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Predicting Iraq's demographic changes using artificial intelligence

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Abstract. The subject of this article is to predict demographic changes in Iraq using neural networks (artificial intelligence) and provide evidence of a continuous and continuous decline in fertility and negative annual population growth in the future, and the emergence of important and emerging demographic issues. The research method in this study is the use of GMDH software. Two sets of data are selected for input to the neural network. Birth rate and death rate are used as neural network variables. The results show that neural networks perform better for predicting population size. The research method is demographic and documentary analysis. The latest population projections (2024) from the UN Population Division for the world show that Iraq's population will increase in 2030 based on the UN's three scenarios, namely the low, medium and high range. This study examines future changes in the number and annual growth of the population in Iraq, its age and gender composition, and the percentage of the working-age population. Based on the adjusted scenario that will be carried out in this study, the population of Iraq will increase in the coming years. The results of this study showed that achieving demographic balance and equilibrium in the long term should be the focus of population policymaking.

Keywords: Population prediction, neural network, fertility, population size

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التنبؤ بالتغيرات الديموغرافية في العراق باستخدام الذكاء الاصطناعي

أ.م محمد فارس عبد[1] أ.م ليث طالب رشيد[2]
وزارة التخطيط I am running a few minutes late; my previous meeting is running over. مديرية أحصاء ديالى[1]
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المستخلص. موضوع هذه المقالة هو التنبؤ بالتغيرات الديموغرافية في العراق باستخدام الشبكات العصبية (الذكاء الاصطناعي) وتقديم دليل على الانخفاض المستمر والمستمر في الخصوبة والنمو السكاني السنوي السلبي في المستقبل، وظهور قضايا ديموغرافية مهمة وناشئة. طريقة البحث في هذه الدراسة هي استخدام برنامج GMDH. تم اختيار مجموعتين من البيانات لإدخالها إلى الشبكة العصبية. تم استخدام معدل المواليد ومعدل الوفيات كمتغيرات للشبكة العصبية. تُظهر النتائج أن الشبكات العصبية تعمل بشكل أفضل للتنبؤ بحجم السكان. طريقة البحث هي التحليل الديموغرافي والوثائقي. تُظهر أحدث التوقعات السكانية (2024) من شعبة السكان التابعة للأمم المتحدة للعالم أن عدد سكان العراق سيزداد في عام 2030 بناءً على السيناريوهات الثلاثة للأمم المتحدة، وهي النطاق المنخفض والمتوسط والعالي. تدرس هذه الدراسة التغيرات المستقبلية في عدد السكان ونموهم السنوي في العراق، وتركيبته العمرية والجنسانية، ونسبة السكان في سن العمل. بناءً على السيناريو المعدل الذي سيتم تنفيذه في هذه الدراسة، سيزداد عدد سكان العراق في السنوات القادمة. وأظهرت نتائج هذه الدراسة أن تحقيق التوازن الديمغرافي على المدى الطويل ينبغي أن يكون محوراً لصنع السياسات السكانية.

الكلمات المفتاحية: التنبؤ بالسكان، الشبكة العصبية، الخصوبة، حجم السكان

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1-Introduction

Demographers use the theory of demographic transition to analyze and explain the demographic changes of societies. Classical accounts of the theory of demographic transition observe the change from a state of natural equilibrium to a state of voluntary demographic equilibrium. In natural equilibrium, fertility and mortality rates are high due to uncontrollable underlying factors, and as a result, population growth is very low. In the process of development and modernization, fertility, mortality, and population growth rates reach a minimum level; Therefore, societies enter a stage of voluntary equilibrium, The transition from natural equilibrium to voluntary equilibrium, which is accompanied by high population growth, takes more than a century. Classical demographers in the classical versions of the theory of demographic transition believed that when the demographic transition reaches the stage of secondary stability, the population will achieve a constant growth. Therefore, societies achieve a balanced growth of demographic changes, But the demographic and social developments of the leading countries in the demographic transition showed that this does not happen. Some contemporary demographers have tried to analyze the new demographic situation of developed societies in the framework of the theory of the second demographic transition. The theory of the second demographic transition, proposed by contemporary demographers such as Lesthacghe and Van de kaa (1999), provides a relatively clear picture of demographic changes in postmodern societies. Van de kaa (2022) states the fundamental difference between the first and second demographic transitions: If the continuous decline in mortality is the main characteristic of the first demographic transition of societies, then the continuation of fertility below the replacement level is the main characteristic of the second demographic transition. At this stage, natural population growth becomes negative due to the excess of the death rate over the birth rate and the population size of societies begins to decline.

The demographic transition has several dimensions, each of which we describe below:

1-1- Fertility transition

One of the most important aspects of the demographic transition is the fertility transition. Fertility is the most important factor in demographic change and the only natural channel of population entry into any society; In this sense, its changes and fluctuations directly affect the number, size, and structure of the population. The fertility transition refers to the period of time during which a society changes from a state of natural, uncontrolled, and high fertility to a state of controlled, voluntary, and low fertility.

