.3% are due to other independent factors.

Let us consider in more detail three possible socio-demographic scenarios for the post-war recovery of Ukraine, taking into account migration dynamics, birth rates, repatriation policies, economic conditions, and support from the state and the international community. Each scenario reflects a different level of human potential recovery and social stability.
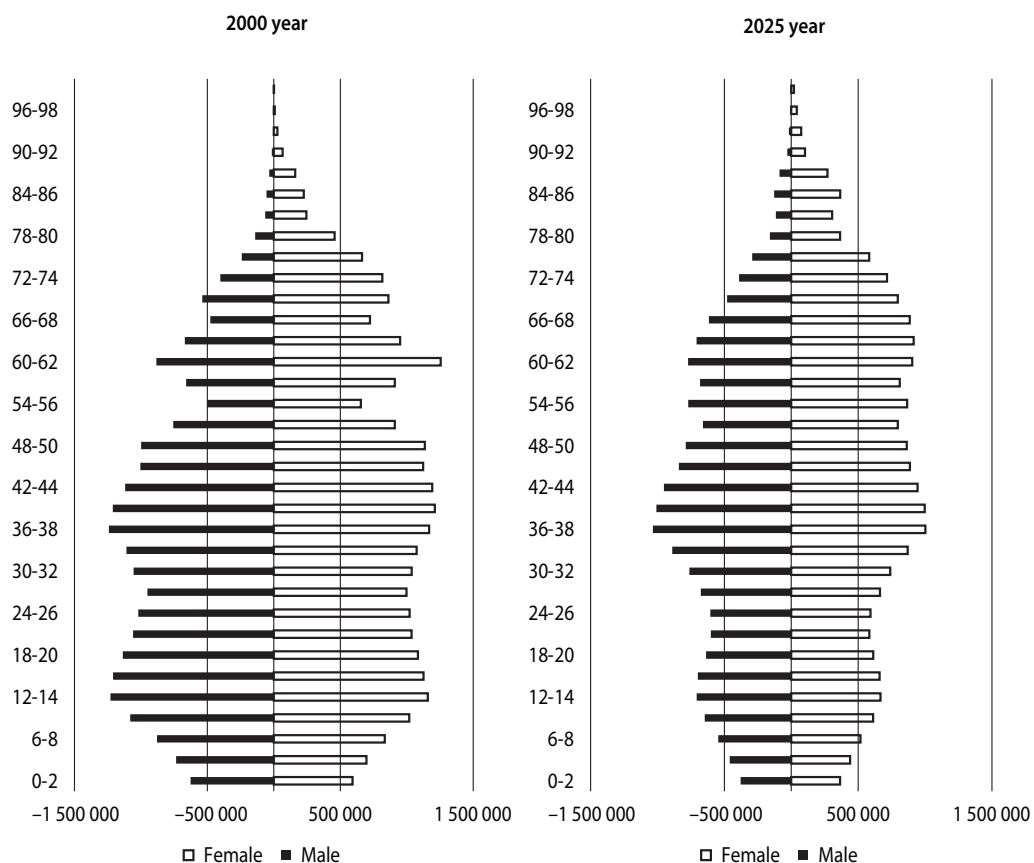
Fig. 4. Gender-age structure of the population of Ukraine in 2000 and 2025, persons
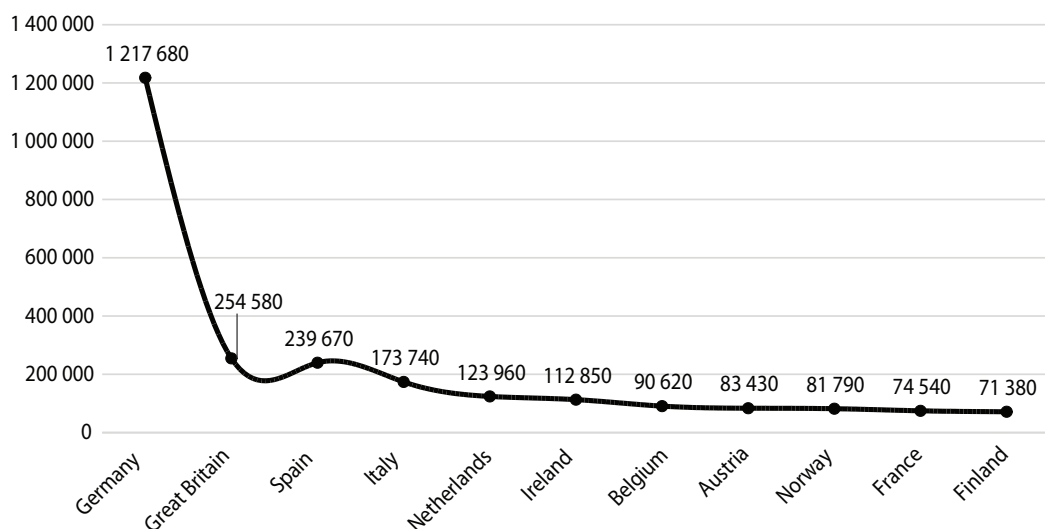
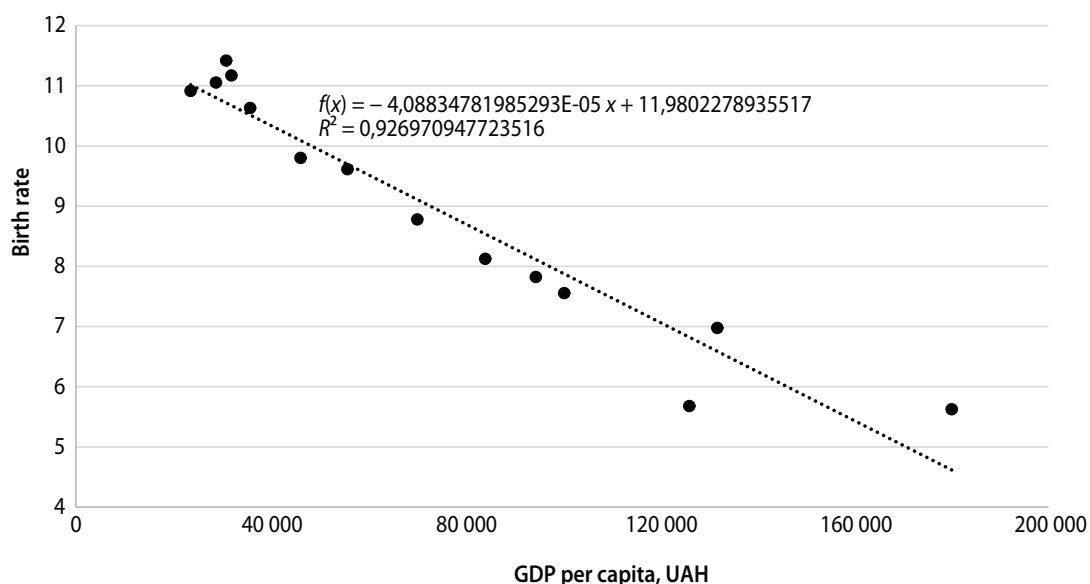**Source:** composed on the basis of [11].
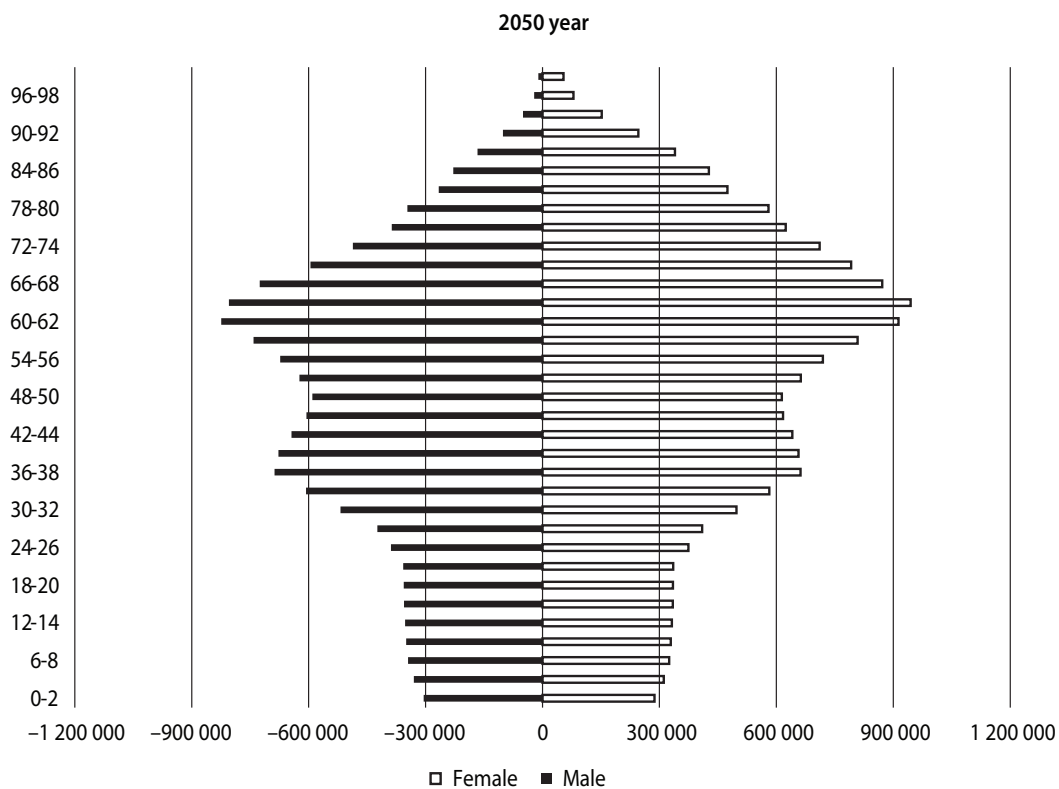
Fig. 5. The forecast of the gender-age structure of the population of Ukraine in 2050 (persons)

