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DEMOGRAPHIC ANALYSIS AND COMPARISON WITH THE POPULATION OF BANGLADESH AND PAKISTAN

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Abstract

Compared to many other nations, Bangladesh has a higher population density. Although population growth is seen as frightening, knowing how it will change in the coming years can help with planning for the nation's future. This article is based on estimates of the country's and Pakistan's future population increase and a comparison of the populations of the two nations. In our calculations, the population of Bangladesh will be close to 211 million, whereas that of Pakistan would be close to 356 million in 2060. Population increase is the largest problem the world has to face since it directly impacts the most basic human being and how society and the state will adapt to it. Additionally, we calculated the prediction for the near future and included a demographic assessment of both countries' rural populations and crime rates in this article. This study compares the precision and closeness of three mathematical models, including the Malthusian or exponential growth model, the logistic growth model, and the least squares model, to forecast population growth in Bangladesh and Pakistan by the end of the twenty-first century. The correct numbers for transgender people are not yet accessible, despite the fact that they are acknowledged as the third sex. Additionally, the paper offers a hypothetical comparison of how the state has responded to its expanding population in the past and how it will respond in the future.

Keywords: Population Model, Mean Absolute Percentage Error, Crime Report and Rural People.

1. INTRODUCTION

Bangladesh is a small South Asian nation with a sizable population. An expanding population has a significant need for food, water, energy, nutrition, and other facilities, as well as for education. An overpopulated planet has negative repercussions such as prosperity, ignorance, crime, unemployment etc. (Ullah et al., 2019). Bangladesh is currently the eighth most densely inhabited country in the world. One of Bangladesh's most pressing challenges in recent years has been the population crisis. The most important component of the globe is its population, but population projection has emerged as one of the biggest global issues (Turchin et al., 2009). Population sizes and growth have a direct impact on a country's economy, policy, culture, education, and environment. They also affect the cost of natural resources(Mondol et al., 2018). Pakistan's population situation shows that the nation is currently witnessing a significant population expansion, 1.92 percent annually during the period, which further changes the demographic view of the nation. Pakistan saw a six-fold increase in population between 1960 and 2022. Pakistan's population is projected to grow to 263 million people by 2030 and to 383 million people by 2050 (https://worldpopulationreview.com/countries/pakistan-population), according to the United nations Population Division's medium prediction. This high population growth is a result of the delayed and slow decline in fertility at the national and provincial.

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Pakistan's population is growing at a rapid rate despite the country's demographic uncertainty (Feeney & Alam, 2003). In several areas of Bangladesh, the population has been expanding quickly. Resources and habitats of Bangladesh are under threat due to population increase (Akhter, 2017). For the projection of the populations of China and India, a population model based on the logistic model and the least squares method has been studied (Michael Rosario & James Antony, 2017). The use of mathematical population modeling to predict exponential population growth has been outlined by Wali & Ntubabare (Wali & Ntubabare, 2011). The rural population is not changing quickly despite the population growth (Hsieh, 2014), and as a result, crime is rising daily. Population estimations are essential for any country to make the best decisions about socioeconomic and demographic development programs, as demonstrated by a comparison of adaptability with the rising populations of Bangladesh and India (A. N. M. R. Karim et al., 2020) . According to a different study (Ofori et al., 2013), the exponential model provided a more accurate forecast of Ghana's population growth than the logistic model (C et al., 2017) conducted additional research on the logistic equation as a model for population growth in Nigeria .There has been a fairly brief study conducted that allows us to understand the demographic makeup of Bangladesh as well as future projections for population growth (Steinmann & Komlos, 1988; Steven & Kirkwood, 2013). Ullah et al. also talked about how Bangladesh will be manipulated in the future for better outcomes (Ullah et al., 2019) (Al Mamun et al., n.d.; R. Karim et al., 2020, 2022) .

However, this study provides no guidance on how to best integrate into the population. Bangladesh and Pakistan are not only neighbors, but also have strong economic, geopolitical, social and most importantly international ties. The competitive nature is constantly vying between her two neighboring states to see who gets the chance to advance over time. Over time, we've had the opportunity to focus on efforts that represent population size (Hussain et al., n.d.) . The study also looked at certain current trends to evaluate the difficulties that both nations are currently facing, the necessity of addressing them, and to identify potential frameworks for future collaboration. Many creators have utilized various models to anticipate the number of inhabitants in various nations. Notwithstanding, how the developing populace is being obliged and engaged by the state, how their fundamental necessities are being met isn`t portrayed all the while (London, 1998) . We have drawn a similar situation of Bangladesh and Pakistan.

2. METHODS AND MATERIALS

The study's main objective is to draw focus on major problems, newly developing future difficulties, and promising prospects related to population expansion and adaptability. Population growth occurs in discrete steps due to successive generations, and there is growing interest in and activity in the field of chaotic behavior related to the topics we have been discussing. Much of this activity is motivated by new and potential applications in a wide range of different fields (Murray, 2002). The study's foundations include secondary data, secondary sources, projection analysis, and population growth modeling (Berkey & Laird, 1986; Clark & Luis, 2020; Mulligan, 2006). The topic has also been determined based on general and particular case studies and research. Government statistics report from studies, journal

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publications, projection articles/reports from newspapers, etc. were the material forms used for the analysis. To predict a country's future population, it is critical to understand the pace of population growth. All of this information is related to demography. Additionally, this technique is utilized to determine the population prediction of such countries in (C et al., 2017; A. N. M. R. Karim et al., 2020; Michael Rosario & James Antony, 2017). To know their population numbers precisely, many nations conduct censuses. The procedure is expensive and requires a lot of materials and manpower. As a result, it is not possible to predict future populations using annual expenditures by conducting annual censuses.

2.1. Implementation

Population dynamic research can make use of a certain category of mathematical model called the population model. In this study, population projections are created using the Malthusian model, the logistic growth model, and the least squares model, respectively.