In the first case, the total fertility rate is more than six children, but in controlled fertility, the fertility level drops to the replacement level (1/2) or even lower. The duration of the fertility transition varies from society to society and according to the level of development and socio-cultural changes. Currently, countries are divided into four categories in terms of the status of the fertility transition:

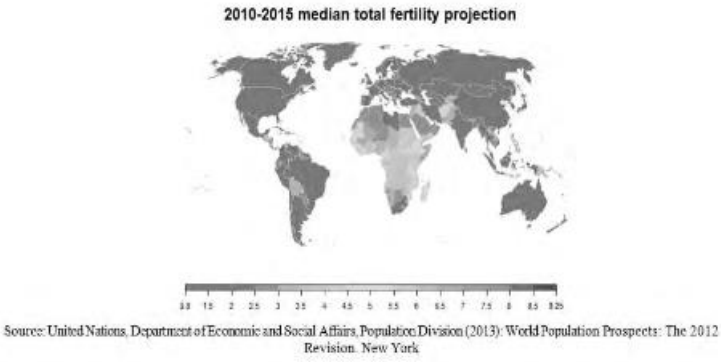
A) **Countries with very low fertility**: This group of countries has a total fertility rate of less than (1.5). As the World Fertility Map 2012 shows, European countries and some Asian countries such as Japan and South Korea are in this situation.

B) **Low Fertility Countries:** These countries have a total fertility rate of less than (2/1). As the 2012 World Fertility Map shows, North American countries, some South American countries, Russia, China, and Iraq are in this situation.

C) **Countries with medium fertility**: These countries have a fertility rate between 1.2 and 3. Some North African countries such as Morocco, Algeria and some South American countries are in this situation.

D) High Fertility Countries: These countries have high fertility levels, and currently some of these countries, mainly located in the African continent, are still in the early stages of fertility transition. Countries such as Niger, Mali, and Chad have high fertility levels.

Map (1): Total fertility rate levels in the world in 2012.

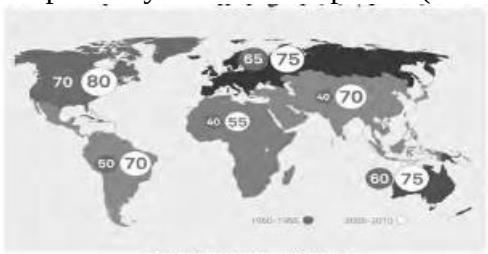


Source: United Nations, Department of Economic and Social Affairs, Population Division (2013): World Population Prospects: The 2012 Revision. New York

2.1- Mortality transition

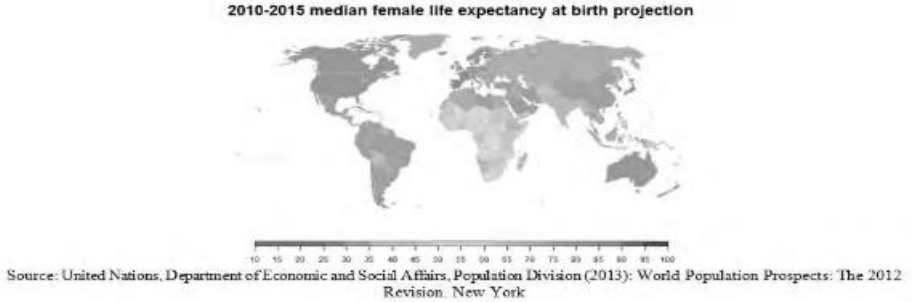
This dimension of population transition refers to changes in mortality and life expectancy from high mortality and low life expectancy to low mortality and high life expectancy. Before the transition period, life expectancy barely reached forty years, and the general mortality rate was more than 35 per thousand. With the improvement of the level of development and health, the mortality rate, especially child mortality, gradually decreases, and the level of life expectancy increases.

Map 2: Comparison of life expectancy levels in the period (1950-1955) and (2005-2010).



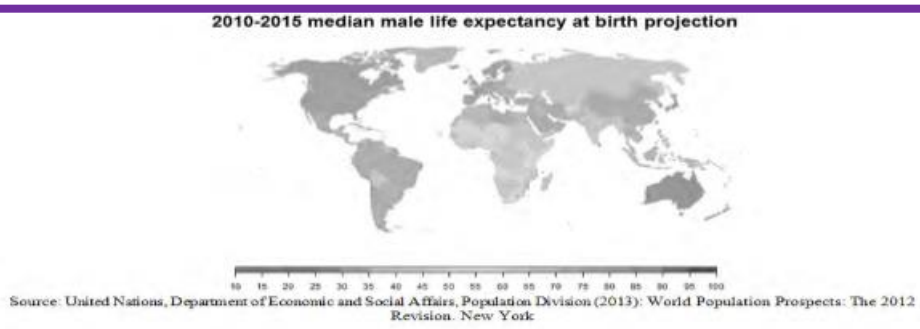
Source: shenoudacapital.com

Map 3: Status of women's life expectancy in the world in 2012.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2013): World Population Prospects: The 2012 Revision. New York

Map 4: Status of male life expectancy in the world in 2013.



