

Growth and distribution of Socio-Demographic and Economic Variables in India using Time Series Trend Models

M. N. Megeri¹ and Bheemanna²

Department of Statistics, Karnatak University's Karnatak Arts College,
Dharwad, 580001, Karnataka, India.

¹E-mail: megerimn@gmail.com

²E-mail: bmjnyak@gmail.com

ABSTRACT

The study of growth pattern of population is a very important phenomenon for framing population policy. The study of socio-demographic and economic variable plays an important role in population policies. In this paper, an attempt is made to study the growth and distribution of socio-demographic and economic characteristics for India. The selected socio-demographic and economic variables viz; Demographic indicators: Total, urban and Rural populations, Birth and Death rates, Infant Mortality rate, Under 5 mortality and Life expectancy at Birth and economic variables; Gross Domestic Product and Age dependency Ratio and Sociological characteristics are Sex ratio and Literacy rate in India from 1971 to 2020 are processed and analyzed by using the different time series trend models. The result of the analysis shows all three populations and Life expectancy at birth shows an increasing trend, vital rates are decreasing, socio-economic variables show an increasing pattern except age dependency ratio. The polynomial trend is best fitted to demographic variables except Rural population and CBR, economic variables and sociological variables.

Keywords: Demographic, Economic, Sociological, Least Square Estimation, MAPE.

Journal of Economic Literature (JEL) Classification System: P25, Q56, J11, J13, E01, C32, C13.

1. INTRODUCTION

The study of the growth and distribution of the Socio-demographic and Economic variables is an important phenomenon to create infrastructure and basic needs of people. According to World Population Prospects (2019), the world's population continues to grow, although at a slower pace than at any time since 1950, due to reduced levels of fertility, an estimated 7.7 billion people worldwide in 2019, the projection indicates that the global population could grow around 8.5 billion by 2030, 9.7 billion by 2050, and 10.9 billion by 2100. Two-thirds of the projected growth of the global population through 2050 will be driven by current age structures and would occur even if childbearing in high-fertility countries falls immediately around two births per woman over a reproductive period.

The population growth in Northern Africa and Western Asia has been slower than in sub-Saharan Africa over the recent decades, the region is also projected to continue to grow through the end of this century, adding 237 million people between 2019 and 2050 and another 170 million people between 2050 and 2100. The world's two most populous regions in 2019 are Eastern and South-Eastern Asia, with 2.3 billion people, representing 30 per cent of the global population, and Central and Southern Asia, with 2.0 billion (26 per cent). Both regions, have experienced rapid population growth since the mid-twentieth century, and are expected to reach their peak size in the coming decades. Eastern and South-Eastern Asia is projected to reach a maximum population size of 2.4 billion around 2038 and Central and Southern Asia is projected reach a peak some 27 years later at 2.6 billion around 2065 (WPP, 2019).

India is the second most populous country in the world, and this country is expected to add nearly 273 million people between 2019 and 2050, present projections indicate that India will surpass China as the world's most populous country around 2027 (WPP, 2019). Malthus (1798) noted that humans were limited in their birth rates due to a shortage of resources. Hence, an increasing population growth coupled with lowering technological progress leads to the creation of famine, which reduces the population growth as well as economic growth. All the societies, at one time or another, move from a near-equilibrium condition of high mortality and high fertility towards a presumed low-fertility and low-mortality equilibrium termed as 'demographic transition' the process Notestein F.W (1945). Drop in mortality is the chief cause of increased life expectancy among different population. On the other hand, fertility decline alters the age ratios and contributes to Population ageing (Watkins 1986; Hohn 1994; Dandekar 1996; UN 2002). Dyson and Hanchate (2000) also made an attempt to estimate India's population by taking the same base year population as Natarajan and Jayachandran (2001). They assumed Crude Birth Rate (CBR) as 24.8 and Crude Death Rate (CDR) as 8.9 in 2001 with the annual growth rate of population as 1.59 percent. According to their estimation India's population would be 1011 million by 2001 (Tim Dyson and Amresh Hanchate, 2000). India has already entered the phase of demographic opportunity and shall continue to remain there until 2020 (Bhat, 2001). In recent times, fertility decline is associated with declining child dependency, whereas the past high fertility increases the size of the working-age population. As a result, the old age dependency increases slowly, but the overall dependency declines. This provides a demographic opportunity for economic growth if employment is made available to the working-age population (Bloom et al., 2003). An important factor in increased life expectancy in India is the contribution of infant and child mortality (Singh and Ladusingh, 2016). Doepke (2004) showed that education and child labor policies significantly affect the decline in fertility. Köge T (2005) established that the youth dependency ratio has a negative effect on the total factor productivity. The shift in age structure related to population ageing has a profound impact on the economy and society (Gulati & Rajan 1991; Visaria 2001; UN 2002). Hondroyiannis and Papapetrou (2002) and (2004) examined the relationship between the demographic changes and the real output in Greece. The results show that a lower infant mortality rate leads to decline in the fertility rate, resulting in decrease in the population, while an increase in real GDP per capita leads to higher fertility implying a positive income effect. The empirical analysis by Choudhry and Elhorst (2010) noted that the GDP per capita is significantly

correlated with the population of working age, but insignificantly correlated to the children and aging dependency ratios. According to Lee and Mason (2010), slower population growth and low fertility give rise to increasing capital intensity and higher per capita income. The research conducted by Song (2013) showed that the population growth rate has a negative effect on economic growth while the working-age population growth rate has a positive impact. These results support that the fast-economic growth in Asia may be impacted to the positive demographic change that happened there. Bloom and Canning (2011) discovered that population growth and age structure have a significant impact on economic growth. They reported that children between 15 and 20 years are of working age and, thus, enabled the nations to have a chance to grow rapidly. In China, Wei and Hao (2010) revealed that a significant contribution of the demographic structure to economic growth is largely attributed to the lower youth dependency ratio resulting from a decline in fertility. In India, Aiyar and Mody (2013) concluded that the working-age population growth rate has a large impact on economic growth. The dynamic quantitative relationship between economic growth and rural-urban migration in India is and found that econometric model suggest that there is positive stable relationship between them by Manojkumar and Megeri, (2017)

In the present study an attempt is made study the growth and distribution of socio-demographic and economic variables using time series models, the first section throws light on Introduction, the second section deals with methods and materials, third section explains about the summary and discussions and last section provides conclusions.