2.2. Malthusian model or exponential model:

Exponential growth is a description of uncontrolled reproduction. The occurrence of this in nature is quite infrequent (Ehrlich & Lui, 1997). Thomas R. Malthus proposed this model, which was briefly reviewed in (Cocks, 1971; Pratap, n.d.)as well as the Malthusian model for a single species population model in (Mondol et al., 2018).

Suppose the initial population is P_0 at a certain time $t = t_0$ ant to determine the new population N after a particular time $t = t_1$ in future and λ is the intrinsic growth rate. Now here the condition for is given below

$$P(t_0) = P_0$$

$$\frac{dP}{dt} = \lambda P(t), t_0 \leq t \leq t_1, P(t_0) = P_0$$

$$\frac{dP}{P} = \lambda dt$$

Now integrating

$$\int \frac{dP}{P} = \int \lambda dt$$

$$\ln P = \lambda t + \delta \ , \qquad \delta \text{ is a integrating constant}$$

$$P = e^{\lambda t + \delta}$$

$$P = e^{\lambda t}.e^{\delta}$$

$$P\delta e^{\lambda t} \tag{1}$$

Using the initial condition, $P(t_0) = P_0$ (2)

From (3.1)

$$P(t_0) = \delta e^{\lambda t_0} \tag{3}$$

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From (3.2) & (3.3)

$$P_0 = \delta e^{\lambda t_0}$$

$$\delta = P_0 e^{-\lambda t_0}$$

$$P(t) = P_0 e^{-\lambda t_0} e^{\lambda t} \qquad \text{Fron (1)}$$

$$P(t) = P_0 e^{\lambda(t-t_0)} \qquad (4)$$

Equation (4) is known as Malthusian growth model.

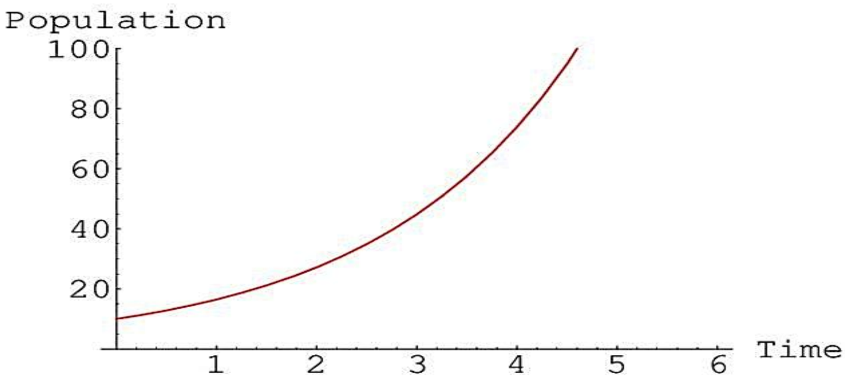

Figure 1: Malthusian Growth Model

2.3. Logistic Growth Model

Belgian mathematician Pierre Verhulst established the logistic model in 1838 (Henson et al., 2003) .He highlighted that population growth is influenced by both the size of the population and how distant this number is from its carrying capacity. As human carrying capacity is dynamic and uncertain (R. Karim et al., 2022; Tsoularis & Wallace, n.d.; Turner et al., 1969). Ecological notions of carrying capacity that are appropriate for nonhuman populations do not capture the element of human choice (Cohen, 1995; Shepherd & Stojkov, 2005). The sigmoid-shaped logistic model describes population growth as exponential, followed by a decrease in expansion and limited by a carrying capacity brought on by ecological factors 1. The Malthusian model was modified to provide a population proportional to both the existing and new terms 2.

$$\frac{\alpha - \beta N(t)}{\alpha} \qquad (5)$$

Where α and β are called the vital coefficient of the population.

As the population number approaches $\frac{\alpha}{\beta}$ this new term will now get very small and eventually tend to zero, assuming enough people respond to limit population growth. Thus, the second term resembles the competition for the available resources that tends to limit population growth. And the modified equation will be accurate utilizing this new concept.

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$$\frac{dN}{dt} = \frac{\alpha N(t)[\alpha - \beta N(t)]}{\alpha} \qquad (6)$$

This first order nonlinear differential equation (6) is known as the logistic law of population growth model.

Solving (6) and applying the initial condition $N(t_0) = N_0$ then (6) become

$$\square \ \frac{dN}{dt} = \alpha N - \beta N^2$$

$$\square \ \frac{dN}{N(\alpha - \beta N)} = \mathrm{dt} \qquad (7)$$

By using separation variables in equation (7) and then integrating we obtain

$$\square \ \frac{1}{\alpha}\left(\frac{1}{N} + \frac{\beta}{\alpha - \beta N}\right) dN = dt \qquad (8)$$

$$\square \ \int \frac{1}{\alpha}\left(\frac{1}{N} + \frac{\beta}{\alpha - \beta N}\right) dN = \int dt$$

$$\square \ \frac{1}{\alpha}[lnN - \ln{(\alpha - \beta N)}] = t + \varepsilon \qquad (9)$$

Now using the initial condition $t = t_0$ and $N(t_0) = N_0$ equation (9) become

$$\square \ t_0 + \varepsilon \ = \frac{1}{\alpha}[lnN_0 - \ln{(\alpha - \beta N_0)}] \qquad (10)$$

$$\square \ \varepsilon \ = -t_0 + \frac{1}{\alpha}[lnN_0 - \ln{(\alpha - \beta N_0)}]$$

Now the equation (9) van be written as

$$\square \ \frac{1}{\alpha}[lnN - \ln{(\alpha - \beta N)}] = t - t_0 + \frac{1}{\alpha}[lnN_0 - \ln{(\alpha - \beta N_0)}]$$

$$\therefore \ N = \frac{\frac{\alpha}{\beta}}{1 + \left(\frac{\frac{\alpha}{\beta}}{N_0} - 1\right) e^{\alpha(t_0 - t)}} \qquad (11)$$

If we take limit of equation (11) as $t \to \infty$, we get

$$\square \ N_\infty = \lim_{t \to \infty} N = \frac{\alpha}{\beta} = K$$

Where K is known as carrying capacity.