Source: Rowland, 1987

2. Artificial Intelligence

Artificial intelligence refers to systems that can respond in a similar way to intelligent human behavior, including understanding complex situations, simulating human thought processes and reasoning methods and responding successfully to them, learning, and the ability to acquire reasoning knowledge to solve problems. Artificial intelligence was first proposed by mathematicians such as Boole, who proposed a series of laws and theories about logic.

Then, with the invention of electronic computers in 1943, the discussion and study of artificial intelligence attracted the attention of scientists of the time. In this situation, it seemed that this machine would be able to simulate intelligent behavior. Despite the doubts of a group of thinkers about artificial intelligence, the production of chess-playing machines and other intelligent systems in various industries became commonplace in at least four decades. The term Artificial Intelligence was first used by a person named John McCorthy, who is considered the father of the science and knowledge of producing intelligent machines. Mr. John McCorthy is also the inventor of one of the artificial intelligence programming languages called. Today, artificial intelligence is widely used in common fields such as computer science, psychology, philosophy, and other sciences.

Today, in the IT markets, many artificial intelligence and forecasting tools are offered in the fields of business, economics, etc. The difference between them is mostly in the way they receive input data and standardize them. According to managers, some of the most important criteria for choosing a forecasting tool are:

- Scope of software offerings in the market and its services,
- Cost of software acquisition,
- Forecasting models and their accuracy,
- Range of input data support,
- User-friendly graphics.

Based on many studies conducted among forecasting software, it has a suitable environment in terms of data acquisition, integration, neural network models, analysis, and pre-data.

According to the documentation of the numerical data grouping method "GMDH", the "GMDH SHELL" software is simple yet advanced software, and is able to effectively integrate and use data in the program, and transfer data according to the problem, and finally provide a model for prediction. The way data is processed in the "GMDH SHELL" software is that in the first stage, information is entered from data processing software such as "Excel" into the software. In this stage, each of the cells is read and edited if necessary. To perform this step, data exploration continues. In other words, an exploratory study is carried out on the input data that are appropriate to the case study and affect the prediction and the related variable. Then the software selects the input data and transfers it for prediction. In the operational stage, the database is extracted, but what the software is doing is called the “SOLVER” stage, where the models are extracted, then validation is performed and the best prediction model is selected. The result of this operation is model extraction. The software provides the pre-processing of the forecast and transfers it to the simulation system. In the simulation, the

forecast plots, tables and data significance, their performance are simulated, while what the user sees is the extracted forecast. The strengths of this software are:

- Compatible with Windows environment.
- User-friendly and has multiple active windows at the same time.
- Receives data from "xls" and "csv".
- Performs problems and problems related to the predictions of various time series and complex.
- Easily selects suitable and usable data from other data.
- Transfers data exactly according to the problem and eliminates inappropriate inputs.
- Establishes the fundamental principles itself.

3. A look at past and recent developments in Iraq's population

Today, Iraq is one of the most multicultural countries in the region and the world, with a diverse indigenous population.

The population is estimated to be 45,520,500 (Iraqi residents) in 2025, and over 10 million people live abroad of whom the majority are Arabs (75%), followed by Kurds (20%), Chaldean-Assyrians (10–15%) (500,000+ (in Iraq) for a total of 2 million including immigrants), Turkmen (3 million), Iraqi Afro-Iraqis (1 million), Yazidis (500,000–900,000), and Shabak people (300,000–500,000). Other minorities include Iraqi Armenians, Mandaeans, Yarsans, Dumas and Kavlia (of Indian descent), Iranians (of Persian descent), Saqr and Chechens (of North Caucasian descent), and others. Iraqis are 64% Shia Muslim, 31% Sunni Muslim, 10–15% Christian (the majority are Syriac, but there are also Orthodox and Maliki Orthodox in Iraq), 1.4% Yazidi, and several other indigenous religions.[21] The most widely spoken languages are Arabic with an Iraqi dialect (which is spoken by everyone living in Iraq), Kurdish, Syriac, and Iraqi Turkmen with a Turkish accent are also spoken in the country. Due to the last Iraqi census being over 30 years ago, the percentages of the various ethnic groups living in Iraq vary from source to source. It is anticipated that a new census of Iraq will be conducted in 2020, which will clearly identify the population of each ethnic and religious group in Iraq.

