

# **Demographic Prediction of Population Size and Composition in Iraq**

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# **Correspondence:**

Husam A. Rasheed husamstat@uomustansiriyah.edu.iq Abstract

*The significant increase in population growth rates is the largest in* most developing countries, including Iraq, the increase is accompanied by a change in the characteristics of the population in terms of size, composition and distribution, this leads to a review of existing population policies, to be able to cope with the pressures that overpopulation poses on sustainable development efforts and future plans. Hence, there is always a need to make estimates of future population numbers and the changes that are likely to accompany the composition and distribution of the population at the level of different activities and areas of life. The methods of estimation differ from each other on the basis of each applied in completely different circumstances from the other, the reason for the difference is due to the level of accuracy of the data that are used as the basis for making these estimates and predictions indicate an increase or decrease in the number of future populations. This research deals with the use of some of the estimation methods that will be applied to the population in Iraq during a certain period of time, to estimate the numbers of the population in the future and these methods like (Exponential Modified, Logistics), the population numbers during this period (1989-2023) were obtained from the Central Bureau of Statistics, and by using algorithms prepared by researchers for each method of estimation and During the extracted results, it is clear that the population forecasts of the population of Iraq will be increasing or decreasing in the future.

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### Introduction

When studying demographic analysis, we always need estimates of population numbers and possible changes in their composition and distribution across different activities, population studies are considered one of the studies that follow the changes that occur in the total population and its basic components in terms of values, customs, traditions and others, as well as calculating the basic indicators that measure the rise and fall of population growth in order to estimate the number of population during the years, or predict the size of the population for future planning and development plans programs in the long term.

There is a difference in the application of each method of estimation from the other, this is because the circumstances are different for each method, and the difference in the level of accuracy in the data on which it depends in calculating the estimates, and also the difference is due to the calculation of the time periods for the estimate, some are short and some are long-term, which include future estimates, estimating the size of the population in different periods of time requires calculating the population growth rates of any society, therefore, mathematical models are used in population forecasts, which depend on the existence of many different functions that can be employed in the work of population forecasts. [1,2,3]

The research deals with population estimates using some of the mathematical models, to estimate population growth, and also a prediction of the population numbers in Iraq classified by gender (males and females) for the period from 1989-2023 depending on some functions, including the modified exponential function and the logistic function to calculate the population growth rates in Iraq during the mentioned period, as well as comparing the methods of estimation for both males and females and forecasting for the coming years.

## Objective

Comparison of estimation methods between the number of males and the number of females and predicting the numbers of the male and female population in Iraq in the future.

### **Theoretical side**

#### Estimation methods using mathematical models

According to these methods, mathematical methods are used to estimate the number of population and population growth rates based on the number of populations for previous years and for different periods, and these methods;

## **Modified Exponential Function**

These functions are considered population estimation functions and depend on predictions by choosing successive periods with equal periods of time to calculate the annual growth rate and its general formula.[2,4,6]

$$p_t = a + bc^x \tag{1}$$

Since

$$a = p_0 - b \tag{2}$$

$$b = \frac{p_1 - p_0}{c - 1} \tag{3}$$

$$c = \left(\frac{p_2 - p_1}{p_1 - p_0}\right)^{\frac{1}{n}} \tag{4}$$

 $p_2 \cdot p_1 \cdot p_0$  Population numbers for three consecutive periods.

n: The length of the period between two successive values.

x: Number of years in the estimation period.

The annual growth rate according to this model is calculated from the following formula:

increasing rate and then reaches a turning point or inflection point after which the growth rate

This function depends on the fact that the population growth rate begins to increase at an

changes at an increasing and decreasing rate until it approaches an upper limit at which the constant growth rate continues.

This function depends on the fact that the population growth rate begins to increase at an increasing rate and then reaches a turning point or inflection point after which the growth rate changes at an increasing and decreasing rate until it approaches an upper limit at which the constant growth rate continues.. [1,2,7]

The logistic function is calculated from the following formula:

$$p_t = \frac{k}{1 + e^{B_0 + B_1 x}} \tag{6}$$

Since

r = (c - 1)%

**Logistic Function** 

k: Assumed maximum population when x=0

 $p_t$ : Estimated value of population in the period(t).