Now substituting $t = t_0 , t = t_1 , t = t_2$ in equation (3.11) and the values of N_0 , N_1 , N_2

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respectively where $t_0 < t_1 < t_2$ are equally spaced time, then equation (11) becomes,

$$\frac{\beta}{\alpha}\left(1 - e^{\alpha(t_0 - t)}\right) = \frac{1}{N_1} - \frac{e^{\alpha(t_0 - t_1)}}{N_0}$$

$$\frac{\beta}{\alpha}\left(1 - e^{\alpha(t_0 - t)}\right) = \frac{1}{N_2} - \frac{e^{\alpha(t_0 - t_2)}}{N_0}$$

Now eliminating $\frac{\beta}{\alpha}$ we have

$$e^{\alpha(t_0 - t_1)} = \frac{N_0(N_2 - N_1)}{N_2(N_1 - N_0)} \quad (12)$$

Substituting the value of (3.12) in (3.11) we obtain

$$\frac{\beta}{\alpha} = \frac{{N_1}^2 - N_0N_2}{N_1(N_0N_1 - 2N_0N_2 + N_1N_2)} \quad (13)$$

Now using the limiting value of N as $N_\infty = \lim_{t\to\infty} N = \frac{\alpha}{\beta} = K$ in the above equation and the Carrying capacity is

$$K = \frac{\alpha}{\beta} = \frac{N_1(N_0N_1 - 2N_0N_2 + N_1N_2)}{{N_1}^2 - N_0N_2} \quad (14)$$

Hence from the equation (3.12) we obtain

$$\alpha = \frac{1}{t_0 - t_1} ln \frac{N_0(N_2 - N_1)}{N_2(N_1 - N_0)} \quad (15)$$

Simplify the equation (11) we get

$$\therefore N(t) = \frac{KN_0}{N_0 + (K - P_0)e^{\alpha(t_0 - t)}} \quad (16)$$

The above equation is known as Logistic Growth Model.

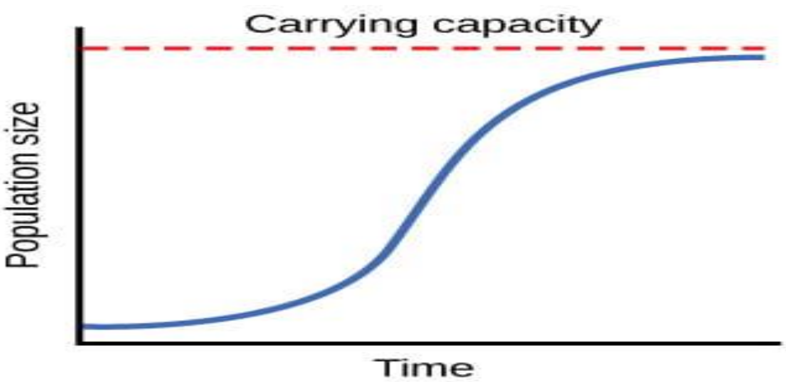

Figure 2: Logistic Growth Model

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2.4. Least Square Model

Linear regression is a prediction algorithm that provides a linear relationship between the values of a dependent variable and the value of an independent variable (Utama & Informatika, 2018) . When a time-series table is available, the least square model is used to determine future projections based on the time-series table's past trends (A. N. M. R. Karim et al., 2020). This model is a very simple method for any projection that uses a straight line developed from previous data (Mamat et al., 2019) .

$$Y = a + bX \tag{17}$$

Where Y is dependent variable and X is independent variable .The regression line has two parameters: a intercept and b slope (gradient)

$$a = \frac{\sum Y}{N} \quad \& \quad b = \frac{\sum XY}{X^2}$$

$$\sum Y = Na + b\sum X \tag{18}$$

$$\sum XY = a\sum X + b\sum X^2 \tag{19}$$

Where: $\sum X$ = The sum of all observations of X.

$\sum Y$ = The corresponding sum of all the observation of Y.

$\sum XY$ = The sum of all the products of X and Y.

N = Total number of observations.

The next step is to solve equations (18) and (19) to find the values of a and b, which must then be substituted in (17). It then turns into a straight line and provides the values of Y for each value of X = 1, 2, 3, 4, 5, 6…………. . Least Square Model is the name of the method used to calculate future projections.

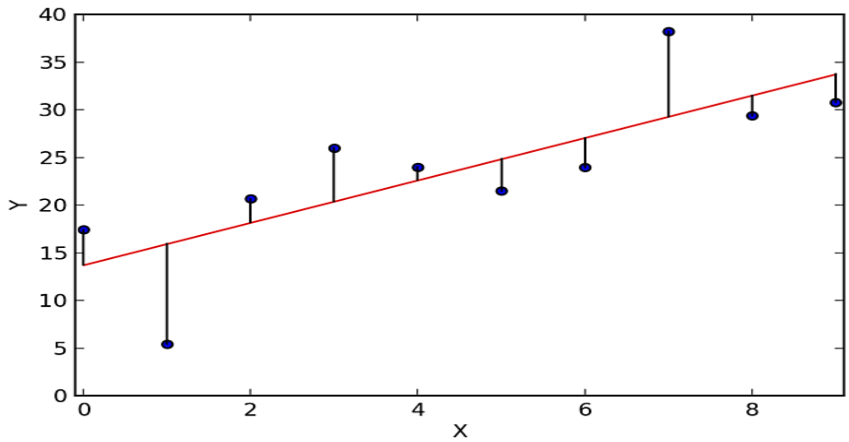

Figure 3: Least Square Regression Model

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2.5. Calculation Of Different Models And Adaptation

Malthusian Model: By using this method to calculate the growth rate for both Bangladesh and Pakistan with the equation (4). From Table-1, we can determine