4. Iraq Population Projections

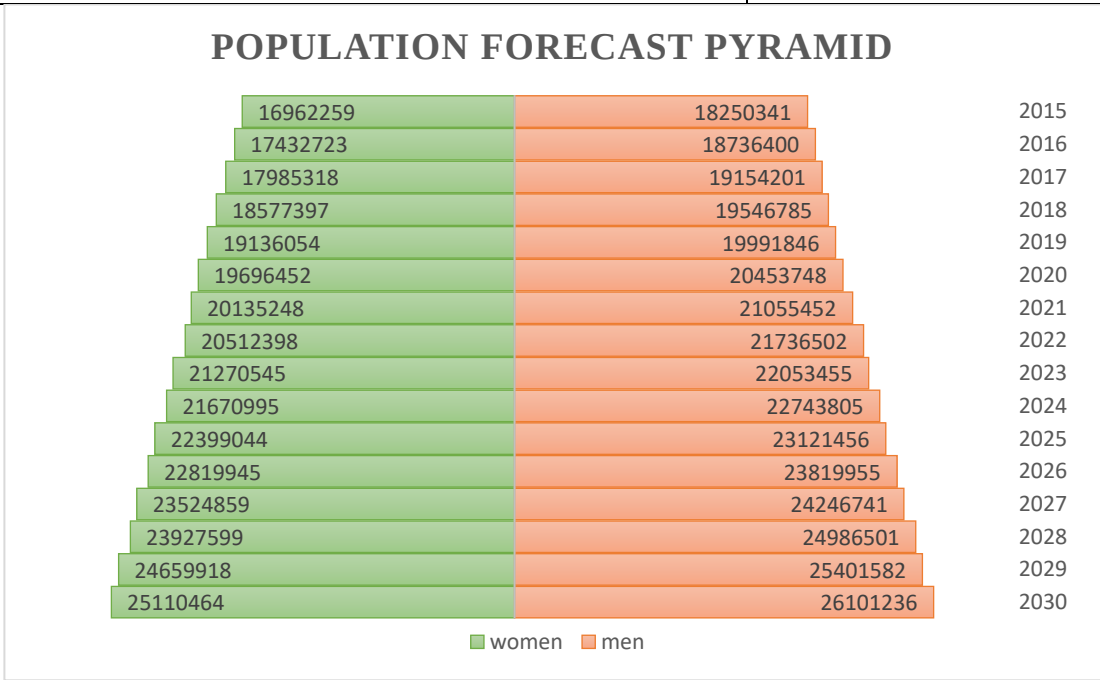
Every four years, the UN Population Division predicts different levels of fertility and mortality for countries' demographic developments over a fifty-year time horizon and in three different scenarios (low, medium, and high population growth) based on the results of national censuses and assumptions.

Table (1) shows a comparison of the results of Iraq's population projections based on three scenarios from the United Nations Population Division between 2015 and 2030.

Population Estimation of Iraq (2015-2030)

Total Population	Year
35,212,600	2015
36,169,123	2016
37,139,519	2017
38,124,182	2018
39,127,900	2019
40,150,200	2020
41,190,700	2021
42,248,900	2022
43,324,000	2023

44,414,800	2024
45,520,500	2025
46,639,900	2026
47,771,600	2027
48,914,100	2028
50,061,500	2029
51,211,700	2030



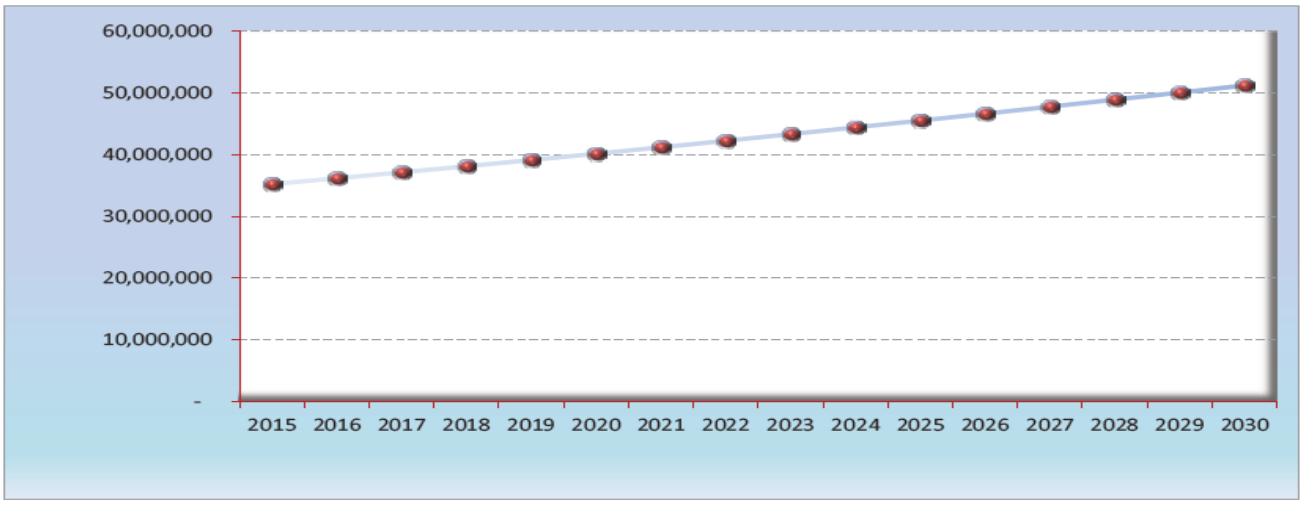


Table (1): Shows a comparison of three forecast scenarios (low limit, medium limit, and high limit) up to the 2030 horizon.