2. METHODS AND MATERIALS

The data on Mortality, Fertility and Life expectancy at birth, Age dependency ratio, Infant Mortality Rate, under 5 Mortality Rate, Total Fertility Rate and sex ratio were obtained from published statistical report of SRS. The total population, urban population and rural population were obtained from the census 1991, 2001 and 2011 from the office of Registrar General India; GDP data was obtained from Economic Survey of India. To study the growth, pattern and distribution of Socio-demographic and Economic characteristics of the population, the time series models were used to study the growth pattern of these characteristics. The study uses time series models such as Linear, Exponential and Polynomial trends and also goodness of fit test was checked by calculating Mean Absolute Percentage Error (MAPE).

There are three time series models given by

2.1. Linear trend

Let x represent time and y the value of the variable and let the equation is given by

$$y = \beta_0 + \beta_1 x$$

Where β_0 and β_1 are constants

2.2. Polynomial trend

Let x represent time and y be value of the variable and let the equation is given by

$$y = \beta_0 + \beta_1 x + \beta_2 x^2$$

Where β_0 , β_1 and β_2 are constants

2.3. Exponential trend

Let x represent time and y be value of the variable and let the equation is given by

$$y = \beta_0 \beta_1^x$$

Where β_0 and β_1 are constants

Taking logarithms of both sides of equation, we get

$$\log y = \log \beta_0 + x \log \beta_1$$

There are various tests but we have selected only a test so that MAPE as a result test proper for our models.

2.4. Test for Accuracy of the model

There are various tests for testing goodness of fit of the model but we have selected only MAPE as the suitable test for our model.

2.4.1. Mean Absolute Percentage Error (MAPE)

One of the most important current utilized to degree the estimating accuracy of a model. This is the average percentage error when direction of the error is ignored. It is the degree of the accuracy in a fitted time series values in statistics, specifically in growth curves. It usually expresses accuracy in percentage and is defined as;

$$MAPE = \frac{1}{n} \left(\sum_{t=1}^n \left| \frac{A_t - E_t}{A_t} \right| \right) * 100$$

Where, A_t – The Observed values at time t and E_t – The Estimated values at time t .

3. ANALYSIS AND INTERPRETATION

The study analyses the Demographic, Sociological and Economic variables for 50 years from 1971 to 2020. The selected Demographic variables viz; Total population, Urban population, and Rural population, Crude death rate, Crude birth rate, Infant mortality rate, Under-5 mortality rate and Total fertility rate and Life expectancy at birth are analyzed.

3.1. Growth and distribution of Demographic Variables

The Demography examines the size and composition of populations, as well as the movement of people from locale to locale and Demographers also analyze the effects of population growth and its control. Figure 1, demonstrates the total population which got increased by 0.84 billion in the last 50 years, initially from 0.55 billion to current 1.39 billion. There is an increase in Urban population by 0.36 billion in the last 50 years, which began from 0.11 billion to present 0.47 billion because of the increase in job, business opportunities, and infrastructures in urban areas.

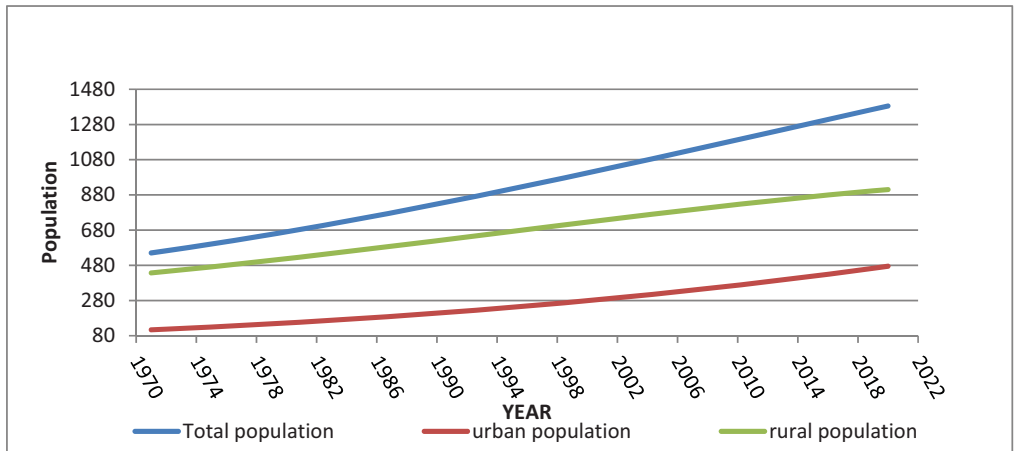


Figure 1. Trend for Total population, Urban population and Rural population for India from 1971 to 2020.

The rural population got increased by 0.47 billion in the last 50 years, initially from 0.43 billion to current 0.91 billion but declining trend is noticed in birth and death rates, which are at third stage demographic transition in India because family planning was given more importance; infant mortality rate also got decreased, standard of living also increased, and women's status got a tremendous change. The growth of these three populations has shown increasing trend as they followed same pattern, but growth rate of urban population is higher than rural population because of advancement of technology and infrastructural development in cities.