Source: composed on the basis of [11].

Fig. 6. The number of registered refugees from Ukraine in European countries as of April 30, 2025, persons

Source: composed on the basis of [12].

$$f(x) = -4,08834781985293\text{E-}05\,x + 11,9802278935517$$
$$R^2 = 0,926970947723516$$

Fig. 7. Regression model of the relationship between the birth rate and GDP per capita in Ukraine for the years 2010–2023

Source: composed n the basis of [13; 14].

The optimistic scenario is the most desirable, but also the most ambitious. This scenario envisions that Ukraine not only minimizes the negative consequences of the war, but also transforms the crisis into an opportunity for dynamic demographic growth.

1. Mass return of Ukrainians and an influx of immigrants:

1.1) Large-scale investments (for example, through the EU's «Marshall Plan» and the similar plans from other international partners) can stimulate rapid economic growth, creating new, high-paying jobs;

1.2) Restoring security and modernizing infrastructure (roads, hospitals, schools, housing) are crucial for establishing a sense of stability;

the mass return of initial groups, particularly young professionals, can create a «chain reaction effect», encouraging others to return as social and professional networks develop;

2. Increase in birth rates:

2.1) Strong financial support for families (increased payments, tax benefits), affordable housing, and quality social services (nurseries, kindergartens) can significantly reduce economic barriers to childbirth;

2.2) Restoring normal, safe living conditions, overcoming the traumas of war, and fostering a sense of national uplift can create a favorable psychological environment for increasing birth rates.