Table (2) presents the average annual population changes.

Table (2): Average annual population changes:

Duration	Low-end scenario	Medium-end scenario	High-end scenario
2015-2017	817000	1000000	1189000
2018-2020	649000	934000	1220000

2021-2023	453000	783000	1130000
2024-2026	340000	654000	972000
2027-2028	245000	574000	924000
2029-2030	141000	513000	934000

As can be seen, based on the low-end scenario, approximately 817,000 people will be added to the country's population annually in the period (2015-2017) and approximately 650,000 people in the period (2018-2020). (Figure 1-6)

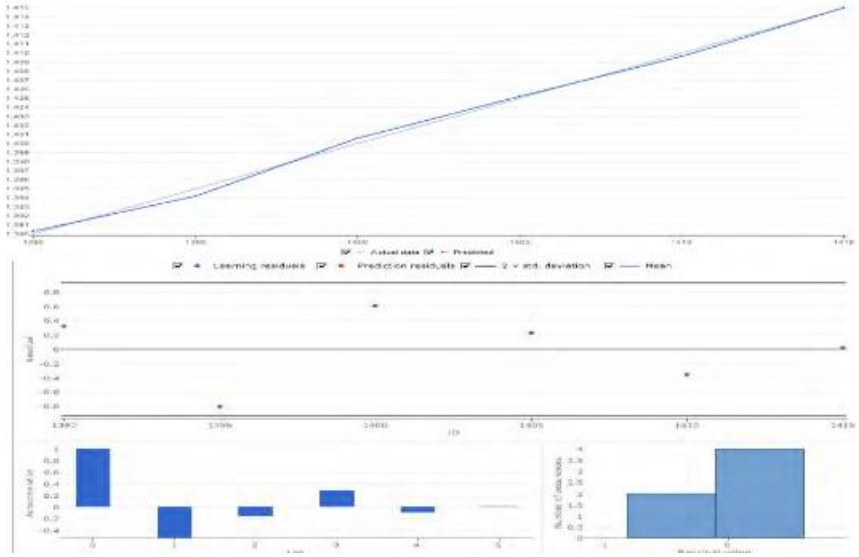


Chart 1: Average annual population changes based on the UN low-end scenario.

Based on the average scenario, about one million people will be added to the country's population annually in the period (2015-2017) and about 930,000 people will be added annually in the years (2018-2020).

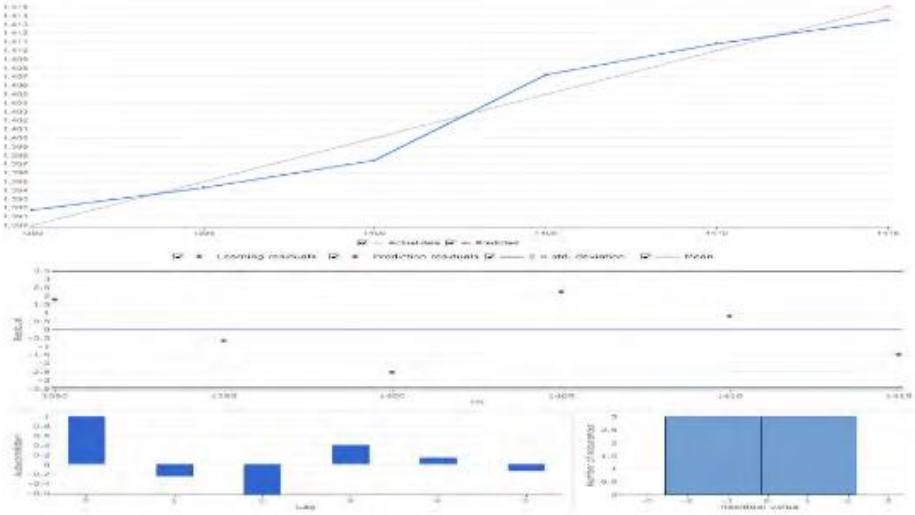


Chart 2: Average annual population changes based on the UN mid-range scenario.

Finally, based on the high-range scenario, the country's population will increase by about 1,180,000 annually in the period (2015-2017) and by about 1,220,000 annually in the period (2018-2020).