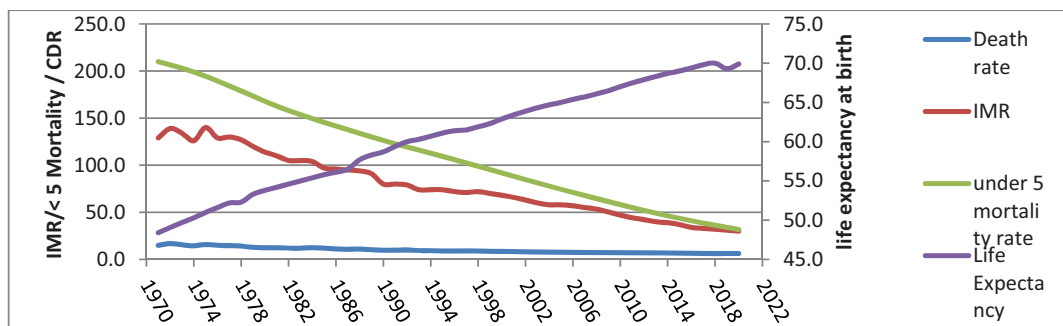


Figure 2. Trend for Crude death rate, Under-5 mortality, IMR and Life expectancy at birth for India from 1971 to 2020.

The information is gathered from SRS. This is used principally in the study of population motions. Since censuses data is collected, it serves as the principal apparatus for making inter estimates of population. The Death rates and Life expectancy at birth is very important factors for deciding the health status of the any nation. Figure 2 indicates pattern of these rates ranging from 1971-2020. The death rate of India has witnessed a significant decline over the period from 14.9 in 1971 to 6.3 in

2020, this means earlier there were approximately 15 deaths per thousand people and it got decreased to 6 people. Both birth and death rates are decreasing gradually over a period of time because of the melioration health care, hygiene, and sanitation, female education, IMR and TFR which got decreased.

The infant mortality rate is an important marker of the overall health of a society. The present level of IMR (30 infant deaths per thousand live births, for the year 2020) is about one-fourth as compared to 1971 (129 infant deaths per thousand live births). IMR in India has declined from 129 in 1971 to 30 in 2020, this means there are 129 IMR per thousand people and is decreased to 30 people. This has decreased because of the betterment of medical care, female education and when it got decreased then birth rate has naturally increased.

Life expectancy at birth measures, health status across all age groups. Has increased from 48.4 in 1971 to 69.9 in 2020; this means there is an increase in life expectancy at birth by 21 years for span of 50 years. It is one of the most frequently used health status indicators. Gains in life expectancy at birth can be imputed to a number of factors, including raising living standards, improved lifestyle and better education, as well as greater access to quality health services. The decline of child mortality was important for the increase of life expectancy. Increasing life expectancy, at a given point in time, middle-aged individuals save more and raise aggregate savings.

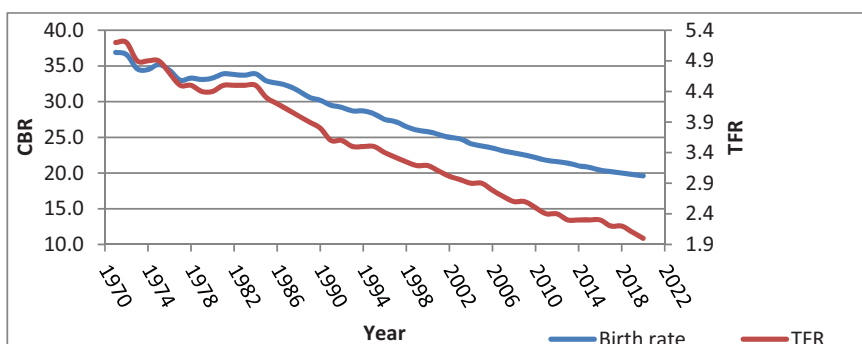


Figure 3. Trend for Crude Birth Rate and TFR for India from 1971 to 2020.

The under-5 mortality rates also got decreased from 209.9 in 1971 to 31.8 in 2020; this means there is decreased in under-5 mortality rate by 178 children deaths per thousand live births in the last 50 years. This is decreasing because of the improvement of the health care facility, air pollution, safe water and sanitation.

The Crude Birth Rate is one of the most basic and important measures in demography. This affects public policy and budgeting for education and health systems. The birth rate for India has declined drastically over period from 36.9 in 1971 to 19.6 in 2020 this means initially there are 37 births per thousand people and is decreased to 20 people.

TFR is the most important measure of fertility. It indicate that it is estimate average number of births per woman her reproductive period. This has also dropped from 5.2 in 1971 to 2 in 2020, this means at the beginning of the study period there are approximately 5 births per women and is decreased to 2 per women. In future, it has average woman having is about 2 children or more over her reproductive period then population growth has increase and otherwise it is expected to decline.

3.2. Economic Variables

An economic indicator is a statistic about an economic activity. The economy of a country as a whole will appear that the output levels of all the goods and services in the economy have a tendency to move together. The selected Economic variables viz. Gross Domestic Product (GDP) and Age dependency ratio are analyzed. GDP is prominent indicator for the economic development of any nation because it gives information about the size of the economy and how an economy is performing, this is increased by Rs. 202922.11 billion in 50 years, initially there are Rs. 476.38 billion and is increased to Rs. 203398.49. The age dependency ratio is decreasing then automatically GDP has increasing clearly see in figure 4. This may be due to the movement of people from children age group peoples to working ages, India finds itself with a potentially higher share of workers as compared with dependents. If working-age people can be productively employed, India's economic growth is also increasing. The increase of these variables increases the life expectancy.

Age dependency ratio is also very important key variable for socio-economic growth. The dependency ratio is important because it shows the ratio of economically inactive compared to economically active. This got decreased by 29 in the last 50 years, initially from 79 to current 48. The working age people's numbers is on the raise, it helps to increase economic growth rate. If age dependency ratio increases then its effect is directly noticed in economic growth because the working age people naturally decreasing then, 0-15 year's age peoples and 65 years and above people's dependents on the 15-64 age working people.