 $B_0$ : Constant

 $B_1$ : Fixed and its value is negative in the ascending growth curve, and its value increases with the acceleration of growth

x = t: The time period required for estimation, starting from the first year

The estimated function is calculated from the following formula:

$$p_t = \frac{k}{1 + e^{b_0 + b_1 x}} \tag{7}$$

### **Predicting Model**

It is clear from the formula of the logistic function that it is similar to the linear regression equation, but it is not possible to apply the ordinary least squares method to estimate the parameters of the equation due to the lack of the necessary conditions for estimation.

As the number of parameters  $K \cdot B1 \cdot B$  More than the number of variables p,t Therefore, we use another method, which is the three-point method chosen, as in the case of the modified exponential function, to obtain the values of the three parameters according to the following formulas: [2,5,8]

$$b_1 = \frac{1}{n} \log \frac{p_1(p_3 - p_2)}{p_3(p_2 - p_1)} \tag{8}$$

$$b_0 = \log \frac{p_1 - p_2}{p_2 10^{nb_1} - p_1} \tag{9}$$

$$k = p_1 (1 + 10^{b_0}) \tag{10}$$

Since

 $p_3, p_2, p_1$ : Population numbers for three selected successive periods.

The annual growth rate is calculated from the following formula:

$$r = (|b_1| - 1)\% \tag{11}$$

## **Applied Side**

In this aspect, data representing the population numbers classified by gender (males and females) for the State of Iraq and during the time period 1989-2023 will be analyzed to obtain the predictive population numbers for the year 2030 through the use of modified exponential estimation methods and the logistic function for both the male and female population.

1. The modified exponential method, which assumes reliance in its calculations on three years of study, as the first year 1989 was relied upon and assumed as P0, the middle year was 2006 and assumed as P1, and the final year was 2023 and assumed by P2, relying on equations numbered (2), (3) and (4), The following results were obtained.

C=1.01713393 people

b= 323335.0418 people

a=-314382.042 people

By substituting the previous results into Equation No. (1), we obtain the predictive population numbers for the year 2030

P2030 = 271605 people

The annual growth rate can be calculated from Equation No. (5)

r = 171%

We notice from the results that the male population will increase in 2030 compared to 2023 by 249,717, with an annual growth rate of 171%.

The female population is done with the same previous steps. The predictive numbers of females can be obtained by relying on the equations numbered (2), (3), and (4).

C=1.011696943 people

b= 499446.74 people

a= -490971.74 people

By substituting the previous results into Equation No. (1), we obtain the predictive population numbers for the year 2030.

P2030 = 259362 people

The annual growth rate can be calculated from Equation No. (5)

We note from the results that the female population will increase in 2030 compared to 2023 by 237,926, with an annual growth rate of 161%.

This means that the population increase for males is greater than the population increase for females, and this increase can be affected by the factors surrounding the population during the study period.

2. Logistic function: This function relies in its calculations on the same mechanism in which the exponential adjusted function was calculated based on three years of study. It was assumed that the year 1989 = P1, and the year 2006 = P2, as it is the average year that divides the years of study into equal periods, and the year 2023 = P3.

To estimate the male population size based on equations numbered (8), (9), and (10), we obtain the following results:

nB1 = -0.00750883 people

B0= 0.72653764 people

K = 56651.6649 people

By substituting the previous results into Equation No. (7), we obtain the predictive numbers of males for the year 2030.

P2030= 21873 people

The annual growth rate is calculated according to Equation No. (11)

r=75%

By comparing the extracted results, which represent the predicted numbers of males, we notice a decrease in the number of males in the year 2030 compared to the year 2023 by 197,015, with an annual growth rate of 75%.

To obtain the population numbers of predictive females, we follow the same previous steps, relying on the equations numbered (8), (9), and (10). We obtain the results.

nB1 = -0.00906133 people

B0=0.56865216 people

K = 39865.0395 people

By substituting the previous results into Equation No. (7), we obtain the predicted numbers of females for the year 2030

P2030= 17439 people

The annual growth rate is calculated according to Equation No. (11)

r=91%

Comparing the extracted results, which represent the predicted number of females, we notice a decrease in the number of females in 2030 compared to 2023 by 3997, with an annual growth rate of 91%.