Lett_0 = 1960 & t = 2020. The population of Bangladesh P_0= 50.39 & P = 167.42 and also the population of Pakistan is P_0= 45.95 & P = 227.20

Now from the equation (4), we get

For Bangladesh $P(t) = P_0 e^{\lambda(t-t_0)}$

□ 167.42 = 50.39$e^{\lambda(2020-1960)}$

∴ λ =0.020011881

For Pakistan $P(t) = P_0 e^{\lambda(t-t_0)}$

□227.20= 45.95 $e^{\lambda(2020-1960)}$

∴ λ =0.026637947

Hence the general solution or Bangladesh and Pakistan is respectively.

$$P(t) = 50.39\ e^{0.020011881(t-1960)}$$

$$P(t) = 45.95\ e^{0.026637947(t-1960)}$$

Using the general solution, we calculate the population of both countries of 1960 to 2060 in Table-2 and Table-3.

Logistic Model

Again from Table-1,

Let t_0 = 1960 , t_1 = 1990 & t_2 = 2020

Now the population (million) of Bangladesh is N_0 = 50.39 , N_1 =107.14 , N_2 =167.42

Now the population (million) of Pakistan is N_0 = 45.95 , N_1 =115.41 , N_2 =227.20

Putting the above value in equation (14) & (15) we get

For Bangladesh, the carrying capacity K= 227.59 and growth rate α = 0.03801227217

For Pakistan,the carrying capacity K= 426.61 and growth rate α = 0.0374135258

Hence the general solution or Bangladesh and Pakistan is respectively.

$$N(t) = \frac{11468.6}{50.39 + (227.59 - 50.39)\ e^{0.03801227217(1960-t)}}$$

$$N(t) = \frac{19602.9}{45.95 + (426.61 - 45.95)\ e^{0.0374135258(1960-t)}}$$

Using the general solution, we calculate the population of both countries of 1960 to 2060 in

Table-2 and Table-3.

Least Square Model

From Table-1 we have the number of observation N=13 and using the equation (18) & (19) we have the value of a and b.

For Bangladesh a = 37.157692 and b = 10.07275

For Pakistan a = 11.52808 and b = 16.07676

Hence the general solution or Bangladesh and Pakistan is respectively.

$$Y = 37.157692 + 10.07275X$$

$$Y = 11.52808 + 16.07676X$$

This is the Least Square Model's general solution for Bangladesh and Pakistan. Taking X= 1, 2, 3, 4… values to obtain the Y population.

3. RESULT AND DISCUSSION

To calculate the populations of Bangladesh and Pakistan, we employed the Verhulst logistic population model, the Malthusian model, the Least Squares model, and an adaptation of the demographic view. We started by examining data from the Pakistani and Bangladeshi censuses conducted between 1960 and 2020.

Table 1 displays Bangladesh's actual population, density, and growth rate from 1960 to 2020. About 50.9 million people lived in Bangladesh in 1960. In Pakistan, there were 59.61 million people living there at the same period. Tables 2 and Table 3 show the population projections for the two countries through the year 2060 using various population models. Bangladesh's growth rate in 1970 was 2.92%, and using the population model, we can see that the population growth rates for the Malthaus, Logistic, and Least Squares models are respectively 2.02%, 2.79, and 3.92%. The logistic model is here the closest percentage of growth rate. Similarly, Bangladesh's real growth rates from 1990 to 2020 are 2.23%, 1.04%, and 1.15%, respectively, and the percentages that are closest to those actual growth rates are 2.12%, 1.40%, and 1.08%. The growth rate initially increased quickly, but as the year went on, it began to decline. If we compare the actual population growth rates for the years 1970, 1990, 2010, and 2020 to the population model, we can see that they are, respectively, 2.72%, 3.52%, 2.20%, and 1.75%. The closest rates, when compared to a population model, are 2.70%, 2.84%, 2.20%, and 1.85%, which also illustrate the growth rate's quick acceleration as well as its gradual slowing down with time.

The estimated population of both countries up to 2060 is calculated in Table 2 and Table 3 using various population models. Figs. 6 and 7 also display the anticipated population of the two nations. For the accuracy rate of mathematical models, we compare the calculated value of both countries with MAPE in Table 4 if the population is 1960 to 2020. (Fig 8). The MAPE for Bangladesh is 8.56 percent for the Malthusian model, 0.71% for the logistic model, and 1.75 percent for the least square model, respectively. These indicates that the logistic model

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has a lower error and is therefore more suitable for projecting the population of Bangladesh. The MAPE of Pakistan's population from 1960 to 2020 shows respectively 6.15%, 3.49%, and 9.02% for the Malthusian model, the Logistic model, and the Least Squares model, demonstrating that the Logistic model is more accurate than the other two.

Table 1: Actual population

Year	Actual Population(millions)		Density		Growth rate	
	Bangladesh	Pakistan	Bangladesh	Pakistan	Bangladesh	Pakistan
1960	50.39	45.95	387.16	59.61	2.58%	2.30%
1965	58.50	51.84	449.41	67.25	3.03%	2.44%
1970	67.54	59.29	518.87	76.91	2.92%	2.72%
1975	74.71	68.13	573.87	88.38	2.04%	2.82%
1980	83.92	80.62	644.77	104.59	2.36%	3.43%
1985	95.95	97.12	737.18	125.99	2.72%	3.79%
1990	107.14	115.41	823.14	149.72	2.23%	3.51%
1995	117.79	133.12	904.92	172.68	1.91%	2.90%
2000	129.19	154.37	992.50	200.25	1.86%	3.01%
2005	140.91	174.37	1082.53	226.20	1.75%	2.47%
2010	148.39	194.45	1139.98	252.25	1.04%	2.20%
2015	157.83	210.97	1212.49	273.67	1.24%	1.64%
2020	167.42	227.20	1286.17	294.72	1.15%	1.75%