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ЕКОНОМІКА

3. Involving youth in national reconstruction programs:

3.1) Reconstruction programs will create demand for young specialists, engineers, architects, and builders;

3.2) The State will be able to invest in retraining and education programs that cater to the needs of the developing labor market.

An optimistic scenario is only possible with a rapid and effective synergistic effect between economic, political, and social recovery. In such a case, Ukraine can not only restore but also renew its human capital, attracting both its citizens from abroad and new residents. This will allow for compensating losses and laying the foundation for sustainable and dynamic development for decades to come.

The baseline scenario is based on the assumption that Ukraine will be able to implement effective and targeted policies that will neutralize the worst demographic threats. This scenario is realistic, as its achievement is possible with active and coordinated governance, drawing on the successful experiences of other countries in post-war recovery and migration management.

1. Targeted State policy to stimulate repatriation:

1.1) Ensuring affordable housing, preferential loans, or compensation is critically important for the return of refugees;

1.2) Creating new jobs, retraining, and entrepreneurship support programs are key to restoring economic activity.

2. Moderate return of the population:

2.1) Western Europe is the main region where Ukrainians have emigrated, and the distance to Ukraine is relatively small, which facilitates their return;

2.2) Families with children may be more inclined to return if conditions for quality education and access to medical services are created in Ukraine.

3. Activation of programs to increase birth rates:

3.1) Increasing the amount of childbirth benefits, supporting large families, and tax incentives can partially compensate for the financial costs of raising children (the experience of France and Sweden shows that comprehensive support for families positively affects the birth rate).

4. Restoration of the education, health care, and employment systems:

4.1) Restoring the health care system, including access to quality medical care and preventive programs, is key to reducing mortality and improving the overall health of the population;

4.2) The restoration of schools, universities, and vocational-technical educational institutions is an important factor for the return of families with children, as parents seek quality education for their offspring.

The baseline scenario is realistic, as it assumes that political will and effective coordination can turn negative trends around. In this scenario, the State does not merely react to the crisis but actively manages processes, creating conditions for recovery. Thus, the baseline scenario is not just an assumption but also a plan of action based on successful experiences and scientific approaches that allow transforming the demographic challenge into an opportunity for sustainable development.

The pessimistic scenario, or the scenario of demographic depression, is based on the analysis of risks and negative trends that could deepen without effective State regulation.

1. Mass non-return of emigrants (and prolonged emigration of highly qualified personnel):

1.1) The longer people stay abroad, the more they integrate into the new society (they adapt to the labor market, children go to local schools, social ties are formed);

1.2) The constant risks (such as shelling, mine danger) and concerns about future stability create a psychological barrier to repatriation;

1.3) The outflow of highly qualified specialists (programmers, doctors, scientists) has long-term consequences, as these professionals quickly find high-paying jobs abroad.

2. Low birth rate:

2.1) War is a colossal stress factor, and fear for the future, post-traumatic stress disorder, and uncertainty about tomorrow directly influence reproductive behavior;

2.2) Declining incomes, rising unemployment, high inflation, and a lack of housing make raising children financially unmanageable for many families.

3. Aging population and deepening demographic crisis:

3.1) The outflow of youth and declining birth rates lead to a decrease in the share of the population of reproductive and working age, which in turn increases the relative percentage of older people;

3.2) The reduction in the number of taxpayers (the working population) and the increase in the number of pensioners create a significant financial burden on the State budget, negatively affecting the stability of the pension system, healthcare funding, and social benefits;

3.3) The low birth rates today will mean fewer young people in 20–30 years, which will accelerate the aging process of the population in the future.

In a pessimistic scenario, the lack of effective government measures leads to mutually reinforcing negative demographic factors. In particular, low birth rates, exacerbated by psychological and economic factors, accelerate the aging of the population. At the same time, prolonged emigration results in a critical loss of labor potential, which is the foundation of the economy. In aggregate, these processes – aging and the loss of the workforce – significantly increase the social burden on government finances. This creates a self-reinforcing cycle of demographic degradation, which poses a direct threat to the long-term viability and economic recovery of Ukraine.