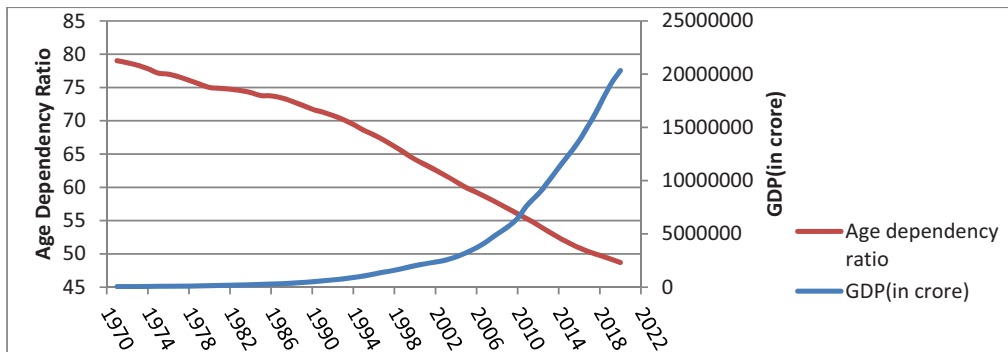


Figure 4. Trend for Age dependency ratio and GDP for India from 1971 to 2020.

They have rising life expectancy raises the saving rate at both the household level and aggregate level, and that it raises the growth rate of output per capita. Albeit, a rising old-age dependency rate lowers the aggregate saving rate, whereas a rising total dependency rate reduces the growth rate of per capita output. When people get a high income, they do not desire more children as they are earning high, so they don't feel the need of depending on their children. An increase in income will give a secure and positive feeling in India and the birth rate gets reduced positively.

3.3. Sociological Variables

Social indicators play an important role in checking the social system, helping to identify changes and to guide mediation to alter the course of social change.

The selected Sociological variables viz; Literacy Rate and Sex Ratio are analyzed.

Literacy is a very important key variable for socio-economic growth. Literacy develops human resources which is very necessary for the economic development. Importance of education cannot be refused in the economic development of the country. The Literacy rate got increased by 53 per cent in the last 50 years, initially from 34 per cent to the current 87 per cent. The human resource includes the population, its growth rate; skills, standard of living and the working capacity of the labor force, and all the above factors can be enhanced by increasing the literacy rate of a population. The literacy rate has been on a continuous rise and the total fertility rate has taken a continuous fall and will decrease the population growth. The better education will lead to higher GDP as human capital is an important cause of growth and higher GDP per capita will lead to better education due to more investment in education. Increased female literacy rate will only have a stronger impact on the TFR level.

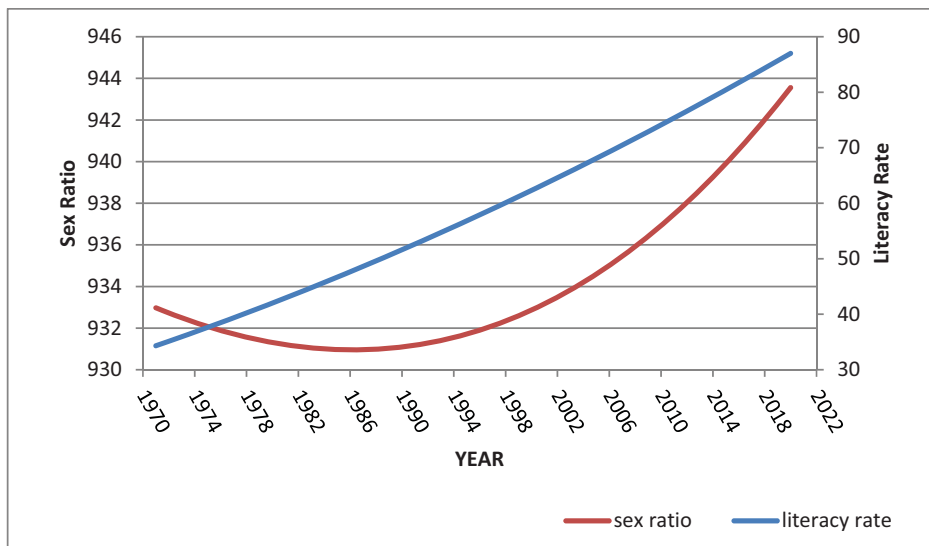


Figure 5. Trend for Sex ratio and Literacy rate for India from 1971 to 2020.

Sex ratio is also very important key for socio-economic growth. This is providing an indication of both the relative survival of females and males. Sex ratio has increased by 11 points in the last 50 years, initially from 933 (per 1000 male) in 1971 to current 944 (per 1000 male) in 2020. There are several causes which attributes to the decline in the number of girls. Sex ratio at birth impacted by sex selective abortions, son preference, high mortality rate, female feticide, and neglect of the girl child are the main reasons. Science and technology is supposed to help to achieve progress of society, it was being used to detect the gender of fetus and unfortunately, a lot of sex selective abortions are taking place today. The preference for sons has deep roots in India for cultural and economic reason.

3.4. Estimation of Socio-demographic and Economic variables

In order to study the growth and distribution of the Socio-demographic and Economic characteristics of the population more scientifically one can use the for different models and estimate these characteristics by estimations parameters of the model with help of the least square, the following table 1 summarizes the Socio-demographic and Economic phenomenon variables and a comparison of the estimates of these models is carried out.

3.4.1. Estimation of demographic characteristics

Demographic characteristics play an important role in deciding about demographic transition. This study the demographic trend and also estimates these characteristics namely Total population, Urban population and Rural population, Birth rate, Death rate, IMR, TFR, Life expectancy at Birth and under 5 mortality rate using least square principles by three different time series models.