Source: https://worldpopulationreview.com/countries/bangladesh-population &

https://worldpopulationreview.com/countries/pakistan-population

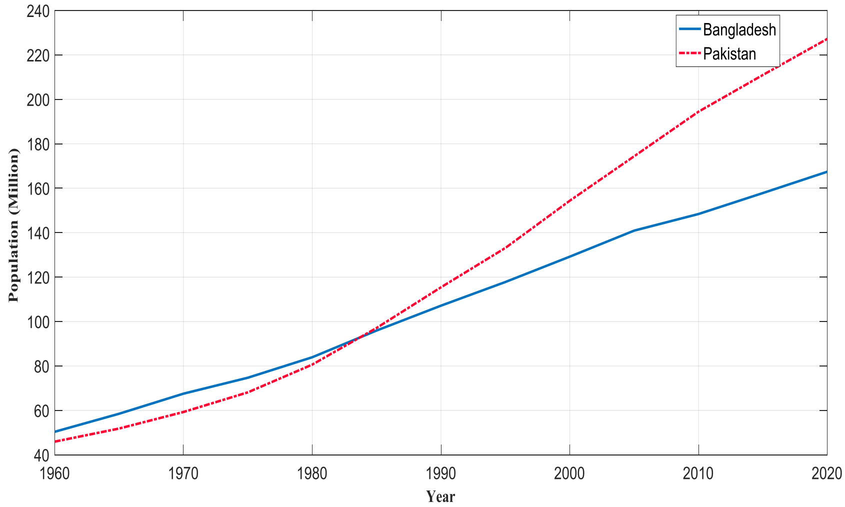

Figure 4: Actual population of Bangladesh and Pakistan

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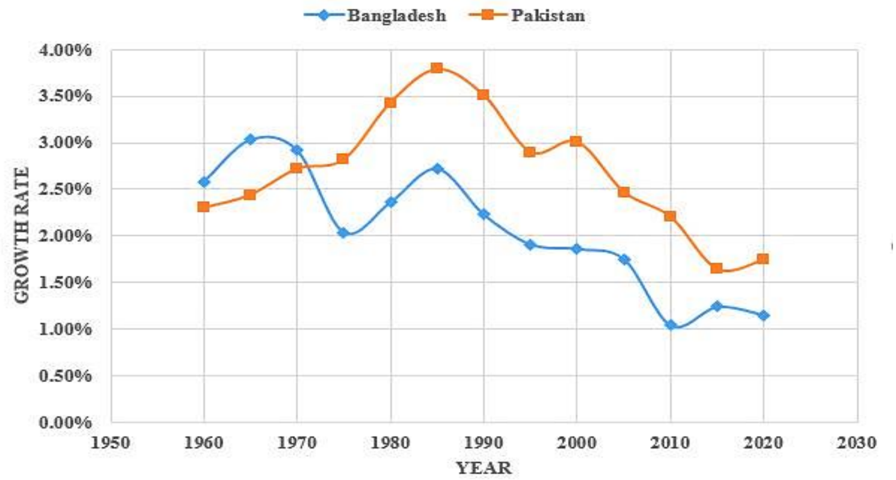

Figure 5: Growth rate population of Bangladesh and Pakistan

Table 2: The expected population of Bangladesh

Year	Malthus Model	Logistic Model	Least square model
1960	50.39	50.39	47.23
1965	55.69	58.24	57.3
1970	61.55	66.84	67.37
1975	68.03	76.15	77.44
1980	75.19	86.07	87.52
1985	83.11	96.45	97.59
1990	91.85	107.14	107.67
1995	101.52	117.96	117.74
2000	112.19	128.66	127.81
2005	124.01	139.14	137.88
2010	137.05	149.17	147.96
2015	151.48	158.64	158.03
2020	167.42	167.42	168.1
2025	185.04	173.45	178.18
2030	204.51	182.69	188.25
2035	226.03	189.15	198.32
2040	249.82	194.85	208.39
2045	276.11	199.83	218.47
2050	305.17	204.14	228.54
2055	337.28	207.85	238.61
2060	372.77	211.01	248.68

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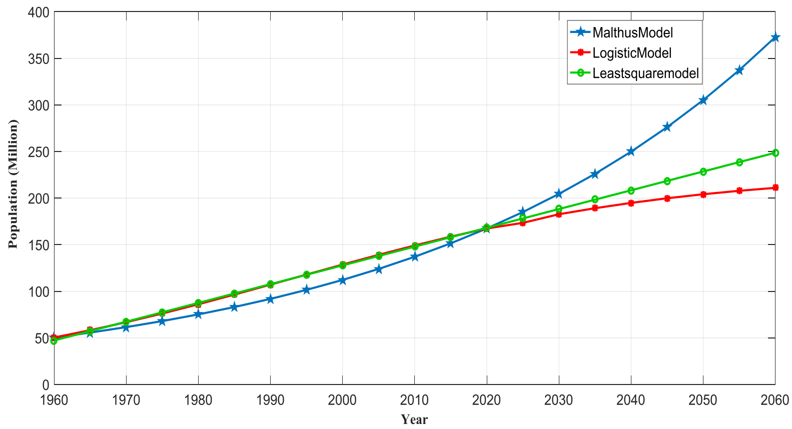

Figure 6: Projected Population of Bangladesh

Table 3: Projected Population of Pakistan

Year	Malthus Model	Logistic Model	Least square model
1960	45.95	45.95	27.61
1965	52.49	54.21	43.68
1970	59.98	63.68	59.76
1975	68.52	74.5	75.83
1980	78.28	86.71	91.92
1985	89.43	100.35	107.99
1990	102.18	115.41	124.06
1995	116.73	131.82	140.14
2000	133.36	149.43	156.21
2005	152.36	168.06	172.29
2010	174.06	187.44	188.37
2015	198.88	207.27	204.45
2020	227.2	227.2	220.53
2025	259.57	246.89	236.6
2030	296.55	266.01	252.68
2035	338.79	284.27	268.75
2040	387.06	301.42	284.83
2045	442.21	317.31	300.91
2050	505.2	331.82	316.91
2055	577.18	344.89	333.07
2060	659.42	356.55	349.14