Based on the theoretical foundations of socio-demographic scenarios for post-war recovery, we will construct a model to forecast the population of Ukraine in 2030, 2035, 2040, 2045, and 2050.

The main formula for forecasting the population of Ukraine for 2030 will be as follows (2):

$$
\begin{aligned}
\text{Population}_{2030} = \text{Population}_{2023} + \\
(\text{Births}_{2021} - \text{Deaths}_{2021} + \\
\text{Net Migration}) \times 7,
\end{aligned}
\tag{2}
$$

where Population_{2030} – is the projected population of Ukraine at the beginning of 2030; Population_{2023} –

is the population of Ukraine at the beginning of 2023; Births_{2021} – is the number of births in 2021; Deaths_{2021} is the number of deaths is 2021 + Net migration is the annual increase/decrease in the population of Ukraine (2021 was chosen as a relatively stable pre-war period in terms of demographic recovery).

Let's consider the elements of the formula for the optimistic scenario (3):

– the average number of births is 10% higher than in the pre-war period (2021);

– a significant decrease in mortality due to improvements in the healthcare system and a reduction in military losses, meaning the average number of deaths is 15% lower than in 2021;

– a high positive migration balance (notable return of refugees and attraction of foreign specialists), thus the average net migration is +250,000 persons.

$$\begin{aligned}\text{Population}_{2030} = \text{Population}_{2023} + \\ + ((\text{Number of births}_{2021} \times 1.1) - \\ - (\text{Number of deaths}_{2021} \times 0.85) + \\ + \text{Net migration})) \times 7.\end{aligned} \quad (3)$$

The elements of the formula for the baseline scenario will be as follows (4):

– stabilization of the birth rate is expected at the level of 2021, but without significant growth;

– a slow decline in mortality, therefore the average annual number of deaths is 5% lower than in 2021;

– a gradual return of refugees, but at a moderate pace, so the average annual net migration amounts to +50.000 persons.

$$\begin{aligned}\text{Population}_{2030} = \text{Population}_{2023} + \\ + ((\text{Number of births}_{2021} \times 1) - \\ - (\text{Number of deaths}_{2021} \times 0.95) + \\ + \text{Net migration})) \times 7.\end{aligned} \quad (4)$$

The elements of the formula for the pessimistic scenario will be as follows (5):

– a further decline in birth rates due to socioeconomic difficulties, so the average annual number of births is 10% lower than in 2021;

– a high mortality rate (for example, due to underfunding of healthcare and epidemiological problems), therefore the average annual number of deaths is 5% higher than in 2021;

– a negative migration balance (the outflow of the population continues), so the average annual net migration amounts to –50,000 persons.

$$\begin{aligned}\text{Population}_{2030} = \text{Population}_{2023} + \\ + ((\text{Number of births}_{2021} \times 0.9) - \\ - (\text{Number of deaths}_{2021} \times 1.05) + \\ + \text{Net migration})) \times 7.\end{aligned} \quad (5)$$

Parameters for the population forecasting model in Ukraine are provided in the *Tbl. 1*.

The *Fig. 8* shows three scenarios for the population forecast of Ukraine for the period 2023–2050. Specifically, in 2023, all scenarios «start» from the same mark – 37.7 million persons. According to the optimistic forecast, the population will decrease at a slow pace and by 2050 will reach 36.2 million persons, indicating the possibility of stabilizing the demographic situation with active state policies, effective reintegration of citizens, and the return of emigrants. The baseline scenario assumes a more significant population decline – down to 27.9 million persons by 2050, suggesting a gradual decrease without substantial compensatory measures. The worst dynamics are shown by the pessimistic scenario – by 2050, the population in Ukraine may decrease to a critical 22.3 million persons.