Through the results extracted for the two methods and the classified population numbers, they can be included in the following table:

Table No. (1) shows the results of estimates for the numbers of males and females for the year 2030

Females No.		Males No.	
259362	Modified exponential	271605	Modified exponential
%116	Annual growth rate	%171	Annual growth rate
17439	Logistic function	21873	Logistic function
%91	Annual growth rate	%75	Annual growth rate

By observing Table No. (1) and comparing the estimated results for the number of males and females for the year 2030 with the number of males and females for the year 2023, as it is the last year and closest to the predicted year, we conclude the following:

- 1. The results of estimating the number of males predicted according to the modified exponential method appeared to be 271,605 for the year 2030, with a growth rate of 171%, compared with the number of males, 21,888 for the year 2023, while it was found that the number of males predicted according to the logistic method was 21,873 for the year 2030, with a growth rate of 75%, compared with the number Males: 21,888 for the year 2023, which indicates that the number of males will increase in the future according to the exponential modified function, while the results of the logistic function showed that the number of males is decreasing over time.
- 2. The results of estimating the number of females predicted according to the modified exponential method appeared at 259,362 for the year 2030, with a growth rate of 116%, by comparing it with the number of females, 21,436 for the year 2023. It was found that the number of females will increase in the future according to this function, while it was found that the number of females predicted according to the method Logistics: 17,439 for the year 2030, with a growth rate of 91%, compared to the number of females, 21,436 for the year 2023. It shows us that the number of females is constantly decreasing over time according to this function.

## **Conclusions and Recommendations**

- **1.** The number of males predicted according to the modified exponential and logistic methods is increasing compared to the number of females.
- **2.** The estimate of the numbers of males and females according to the modified exponential method will continue to increase in the year 2030 compared to the year 2023.
- **3.** Estimating the numbers of males and females according to the logistical method will be constantly decreasing in the year 2030 compared to the year 2023.
- 4. The estimated numbers of males and females according to the modified exponential method are constantly increasing. Therefore, it is considered better than the logistic method, which has shown that the estimated numbers of males and females are decreasing during the coming period.
- 5. We recommend using other estimation methods to estimate population numbers for future years.
- 6. Make estimates of other data, such as births and deaths for males and females.

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## المستخلص

إن الزيادة الكبيرة في معدلات النمو السكاني هي الأكبر في معظم الدول النامية بما فيها العراق، ويصاحب هذه الزيادة تغير في خصائص السكان من حيث الحجم والتركيب والتوزيع، مما يؤدي إلى إعادة النظر في السياسات السكانية القائمة، لتكون قادرة على مواجهة الضغوط التي يشكلها الاكتظاظ السكاني على جهود التنمية المستدامة والخطط المستقلية.

ومن هنا فإن هناك حاجة دائما إلى إجراء تقديرات للأعداد السكانية المستقبلية والتغيرات التي من المحتمل أن تصاحب تركيبة السكان وتوزيعهم على مستوى الأنشطة ومجالات الحياة المختلفة.

تختلف طرق التقدير عن بعضها البعض على أساس أن كل منها تطبق في ظروف مختلفة تماماً عن الأخرى، ويعود سبب الاختلاف إلى مستوى دقة البيانات التي تستخدم كأساس لإجراء هذه التقديرات والتنبؤات التي تشير إلى زيادة أو نقصان في عدد السكان في المستقبل.

يتناول هذا البحث استخدام بعض طرق التقدير التي سيتم تطبيقها على السكان في العراق خلال فترة زمنية معينة لتقدير أعداد السكان في المستقبل وهذه الطرق مثل (الأسية المعدلة واللوجستية) تم الحصول على أعداد السكان خلال هذه الفترة (1989-2023) من الجهاز المركزي للإحصاء، وباستخدام الخوارزميات المعدة من قبل الباحثين لكل طريقة من طرق التقدير ومن خلال النتائج المستخرجة يتضح أن التنبؤات السكانية لسكان العراق سوف تتزايد أو تتناقص في المستقبل.

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