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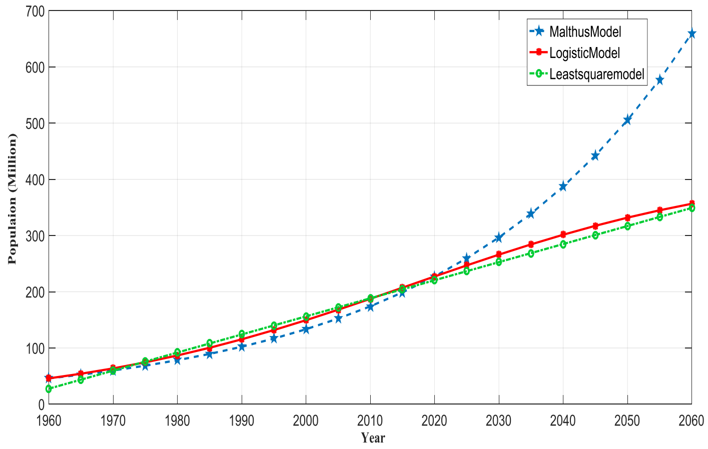

Figure 7: Projected Population of Pakistan

Table 4: Mean Absolute Percentage Error (Population Model)

Model / Country	Malthus Model	Logistic Model	Least square model
Bangladesh	8.56%	0.71%	1.75%
Pakistan	6.15%	3.49%	9.02%

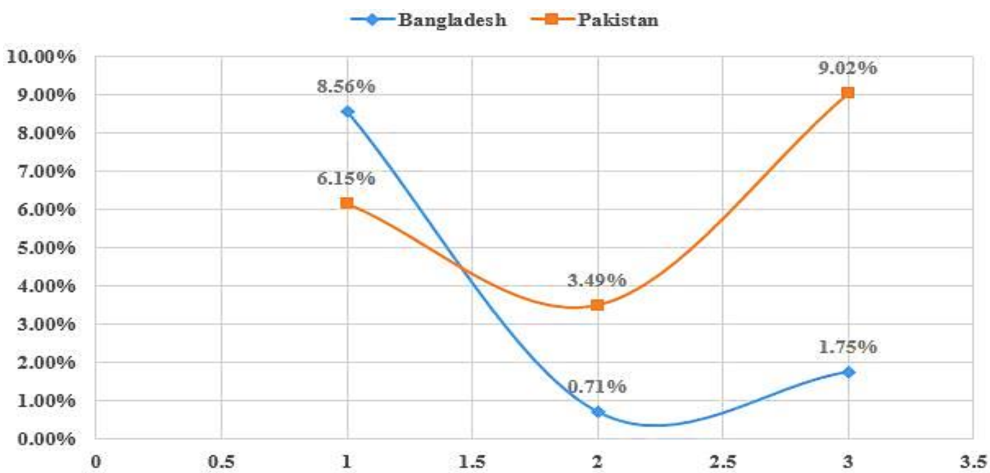

Figure 8: Mean Absolute Percentage Error (Population model)

We also computed the annual percentage change in crime in each countries and the crime forecast through the year 2100. The actual crime report reveals that in a population of around 100K, where it was previously believed that the crime rate was significantly declining (table 5), the crime rate has actually been steadily rising from 2006 to 2012, according to table 6. Table 6's anticipated crime report compares both Bangladesh and Pakistan. The crime rate for Bangladesh would be 1.74 & 0.59 in 2050 and 2100, while it would be 0.44 & -6.49 in Pakistan. Which indicates that it will decline. In Fig. 9, the projected crime report and the annual change

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in crime as a percentage are displayed. According to Tables 6 and 7, more over 50% of the population resides in rural areas. We may use the demographic model to forecast both countries' future rural populations. According to Table 7, there will be 100.29 and 116.63 million rural dwellers in Bangladesh and Pakistan, respectively, in 2020. In 2050 and 2100, Bangladesh will have 102.01 and 102.72 rural residents, compared to 150.16 and 204.77 in Pakistan. Figures 11 and 12 show that this supports the assertion that more than 50% of the people in both nations live in rural areas.

Table 5: Actual Crime Report

Year	Crime per 100K		Annually change %	
	Bangladesh	Pakistan	Bangladesh	Pakistan
2001	2.8273	6.5715	-	-
2002	2.6442	6.3297	-6.48	-3.68
2003	2.5751	6.1048	-2.61	-3.55
2004	2.8485	6.1367	10.62	0.52
2005	2.5835	6.1022	-9.3	-0.56
2006	2.9563	6.126	14.43	0.39
2007	2.7078	6.2905	-8.41	2.69
2008	2.8405	7.0254	4.9	11.68
2009	2.8912	7.1163	1.78	1.29
2010	2.7023	7.3513	-6.53	3.3
2011	2.6569	7.5597	-1.68	2.83
2012	2.7244	7.3932	2.54	-2.2
2013	2.8757	7.2869	5.55	-1.44
2014	2.9214	6.7976	1.59	-6.71
2015	2.5823	4.7566	-11.61	-30.03
2016	2.2731	4.1821	-11.97	-12.08
2017	2.2225	3.9609	-2.23	-5.29
2018	2.3733	3.8831	6.79	-1.96
2019	2.4123	3.7647	4.32	-3.05
2020	2.3154	3.8435	-1.72	2.09

Source:https://www.macrotrends.net/countries/BGD/bangladesh/crime-rate-statistics & https://www.macrotrends.net/countries/PAK/pakistan/crime-rate-statistics

Table 6: Projected Crime Report (Using Least Square Method)