The forecast in the Fig. 8 reflects the real challenges faced by Ukraine as a result of the war, the migration crisis, declining birth rates, and an aging population. The significant differences between the scenarios underscore the importance of the State demographic poli-

Table 1

Indicators for the population forecasting model in Ukraine

Indicator		Optimistic scenario	Baseline scenario	Pessimistic scenario
Population in 2021, persons		44 298 591.0		
Population in 2023, persons		37 732 781.0		
Number of births in 2021, persons		309 089.0		
Number of deaths in 2021, persons		759 003.0		
Birth rate coefficient		1.1	1.0	0.9
Mortality rate coefficient		0.9	1.0	1.1
Net migration, persons		250 000	50 000	–50 000
Population forecast for Ukraine (by year)	2030	37 313 917.5	35 166 253.1	33 718 588.7
	2035	37 038 144.2	33 356 433.8	30 874 723.4
	2040	36 762 371.0	31 546 614.6	28 030 858.2
	2045	36 486 597.7	29 736 795.3	25 186 992.9
	2050	36 210 824.5	27 926 976.1	22 343 127.7

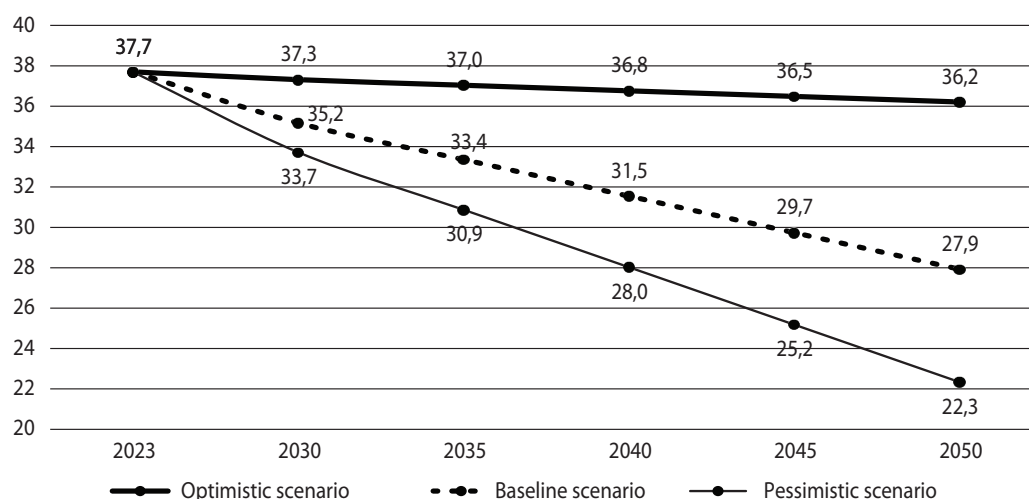**Source:** composed by the author on the basis of [9; 10].

Fig. 8. Population forecast for Ukraine in 2030–2050

Source: composed by the authors.

cy: supporting young families, encouraging the return of Ukrainians from abroad, and improving living conditions. The forecast also highlights the need for interdepartmental coordination in the areas of healthcare, education, housing policy, and employment. Thus, the presented scenarios are not just numerical projections but also a call to action for forming a viable and socially oriented strategy for demographic recovery.

The restoration of human potential after the war in Ukraine is a cornerstone for achieving long-term sustainable development. At the national level, it is advisable for the government to adopt a comprehensive Human Capital Recovery Strategy by 2030, focusing on repatriation, reintegration, and demographic revival. This requires improving the legal framework to support returning refugees and internally displaced persons through access to housing, employment, and education. Building a national demographic monitoring system in real-time will be crucial for making informed decisions and tracking regional disparities. At the same time, reforming the education system and strengthening healthcare infrastructure are aimed at providing a foundation for a healthy, qualified, and resilient population (*Fig. 9*).

