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A Study on Population Projection using the Logistic Curve method in Time series analysis with reference to India

KEYWORDS: Population, demography, projection, time series, logistic growth curve and method of three selected points.

Dr. R. Ravichandran

Associate Professor and Head, Department of Statistics, Government Arts College (Aut), Karur -639005. Tamil Nadu, India.

ABSTRACT *Population projection is the numerical outcomes of a particular set of assumption could be various types as long as they are related to the population changes. The method of three selected points of Logistic growth curve method in Time series analysis is used as a model for population growth. The result in this paper support the view that the logistic curve can provide reliable projection of the total population of India and its state Tamil Nadu. It is concluded that the long-term population projection gives accurate results.*

Introduction:
Population in the World currently growing at a rate of 1.1.0% per year. The average population changes currently estimated at round 75 million per year. According to Census of India 2011, India's population in 1901 was about 238.4 million which is increased by more than four times in 110 years to reals population of 1210 million in 2011.

Population projection has an important place in demography. On the basis of certain assumption, population projection seeks to estimate the future growth pattern of population, its size, migration births and death rate etc. The importance of projection is not only for demography, but it is also equally important for economists. Census is conducted after every 10 years in India. In the matter of allocation, of resources i.e. for investment in fields like education, housing, public health, transport and communication etc. the knowledge of future growth of population is very essential. This can be helped by population projection. Planning is essential in every walk of economic life. For family planning, population projection becomes essential. The extent of the activities of Family Planning can be varied on the basis of population projection.

The importance of future population estimates for countries attempting to plan their economic and social development. The primary needs of the people, which the development programs aim to satisfy, cannot be gauged rationally without regard to the expected size and composition of the population, nor can be the national resources are appraised adequately without considering labour, the supply of which depends primarily on population size and structure.

Projection is sometimes useful, to calculate the growth of population that would result from the specified future period of the current fertility or mortality rates, or from the admission of a stated number of immigrants; or to determine the rates of fertility, mortality and migration that would be required to achieve a population of a stated size within a given length of time. Such calculations made without regard to the probability that the stipulated condition of fertility, mortality or migration will actually materialize, may be very helpful in evaluating the merits of various proposals relating to population policy.

Review of literature:
Population projection is must for development of any nation. Long-term population projection gives accurate result. (Leach, 1981). The purpose of the projection is to provide glimpses in the India's long-term population future. Projecting population from 2021-2091 such a period is quiet lengthy but future population size is a direct result of demographic trends generations before. According to Population Research Bureau (PRB), while projections for closer time period are more likely to prove accurate, long term consequences are necessarily obscured. Recognizing the fact, two projections are made for this study.

According to O'Neil et.al. some national population projections have been made based on analysis of time series of either aggregate population size, or of vital rates. Aggregate time series models do away with the cohort component method entirely. S- Shaped Logistic curve is a method to extrapolate past changes in population size. Historical trends in total fertility and life expectancy as well as population size are well –approximated by logistic curve.

More studies , Leach (1981), O'Neil et.al (2001), Jiang and Jin (2007), Wilson T and Reesp (2005), Schoen R (2006), Saboia (1974), Chatfield (2004), it was concluded that the logistic model provides little basis for extending trends in to the long term future. Thus the direct projection of population may have more historical information upon which to draw the cohort component projection. Leach (1981), re-examined the approach using data from several countries and found it , the logistic curve is useful in describing historical changes in population size and for short term projection. The total fertility rate, mortality rate, migration concepts are taking important role in increasing the population in any nation.

With respect to the dimensionality of population projection the simplest models rely on the extrapolation of population size, population growth rates or crude rates related to particular components of demographic change such as fertility, mortality, migration more detailed typological found in Guy J Abel et. al. (2010).

Objectives of the Study:
The main purpose of this study is to project India population at national and Tamil Nadu level, Tamil Nadu is one of the states of India. A fundamental principle for this study is to perform the projection with consistency of method. Thus future population trends are projected in the same way for India and Tamil Nadu. The method of three selected points of logistic growth curve in Time Series analysis has been used to fit these data and to make the projection of the population from the year 2021 to 2091.