Table 1: Estimation of coefficients for Socio-demographic and Economic variables for India from 1971 to 2020 by using different time series trend models.

Variables	Coefficients	Linear trend	Exponential trend	Polynomial trend
Total population	β_0	938906695.6	904875745.7	923171877.5
	β_1	17316899.06	1.019187238	17316899.06
	β_2	--	--	75557.34964
Urban population	β_0	262124578.6	240491128.3	245056670.7
	β_1	7292062.409	1.029629756	7292062.409
	β_2	--	--	81958.74125
Rural population	β_0	676782117	660798959.1	678115206.8
	β_1	10024836.65	1.015371566	10024836.65
	β_2	--	--	-6401.391617
Crude Birth rate	β_0	27.82754299	27.30804296	27.92107436
	β_1	-0.365396092	0.986665892	-0.365396092
	β_2	--	--	-0.00044913
Crude Death rate	β_0	9.884911478	9.466198198	9.132341459
	β_1	-0.199346419	0.980271341	-0.199346419
	β_2	--	--	0.003613782
IMR	β_0	78.58572606	71.46830627	74.89340686
	β_1	-2.243156471	0.969694901	-2.243156471
	β_2	--	--	0.017730224

TFR	β_0	3.489788103	3.360958863	3.441780381
	β_1	-0.064610171	0.981068785	-0.064610171
	β_2	--	--	0.000230529
life Expectancy at birth	β_0	60.5452	60.19419933	61.11372885
	β_1	0.44492581	1.00748416	0.44492581
	β_2	--	--	-0.00273003
Under-5 mortality rate	β_0	111.572	97.69514413	106.3827692
	β_1	-3.666141657	0.963622739	-3.666141657
	β_2	--	--	0.024918275
GDP(in Crore)	β_0	3794053.7	1020820.101	640616.97
	β_1	309706.0835	1.13607089	309706.0835
	β_2	--	--	15142.55333
Age dependency ratio	β_0	66.02550158	65.30546646	67.68013024
	β_1	-0.649527081	0.989891512	-0.649527081
	β_2	--	--	-0.007945396
Literacy rate	β_0	58.51046492	56.41167851	57.36796585
	β_1	1.07531926	1.019075413	1.07531926
	β_2	--	--	0.00548619
Sex ratio	β_0	934.0461338	934.0393063	931.8048304
	β_1	0.20518242	1.000219261	0.20518242
	β_2	--	--	0.010762561

For linear model, the co-efficient β_1 for different demographic variables viz; Total population, Urban population, Rural population, and Life Expectancy at Birth respectively, are 17316899.06, 7292062.409, 10024836.65, and 0.444 and these values are positive indicating an increase in the magnitude of these variables. This true because all the three populations are increasing from 1971-2020 and also there is increase in life expectancy at birth which is observed for the same period due to advancement in health, Infrastructural facilities in India over period of time. The Crude Birth Rate, Crude Death Rate, IMR, TFR, and Under 5 Mortality Rate are -0.3654, -0.1993 -2.2431, -0.0646, and -3.6661 respectively and these coefficients (β_1) is a negative values for all these variables which reveals that a decrease in the magnitude of these variables is due to the improvement of the health care facility, female education, air pollution, safe water, and sanitation in three trends models.

The value of β_1 for Total population, Urban population, Rural population, and Life Expectancy at Birth are 1.0192, 1.0296, 1.0154, and 1.0075 respectively and these growth coefficients of β_1 is greater than one for all these variables indicating an increase in the magnitude of these variables and the Crude Birth Rate, Crude Death Rate, IMR, TFR, and Under 5 Mortality Rate are 0.9867, 0.9802, 0.9697, 0.9810, 0.9636 respectively coefficients β_1 is less than one for all these variables tells that there is decrease in the magnitude of these variables in exponential trend model.

The value of β_1 and β_2 for Total population, Urban population, Rural population and Life Expectancy at Birth and these growth coefficients of β_1 values 17316899.06, 7292062.406, 10024836.65, and 0.444 are respectively and β_2 values 75557.3496, 81958.7412, -6401.3916, and -0.00023 are respectively a positive value or the β_1 is a positive value and β_2 is a negative value for all these variables, say that

an increase in the magnitude of these variables and the Crude Birth Rate, Crude Death Rate, IMR, TFR, and Under 5 Mortality Rate and these growth coefficients of the β_1 values -0.3654, -0.1993, -2.2431, -0.0646, and -3.6661 and β_2 values -0.0004, 0.0036, 0.0177, 0.00023 and 0.0249 respectively are negative values or the β_1 is a negative value and β_2 is a positive value for all these variables suggest that a decrease in the magnitude of these variables in polynomial trend model (See Table 1).

3.4.2. Estimation of Economic characteristics

Table 1 reveals the estimation of Gross Domestic Product (GDP) and Age Dependency Ratio using least square principles by three different time series models. For linear model, the coefficient β_1 GDP value 309706.0835 is a positive value, for this variable tells that an increase in magnitude and the Age Dependency Ratio coefficient β_1 value -0.6495 is a negative value for this variable indicating decrease in magnitude.

The coefficient value of β_1 for GDP 1.1360 is greater than one for this variable imply that increasing in magnitude and the Age Dependency ratio value 0.9899 and its growth coefficient β_1 is less than one for this variable signify that decrease in magnitude in the exponential trend model.