At the regional level, balanced territorial development should be a priority to stimulate the return of the population and economic revival [35]. The creation of demographic centers with strong infrastructure and employment opportunities will solidify reintegration efforts. Incentives for sensible relocation, such as tax benefits and housing support, can help restore the population in de-occupied or strategically important areas. It is advisable to activate public-private partnerships and regional investment funds to restore the sectors of education, healthcare, and employment, especially in regions with high return potential.

At the local level, the establishment of local reintegration centers will assist with psychosocial support, vocational counseling, and access to public services. Empowering young people through education, civic engagement, and leadership programs will help preserve and activate their
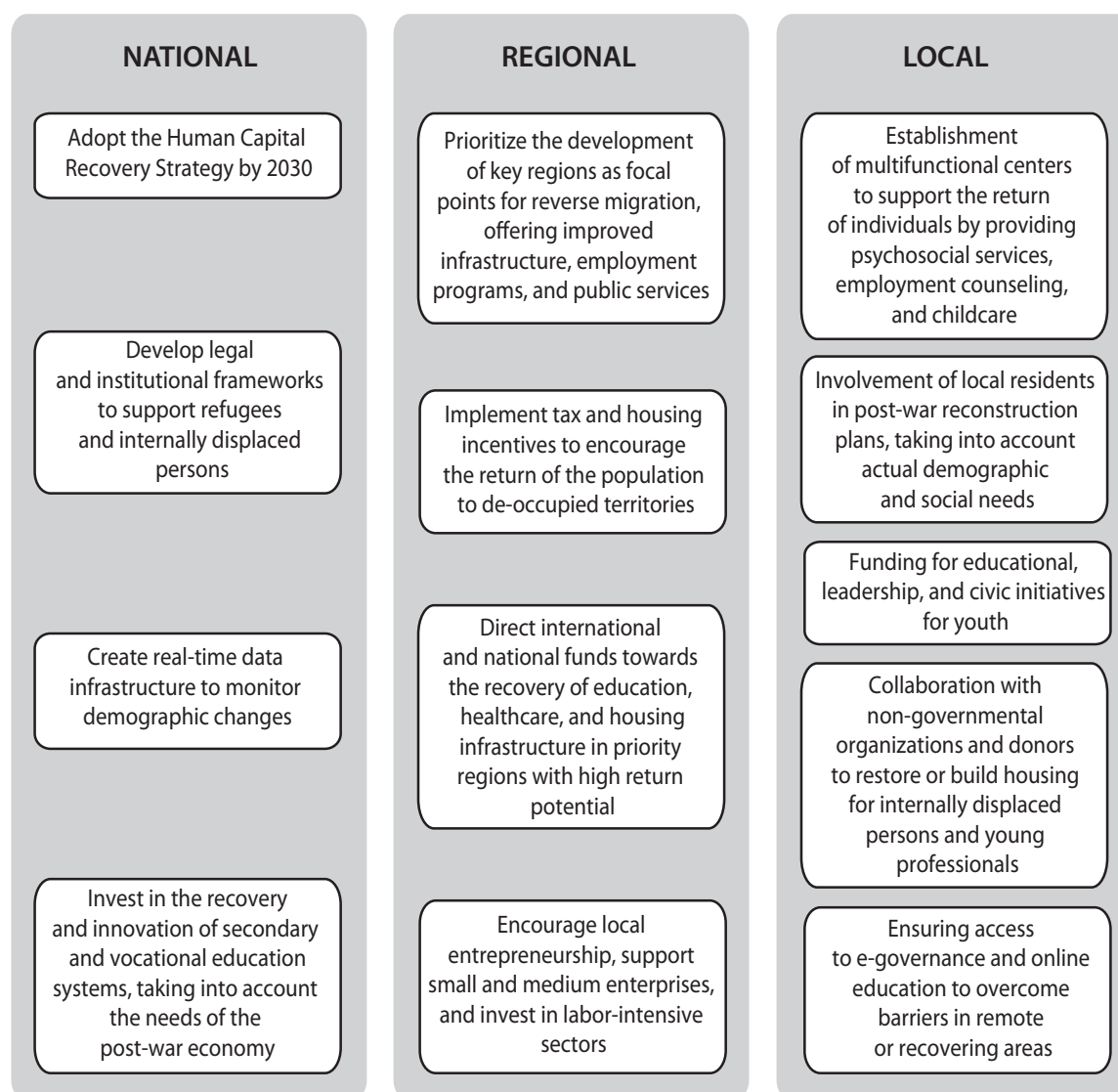
potential. Together, these measures create a comprehensive political foundation that focuses people on post-war recovery and the future development of Ukraine.