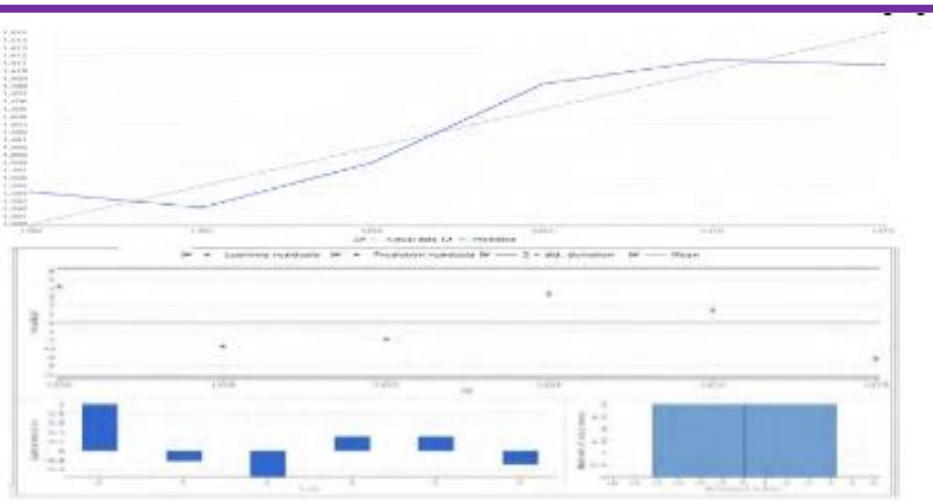


Chart 3: Average annual population changes based on the UN high-end scenario.

All scenarios will have a decreasing trend; meanwhile, the rate of decrease in the low-end scenario is faster than the other forecast scenarios.

Table (3) reports the results of the total fertility rate projections based on the three UN low-end, medium-end, and high-end scenarios. According to the low-end scenario, the total fertility rate will increase from 1.68 in 2015-2017 to 1.33 in 2029-2030. According to the medium-end scenario, the total fertility rate will increase from 1.93 in 2015-2017 to 1.83 in 2030-2029. According to the high-end scenario, the total fertility rate will increase from 2.18 in 2015-2017 to 2.33 in 2030-2029. The past and present trends of fertility changes in Iraq are more consistent with the low-end scenario.

Table (3): Changes in fertility rates based on UN scenarios.

Scenarios	**Low-end scenario**		**Medium-end scenario**		**High-end scenario**	
Indicators	**Crude Fertility Rate**	**Total Fertility Rate**	**Crude Fertility Rate**	**Total Fertility Rate**	**Crude Fertility Rate**	**Total Fertility Rate**
2015-2017	16.6	1.68	19.0	1.93	21.3	2.18
2018-2020	13.5	1.49	16.8	1.89	19.9	2.29
2021-2023	11.0	1.36	14.4	1.86	17.7	2.36
2024-2026	9.9	1.34	12.9	1.84	15.6	2.34
2027-2028	9.2	1.34	12.2	1.84	14.9	2.34
2029-2030	8.7	1.33	11.0	1.83	15.0	2.33

In Table (4), the developments of two major mortality indicators, namely crude mortality rate and life expectancy at birth, are projected based on three scenarios of low, medium and high range, the United Nations population projection from 2015 to 2030. In all three scenarios, changes in life expectancy at birth in the country will change uniformly; But the crude mortality rate in the low range scenario shows a greater increase. And it will reach a figure of about 6.8 per thousand at the end of the forecast period.

Table (4): Changes in mortality rates and life expectancy based on UN scenarios.

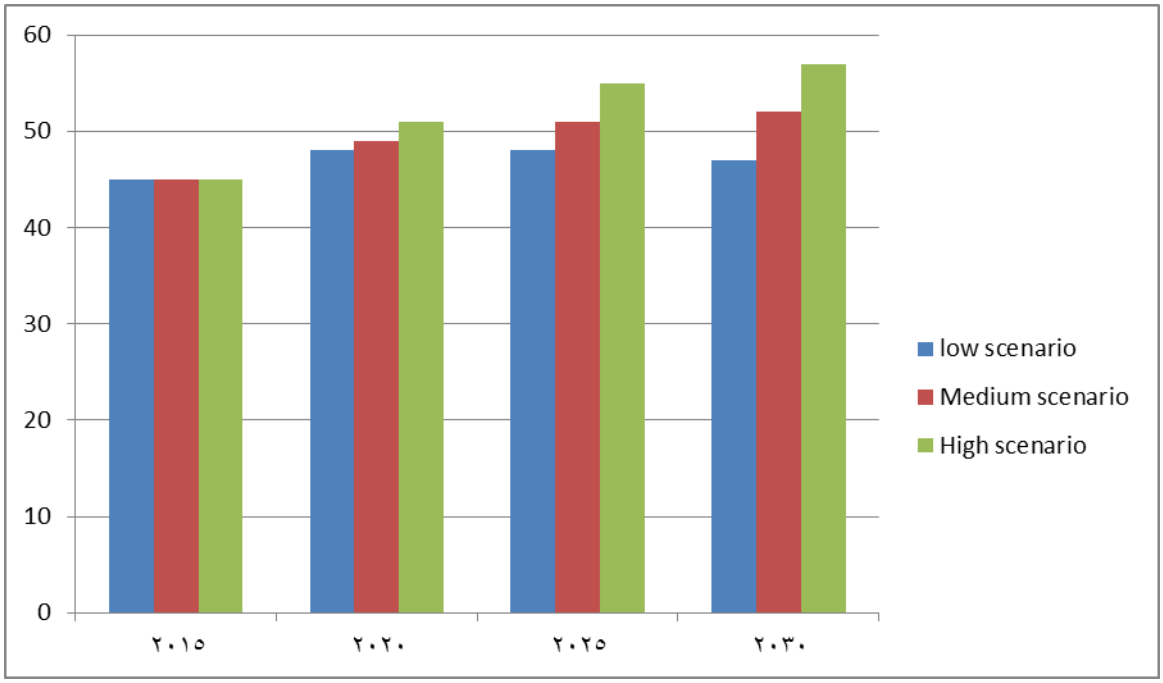
Scenarios	**Low-end scenario**		**Medium-end scenario**		**High-end scenario**	
Indicators	**Crude Fertility Rate**	**Total Fertility Rate**	**Crude Fertility Rate**	**Total Fertility Rate**	**Crude Fertility Rate**	**Total Fertility Rate**
2015-2017	5.2	73.9	5.2	73.9	5.2	73.9