Methodology:
The methodology carryout to the study is given in details. Though there are different methods available to project population under mathematical and statistical methods, the logistic curve model has been applied to project the pop-

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ulation data for India and Tamil Nadu. According to Leach (1981), a single function may apply over relatively extended periods of time and that the logistic curve does offer a model of long term changes in population. According to Gupta and Kapoor (1978), the logistic growth curve is fitted to project the population data by the method of least square. The results are discussed for the model

$$Y_t = \frac{k}{(1+be^{-at})}.$$

Where Y_t is the population for t years after the starting population level.

$$a = \frac{1}{n}(\log d_1 - \log d_2), \qquad b = (\frac{k}{y0}) - 1$$

$$d_1 - (\frac{1}{y0} - \frac{1}{y2}), \qquad d_2 - (\frac{1}{y2} - \frac{1}{y4})$$

$$k = 1/(\frac{1}{y0} - c), \qquad c = [\, d_1^2/(d_1 - d_2)]$$

A successful fit results in positive values of k and a but data which deviate too far from the model results in either a fit to a curve with negative k or negative. Thus the fit is tried for 5 points and from five points 3 census data are taken at equal time intervals has been employed.

Analysis:

The following population figures are taken as secondary data from the census*. India is the second most populous country in the world .Tamil Nadu is one of the states of India.

Table:1. Population of India since 1975*

Year	Population in millions	
	India	Tamil Nadu
1971	548.1597	41.199
1981	685.1847	48.408
1991	846.3027	55.859
2001	1027.0153	62.460
2011	1210.1934	72.139

* http://www.censusindia.gov.in/

From the above five year, three points are selected for the time series analysis. The year 1971 is the first point and considered as y_0 likewise 1981 as y_1, 1991 as y_2 2001 as y_3, 2011 as y_4 for both India and Tamil Nadu. The three points y_0, y_2 and y_4 are selected to fit the logistic growth curve.

The logistic growth curve equation for India is

$$Y_t = \frac{k}{(1+be^{-at})},$$

$$k = 2583.640718, \quad b = 3.7132993, \quad a = 0.2963443$$

$$Y_t = \frac{2583.640718}{(1+3.7132993e^{-0.2963443t})}$$

Using the above equation, the population of India is projected for 2021 to 2091. The following table depicts the projected population for India.

Table: 2 Projected Population for India (in millions)

Time / Period (t)	Year	Population
5	2021	1401.237117
6	2031	1587.576084
7	2041	1761.773375
8	2051	1918.274283
9	2061	2053.934569
10	2071	2167.929762
11	2081	2261.224372
12	2091	2336.004601

From the above two tables,(Table No. 1 & 3), the population is doubled in 30 years, i.e. the population compared to the year 1971(548.15) with 2001(1027.01), it is doubled at 30 years. The trend continues for the year 1981(685.18) & 2011(1210.19). At the same time, year 1991(846.3), the population is doubled in 2041 (1761.77) in 50 years. From the table, year 2021,the population is increased nearly 200 million as compared to 2011population and it nearly doubled in 2091, i.e. 1201.19 million increased as 2336.00 million in 80 years. The same trend continues to compare 2001 (1027.01) and 2081 (2261.22) in 80 years. The rapid growth, i.e doubled in 30 years, gradually reduced to doubled in 80 years.

The logistic growth curve equation for Tamil Nadu is

$$Y_t = \frac{k}{(1+be^{-at})}, \quad k = 145.8364, \quad b = 2.5398, \quad a = 0.227673$$

$$Y_t = \frac{145.8364}{(1+2.5398e^{-0.227673t})}$$

Using the above equation, the population of Tamil Nadu is projected for 2021 to 2091. The following table depicts the projected population for Tamil Nadu.

Table:3 Projected Population for Tamil Nadu (in millions)

Time / Period (t)	Year	Population
5	2021	80.4124156
6	2031	88.4960259
7	2041	96.1974048
8	2051	103.3608806
9	2061	109.8770170
10	2071	115.6851205
11	2081	120.7691293
12	2091	125.1491856

From the above tables, (Table No.1 & 3), the population is doubled in 50 years, i.e. the population is compared to the year 1971 (41.199) with 2021 (80.41). Further it doubled in next 60 years i.e. 1981 (48.408) and 2041 (96.197). The population compared to 1991 (55.85) with 2061 (109.87), is doubled in 70 years. Next double in 90years i.e. 2001(62.46) and 2081(125.14). The projected population shows the growth rate is nearly 8 million as uniform up to 2061. Further the growth rate is slightly reduced to nearly 6 million up to 2091. Tamil Nadu population projection reflects the Nation. The fast growth, i.e. double in 50 years gradually reduced as doubled in 90 years.

Conclusions.

Population projections are not true forecast. They are a scenario of future population size which results from the present situation and the assumption made concerning future trends. It may depends on some expectation with various vital factors such as fertility, mortality and migration. It is expected that life expectancy at birth will continue to improve in both examples i.e. India and Tamil Nadu. Tamil Nadu reflects the India's growth rate according to the projection of the study. Fertility trends continue to higher will decide to future population size in India.

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