CONCLUSIONS

The study showed that the full-scale war in Ukraine has caused significant demographic changes: a sharp decline in population, mass emigration, and disruptions to the gender-age structure. According to data from 2023, the population has decreased to 37.7 million persons, the lowest figure since Independence. The Eastern and Southern regions, which suffered both physical losses and migratory depopulation, prove to be the most vulnerable. At the same time, the western regions and EU countries have become the main destinations for internal and external migration.

A significant portion of displaced persons consists of women and children, which creates a gender imbalance and reduces the potential for natural population reproduction. The share of the working-age population has decreased, while the burden on it has increased due to the rise in the elderly population. A comparative analysis of the age-gender pyramids for the years 2000, 2025, and 2050 indicates a gradual transformation of the population structure from a pyramid to an urn-like shape – a sign of deep aging.

The study identified three likely scenarios for the socio-demographic recovery of Ukraine by 2050: optimistic, baseline, and pessimistic. Each reflects a different level of effectiveness of State policy, the scale of return of emigrants, birth rate dynamics, and the potential for social integration. The optimistic scenario shows the possibility of stabilizing the population through active repatriation, investment in human capital, and comprehensive family support. The baseline scenario anticipates a gradual decline in the population due to the limited implementation of recovery policies and moderate birth rates. In contrast, the pessimistic scenario illustrates the threat of a deep demographic depression in the absence of effective State interventions.

NATIONAL	REGIONAL	LOCAL
Adopt the Human Capital Recovery Strategy by 2030	Prioritize the development of key regions as focal points for reverse migration, offering improved infrastructure, employment programs, and public services	Establishment of multifunctional centers to support the return of individuals by providing psychosocial services, employment counseling, and childcare
Develop legal and institutional frameworks to support refugees and internally displaced persons	Implement tax and housing incentives to encourage the return of the population to de-occupied territories	Involvement of local residents in post-war reconstruction plans, taking into account actual demographic and social needs
Create real-time data infrastructure to monitor demographic changes	Direct international and national funds towards the recovery of education, healthcare, and housing infrastructure in priority regions with high return potential	Funding for educational, leadership, and civic initiatives for youth
Invest in the recovery and innovation of secondary and vocational education systems, taking into account the needs of the post-war economy	Encourage local entrepreneurship, support small and medium enterprises, and invest in labor-intensive sectors	Collaboration with non-governmental organizations and donors to restore or build housing for internally displaced persons and young professionals
		Ensuring access to e-governance and online education to overcome barriers in remote or recovering areas

Fig. 9. Ways to restore human potential in post-war Ukraine

Source: developed by the authors.

The modeling results show that the population of Ukraine may fluctuate from 36.2 million persons in 2050 under the optimistic scenario to 22.3 million under the pessimistic scenario. This difference highlights the critical importance of State policy in shaping the demographic future of the country. The forecast underscores the need for prioritized focus on three interconnected areas: the repatriation of Ukrainians, increasing birth rates, and supporting the younger generation. It is extremely important to implement comprehensive socioeconomic measures covering housing policy, education, healthcare, and the labor market. ∎

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