The value of β_1 and β_2 for GDP and its growth coefficients β_1 value 309706.0835 and β_2 value 15142.5533 are positive values and the β_1 is a positive value and β_2 is a negative value for this variable signify that increasing in magnitude and the Age Dependency Ratio and its growth coefficients of the β_1 value -0.6495 and β_2 value -0.0079 are negative values and the β_1 is a negative value and β_2 is a positive value for this variable tells that decreasing in magnitude in the polynomial trend models. The GDP is an increase due to the movement of people from children age group peoples to working ages and the Age dependency ratio is decreasing due to the working-age people are increasing, which helps to increase the economic growth rate in the three trends model.

3.4.3. Estimation of Sociological characteristics

The Sociological variable viz; Literacy rate and Sex ratio are estimated using least square principles by three different time series models. For the linear model, the Literacy Rate and Sex Ratio coefficients β_1 values 1.0753 and 0.2051 are respectively positive values and these variables signify the increase in magnitude.

The Literacy Rate and Sex Ratio coefficients β_1 values 1.0190 and 1.0002 are greater than one for these variables indicating an increase in the exponential trend model. The coefficient value for Literacy Rate and Sex Ratio of β_1 value 1.0753, 0.2051, and β_2 value 0.0054, 0.0107 respectively are positive values and the β_1 is a positive value and β_2 is a negative value for these variables say that an increase in the polynomial trend model. The above three trend models Literacy Rate and Sex Ratio are increasing due to the increased female literacy rate which will only have a stronger impact on the TFR level in the three trends model (See Table 1).

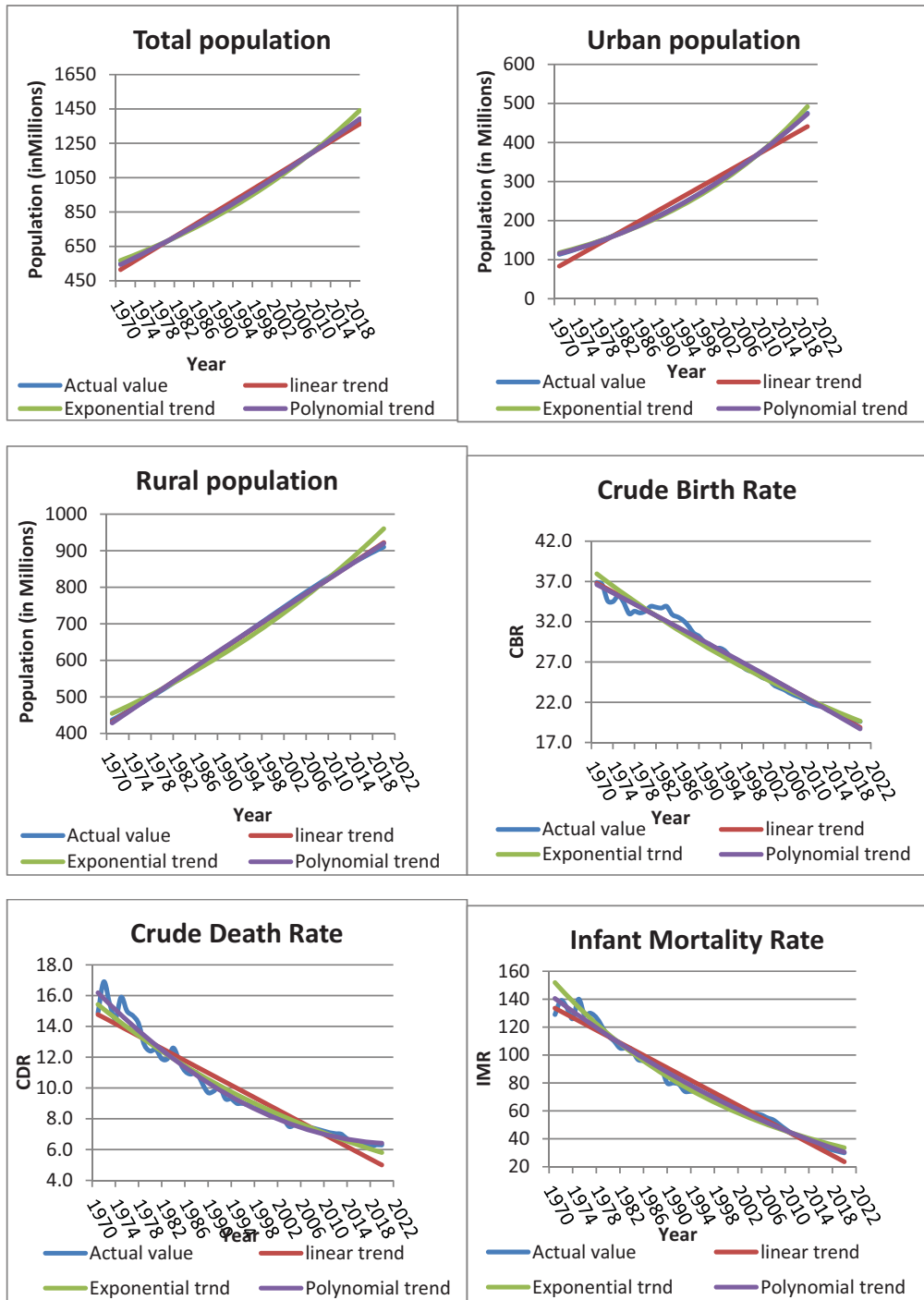
Table 2: MAPE for Socio-demographic and Economic variables for India for different time series trend models.