2018-2020	5.1	75.4	5.1	75.4	5.0	75.4
2021-2023	5.3	76.7	5.1	76.7	5.0	76.7
2024-2026	5.6	78.0	5.4	78.0	5.1	78
2027-2028	6.1	79.2	5.8	79.2	5.4	79.2
2028-2030	6.8	80.4	6.3	80.4	5.8	80.4

Table (5) shows the relative population density index of Iraq and its forecast based on four scenarios (low, medium, high and constant) of the United Nations in the years (2015-2030). According to this table, the relative population density in 2015 based on four different scenarios is about 45 people per square kilometer. According to the United Nations forecasts, this index is increasing in the low scenario until 2026 and then decreasing. In the medium and high scenarios, we continue to witness an increasing trend.

Table (5): Iraq's relative population density index based on three scenarios (low, medium, and high).

Demographic indicators	Medium scenario	Low scenario	High scenario
2015	45	45	45
2020	48	49	51
2025	48	51	55
2030	47	52	57



According to Table (6), the United Nations has predicted, based on different scenarios, that the country's population will increase from 40 million in 2024 to 46 million in 2026 and 51 million in 2030. The annual population growth rate of the country is experiencing a sharp decline, and will reach 0.08 in 2030 from 1.22 in 2020.

Table (6): Changes in population indicators based on UN scenarios in the years (2024-2030).

Year	Population	Annual Population	Annual Population Growth Percentage
2024	40.15	--	1.22
2025	45.52	870000	1.03
2026	46.63	720000	0.73
2027	47.77	480000	0.49
2028	48.91	360000	0.34
2029	50.06	220000	0.23
2030	51.21	160000	0.08

In Table (7), where some demographic indicators are calculated, the total fertility rate of the country will decrease from 1.70 children in 2024 to 1.40 children in 2030. Life expectancy will increase from 73.3 years in 2024 to 79 years in 2030, and the median age will increase from 28 years in 2024 to 43 years in 2030. The percentage of the working-age population will increase slightly from 70.9 percent in 2024 to 72.3 percent in 2029, and then decline, reaching 70.7 percent in 2030. Another calculated indicator is the population aged sixty and over, which will increase from 8.2 percent in 2024 to 22.3 percent in 2030, which promises an aging population in Iraq.

Table (7): Changes in population indicators in the years (2024-2030).

Year	Total fertility rate	Life expectancy at birth	Median age	Percentage of working-age population	Percentage of population over 60 years of age
2024	1.70	73.3	28	70.9	8.2
2025	1.65	74.2	31	71.1	9.2
2026	1.60	75.2	33	71.1	11.0
2027	1.55	76.2	36	71.8	13.0
2028	1.50	77.1	39	72.7	15.6
2029	1.45	78.0	41	72.3	18.5
2030	1.40	79.0	43	70.7	22.3

According to Table (8), the annual population growth rate of the country based on the stabilization of the fertility rate of 2.5 children will decrease from 1.30 in 2024 to 0.81 in 2030. The crude birth rate will decrease from 18.5 children in 2024 to sixteen children in 2030, and the total fertility rate will increase from 1.71 in 2024 to 2.5 children in 2030. The crude death rate will increase from 5.5 to 7.8, and the working- age population (15-64) will increase from 53.84 percent to 68.71 percent.

Table (8): Results of the prediction of Iraq's demographic indicators based on the stabilization of the average fertility rate of 2.5 children per woman.