Year	Crime per 100K		Annually change %	
	Bangladesh	Pakistan	Bangladesh	Pakistan
2001	2.86	7.24	-	-
2002	2.84	7.1	-0.8	-1.92
2003	2.81	6.97	-0.81	-1.95
2004	2.79	6.83	-0.81	-1.99
2005	2.77	6.69	-0.82	-2.03
2006	2.74	6.55	-0.83	-2.07
2007	2.72	6.41	-0.83	-2.12
2008	2.7	6.27	-0.84	-2.16

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2009	2.68	6.13	-0.85	-2.21
2010	2.65	5.99	-0.85	-2.26
2011	2.63	5.85	-0.86	-2.31
2012	2.61	5.72	-0.87	-2.37
2013	2.58	5.58	-0.88	-2.43
2014	2.56	5.44	-0.89	-2.49
2015	2.54	5.3	-0.89	-2.55
2016	2.52	5.16	-0.9	-2.62
2017	2.49	5.02	-0.91	-2.69
2018	2.47	4.88	-0.92	-2.76
2019	2.45	4.74	-0.93	-2.84
2020	2.42	4.61	-0.93	-2.92
2025	2.31	3.91	-0.98	-3.42
2030	2.19	3.22	-1.03	-4.13
2035	2.08	2.52	-1.09	-5.2
2040	1.97	1.83	-1.15	-7.03
2045	1.85	1.14	-1.22	-10.8
2050	1.74	0.44	-1.3	-23.7
2055	1.62	-0.24	-1.39	128
2060	1.51	-0.94	-1.49	17.3
2100	0.59	-6.49	-3.71	2.184

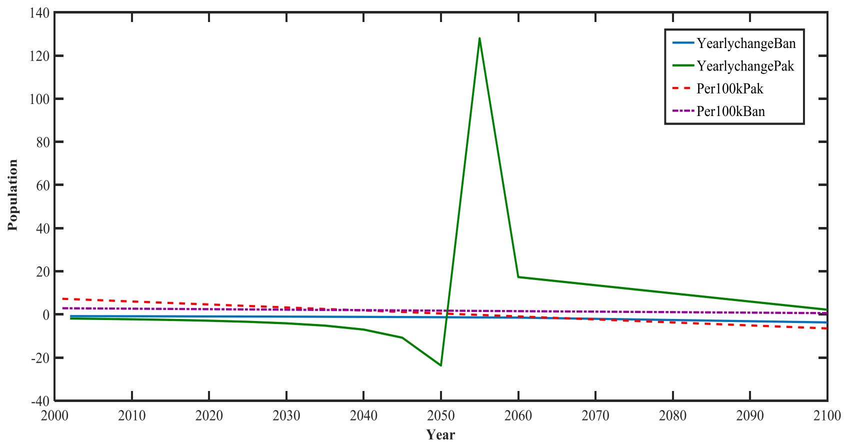

Figure 9: Projected Crime Report (Using Least Square Method)

Table 7: Actual Rural People Report

Year	Rural people (Million)		% Of Total Population	
	Bangladesh	Pakistan	Bangladesh	Pakistan
2000	97.54	95.39	76.41	67.02
2005	101.76	105.83	73.19	66.02
2010	102.62	116.63	69.54	65.00
2015	102.65	127.58	65.69	63.97
2020	101.82	138.80	61.82	62.84

Source: https://www.macrotrends.net/countries/BGD/bangladesh/rural-population & https://www.macrotrends.net/countries/PAK/pakistan/rural-population

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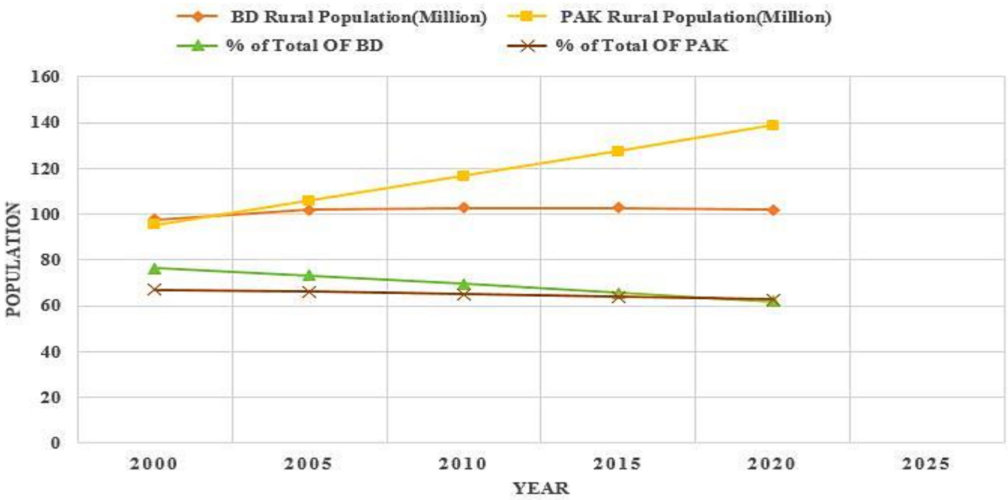

Figure 10: Actual Rural People Report

Table 8: Projected Rural People

Year	Rural people (Million)		% Of Total Population	
	Bangladesh	Pakistan	Bangladesh	Pakistan
2000	97.54	95.93	75.81	64.2
2005	98.41	100.92	70.73	60.05
2010	99.15	106.04	66.47	56.57
2015	99.77	111.29	62.89	53.69
2020	100.29	116.63	59.9	51.33
2025	100.72	122.07	58.07	49.44
2030	101.08	127.58	55.33	47.96
2035	101.38	133.17	53.6	46.85
2040	101.63	138.8	52.16	46.05
2045	101.84	144.47	50.96	45.53
2050	102.01	150.16	49.97	45.25
2055	102.15	155.85	49.15	45.19
2060	102.27	161.53	48.47	45.3
2100	102.72	204.77	45.91	50.11