Variables/trends	MAPE		
	Linear	Exponential	Polynomial
Total population	1.48525592	1.50220858	0.287093854
Urban population	6.03648668	1.44043843	0.333666512
Rural population	0.48470406	1.95431188	0.501012985
Crude Birth rate	1.88270167	2.21190391	1.962409298
Crude Death rate	6.93754413	3.60178161	2.952273822
IMR	5.17955338	5.33050623	3.598777665
TFR	2.52991028	2.60784237	1.973306052
Life expectancy at birth	0.70262562	1.10243528	0.354531106
Under-5 mortality rate	4.902703402	7.33372827	1.029321143
GDP	860.222619	5.17818937	376.4681897
Age dependency ratio	2.12807555	2.89690047	0.870289413
Literacy rate	1.63871582	1.30238701	3.6396E-12
Sex ratio	0.1848173	0.18436904	0.010393743

3.5. Test for Accuracy of the model

In order to test goodness of fit of the model, the mean Absolute percentage Error (MAPE) is used; minimum value of the shows the better fit. Table 2 summarizes the estimated error of various time series trends as well as Scio-demographic and Economic variables for India. The estimated accuracy for the whole data of Scio-demographic and Economic variable is roughly the same for time series trends for India.

Figure 5 explains Total population; the value of MAPE is 1.485256 for linear trend, 1.50221 for exponential trend, and 0.2871 for polynomial trend. For Urban population, the value of MAPE is 6.03649 for linear trend, 1.4405 for exponential trend, and 0.33367 for polynomial. For Rural population, the value of MAPE is 0.4848 for linear trend, 1.9543119 for exponential trend, and 0.501013 for polynomial. For Crude Birth Rate, the value of MAPE is 1.8828 for linear trend, 2.211904 for exponential trend, and 1.96241 for polynomial. For Crude Death Rate, the value of MAPE is 6.94 for linear trend, 3.6079 for exponential trend, and 2.952274 for polynomial. For Infant Mortality Rate, the value of MAPE is 5.1795534 for linear trend, 5.33051 for exponential trend, and 3.5988 for polynomial. For Under-5 Mortality rate, the value of MAPE is 4.903 for linear trend, 7.33373 for exponential trend, and 1.03 for polynomial. For Total Fertility Rate, the value of MAPE is 2.52991028 for linear trend, 2.607842367 for exponential trend, and 1.97331 for polynomial. For Life Expectancy at Birth, the value of MAPE is 0.702625624 for linear trend, 1.102435276 for exponential trend, and 0.355 for polynomial trend.



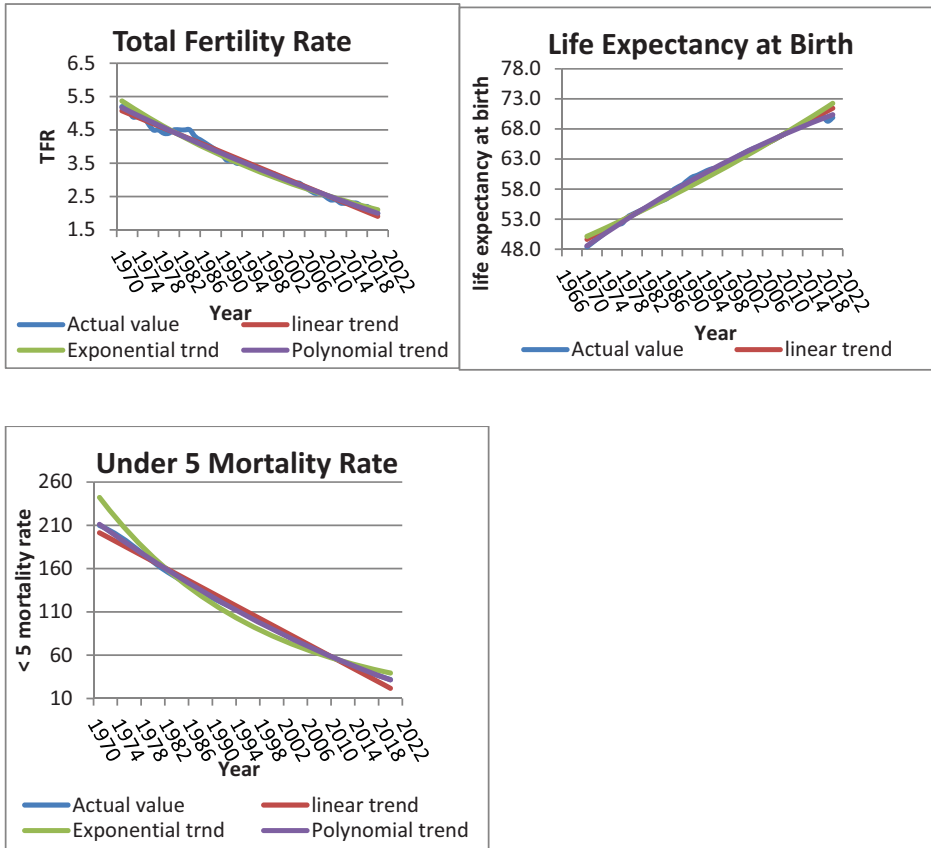


Figure 5. Estimation of Demographic Characteristics by different growth models from 1970–2020.

The Polynomial trend had smallest MAPE value for all the selected demographic variables except Rural population and Crude Birth Rate. Hence, polynomial trend is best fitted for the all demographic variables except these two variables, whereas Rural population and Crude Birth Rate are best fitted for linear trend since data shows the smallest value of MAPE in these two variables (See Figure 5).