Year	Population		Fertility			Mortality		Age Structure		
	Number	Annual growth rate	Number of births (in thousands)	Crude birth rate	Total fertility rate	Crude death rate	Life expectancy	Population size	Share of population 60+	Population aged 15-64
2024	75.2	1.30	1.346	18.5	1.71	5.5	73.3	5.61	7.45	53.84
2025	80.4	1.34	1.463	18.8	1.97	5.4	73.8	6.77	8.41	56.96
2026	85.7	1.28	1.522	18.3	2.24	5.5	74.4	8.42	9.82	59.24
2027	90.7	1.12	1.498	17.0	2.5	5.8	74.9	10.32	11.38	61.97
2028	95.1	0.95	1.468	15.8	2.5	6.3	75.4	12.62	13.26	64.76
2029	99.2	0.84	1.500	15.4	2.5	7.0	75.9	15.03	15.14	67.08
2030	103.3	0.81	1.617	16.0	2.5	7.8	76.4	18.39	17.79	68.71

Chart (4) shows the population of Iraq from 2015 to 2018 based on registered births and deaths from 2015 to 2018 using GMDH software. The high number of registered deaths is due to the implementation of a sudden death registration plan in the provinces of the country. According to the predictions made, it can be said that the demographic situation of Iraq will not be in a favorable situation in the next 50 years. And we will move towards a population decrease.

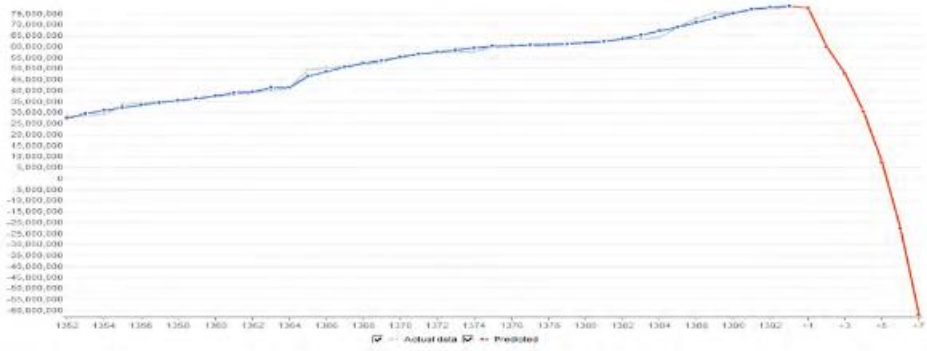
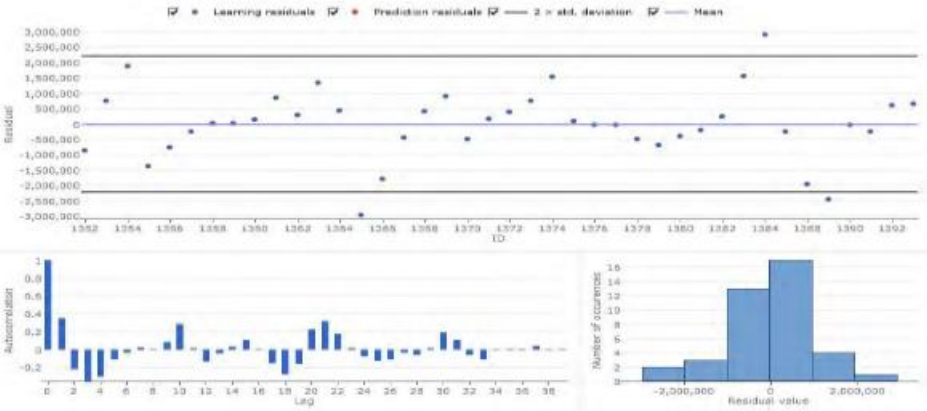


Chart 4: Population projection from 2015 to 2018 based on registered births and registered deaths.



Conclusion

This article examines future changes in the number and annual growth of the population, age and sex composition, number and percentage of the working-age population, and number and percentage of the elderly population in Iraq.

To examine the country's possible change patterns, the UN population projections in different scenarios as well as the author's modified scenario for the period (2015-2030) were used. A possible scenario based on increasing the total fertility rate to 2.5 children per mother by 2030 was also proposed and evaluated. The results showed that the population of Iraq will reach approximately 51.21, 52.8 and 53.46 people by 2030, respectively, based on three low, medium and high growth scenarios. According to the author's modified scenario, the population of Iraq in 2026 is estimated to be about 53 million people. All population forecast scenarios (UN and modified scenario) show that by 2030, between five hundred thousand and one million people will be added to the total population of the country annually; All UN population forecast scenarios show that the life expectancy situation in the country will improve by 2030 and life expectancy in the country will reach an average of eighty years. Forecasts show that the percentage of the country's population over 60 years of age will increase significantly, so that at the end of the forecast horizon, in all three UN forecast scenarios, between 19 and 23 percent of the country's total population will be over 60 years of age, which is noteworthy in terms of socio-economic planning for this age group.

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