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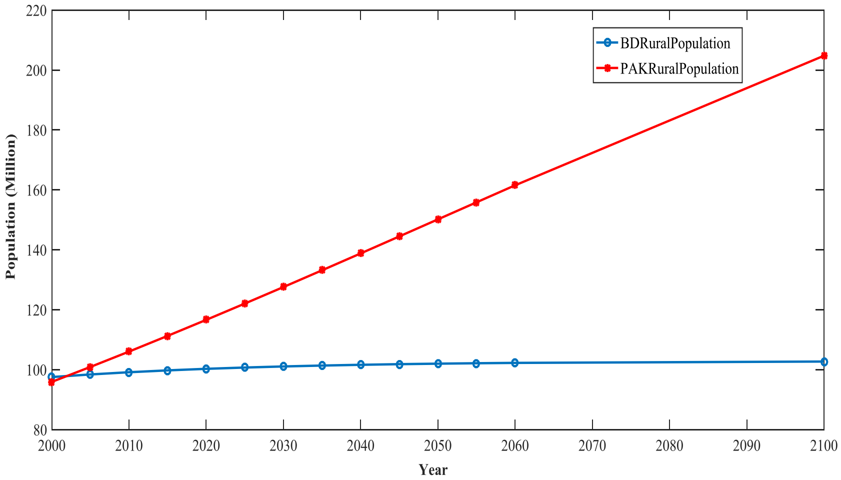

Figure 11: Projected Rural People

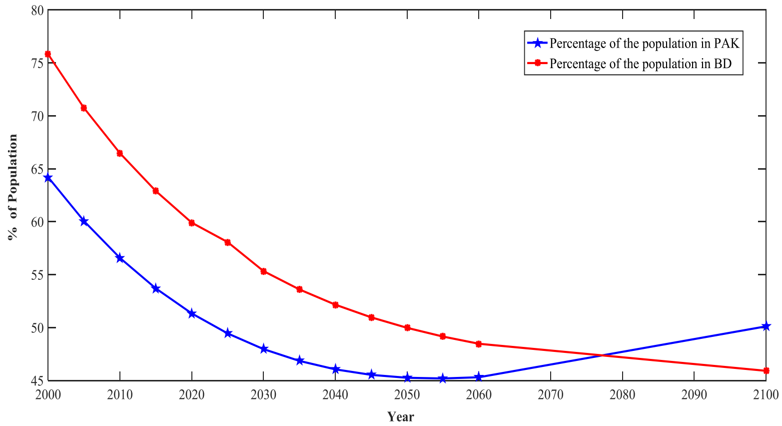

Figure 12: Percentage of the projected Rural Population

The carrying capacity of Bangladesh and Pakistan is, respectively, around 227.59 million and 426.61 million, according to our analysis and research to predict the populations for the next 40 years. As a result, the populations of Bangladesh and Pakistan are projected to be, respectively, 211.01 million and 356.55 million in 2060. It is also shown that the Logistic growth model has relatively little Mean Absolute Percentage Error (MAPE). Finally, from this angle, we may state that for a long-term forecast, the logistic growth model outperforms the least square and the Malthusian models. These models can be used to predict the simple or compound interest on investments in the economic sector, as well as in other fields with dynamic populations, such education, industry, policy, culture, environmental science, and demographics. The exponential growth model's growth rate is constant because it only uses time (t) as an explanatory variable, but it is unable to account for a fall in the rate of population growth. Unconstrained population growth is predicted by the exponential model, however this

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may not always be the case. The majority of people occasionally have resource constraints, but nobody is ever completely alone. Since long-term population increase was not included, the results are invalid. Only when infinite resources may be used to reach the population is the exponential model applicable. For long-term projections with limited resources, the logistic growth model would therefore produce the best-predicted results.

As of 1960, Bangladesh and Pakistan had respective populations of 50.39 and 45.95 million. And the density was 387.16 and 59.61 per square kilometer. But after 60 years, we notice that the population is growing quickly and has reached 1.67.42 million and 227.20 million. Pakistan has a larger surface area than Bangladesh, yet despite Pakistan's faster growth rate, Bangladesh has a higher population density. For Bangladesh, the population density in 2020 is 1286.17 people per square kilometer, but it is only 294.72 people per square kilometer in Pakistan, and it is expected to rise steadily. On the other hand, both countries' crime rates have been declining recently. Future projections indicate that it will decline as well, though more rapidly than Bangladesh. A majority of people more than 50% live in rural areas, as we also noticed. Although people are relocating to cities as time goes on, the majority of them are still in rural areas in both countries, which is a hurdle to becoming a developed nation. Using a quantitative population model, we predict that in 2050, 45.25% of people would live in rural areas, making up 49.97% of the total population. Government should be informed of all population-related issues in both nations. There are still no reliable statistics on the third gender population, despite the fact that they are acknowledged as citizens. The census provides information on the quantity and distribution of women and men, but we are never provided with data on those additional women and men. They are never included in censuses. It is impossible to make growth plans where their numbers are unknown. All upcoming censuses and demographic forecasting studies should, ideally, include those who identify as third sex. For more accurate results, future studies must take into account the variables affecting population increase.

4. CONCLUSION

According to the results of our study, population expansion and adaptation are not kept in check. The carrying capacity of the land and the ability of the resources on common property to meet the needs of the current and future populations may be reduced as a result of the increase of specific features as a result of population growth. The government is unable to keep up with urbanization at the rate at which the population is growing while the area is not. As a result, crime is also rising. Therefore, the majority of our population lives in rural areas, and we are undoubtedly falling behind in the modern world. Therefore, the government should put measures in place to lessen the effects of this increase, such as creating national population plans that involve the conservation of the environment and natural resources. On the other hand, it can help with modifying public social service initiatives, especially those that pertain to housing, education, health care, food, and employment for individuals. Initiatives to foster human development and end deprivation must be organized, constant, and ongoing across consecutive regimes. If there is no check and balance between population expansion and its adaptability, they will be plagued without being blessed. Our investigation's findings show that Bangladesh trails Pakistan in some categories.

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