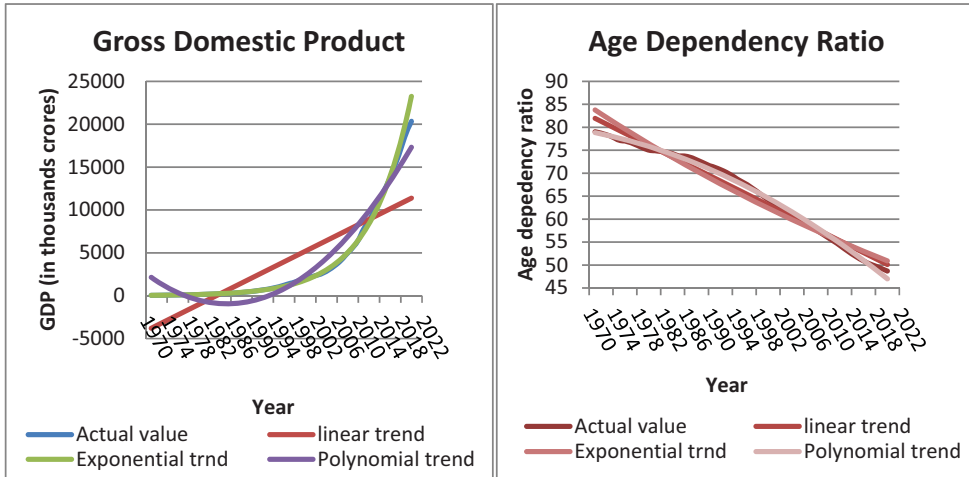


Figure 6. Estimation of Economic Characteristics by different growth models from 1970 – 2020.

Figure 6 explains about the consistency of Economic variable and also goodness of fit. The analysis also shows GDP value of MAPE is 860.223 for linear trend, 5.1782 for exponential trend, and 376.489 for polynomial trend. For Age Dependency Ratio, the value of MAPE is 2.128076 for linear trend, 2.897 for exponential trend, and 0.87029 for polynomial trend.

For GDP and Age Dependency Ratio again MAPE has smallest for the polynomial trend as compared to other two trends. Hence, the polynomial trend is best fitted to GDP and Age Dependency Ratio. Figure 7 shows Literacy rate, the value of MAPE is 1.638716 for linear trend, 1.3024 for exponential trend, and 3.6396E-12 for polynomial trend. For Sex ratio, the value of MAPE is 0.18481753 for linear trend, 0.18437 for exponential trend, and 0.010393743 for polynomial trend.

The MAPE for Literacy rate and Sex ratio are smallest in case of polynomial trend as compared to other trends. Hence, the polynomial trend is best fitted to literacy and Sex ratio.

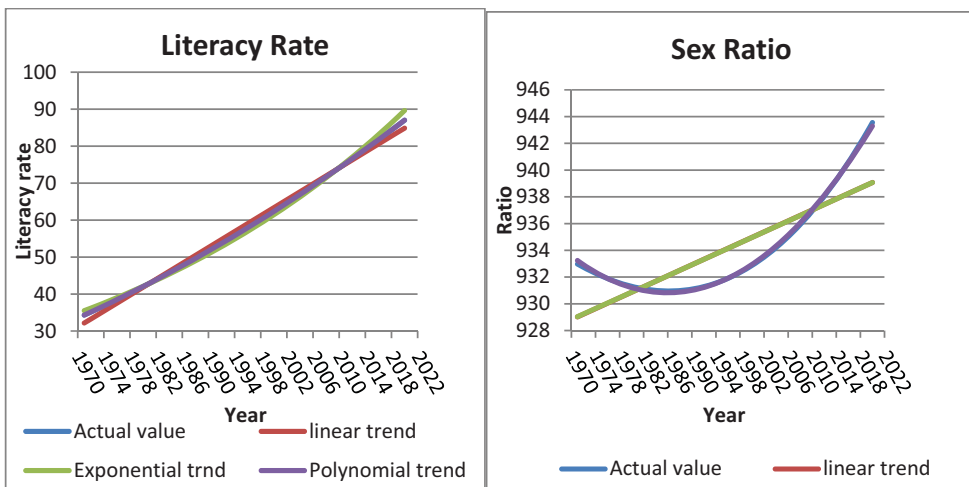


Figure 7. Estimation of Sociological Characteristics by different growth models from 1970 – 2020.

The time series trend of India for literacy rate is slower than that of other variables, so estimated error is slower than that of other variables for polynomial trend and Sex ratio is slower than that of other variables, so estimated error is slower than that of other variables for Linear and Exponential trends. The time series trend of India for GDP is greater than that of other variables, so estimated error is greater than that of other variables for linear and polynomial trends and Under-5 mortality rate is greater than that of other variables, so estimated error is greater than that of other variables for exponential trend.

The Polynomial trend had smallest MAPE for Literacy rate and linear and Polynomial trend had greatest MAPE for GDP. Therefore, the polynomial trend is best fitted for literacy rate as compared to both linear and exponential trends. The linear and exponential trend is best fitted for Sex ratio as compared to polynomial trend.

4. CONCLUSION

The estimation of socio-demographic and economic variables using time series model help us study the trend in scientific manner, the study of growth of these variables are important for making policies regarding urban, rural and health infrastructure development. The present analysis explains how these variables are increasing or decreasing over a period of time from 1971 to 2020?. The following are the some of the conclusions with help of linear, exponential and quadratic time series models

1. Total Population, GDP and Life expectancy at birth are increasing exponentially and rural population increasing linearly.
2. Birth and Death rates are decreasing gradually over a period of time, and also there is improvement in health care facility, the IMR and TFR are decreasing. This indicates India is at the late expanding stage of demographic transition.
3. As age dependency ratio is decreasing more than one-half, consequently GDP of the country is progressing exponentially. This boost the economic growth of the country.
4. Presently there is better sociological conditions compare to earlier days, since all the coefficients VIZ, Demographic, Sociological and Economic variables are significant at 1% level of significance for all the three models.
5. The polynomial trend is best fitted for literacy rate as compared to both linear and exponential trends and the linear and exponential trend is best fitted for Sex ratio as compared to polynomial trend as these have smallest Mean Absolute Errors (MAPE).
6. The polynomial trend is best fitted to demographic variables except rural population and CBR, Economic variables and Sociological variables.

In view of the above facts, it is concluded that framing the policy regarding infrastructure developments like food and shelter for each every people is necessary and also policy regarding the increased health infrastructure is very much essential for sustainable development of the country.

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