

Population of Andhra Pradesh and its Districts on the Way to Zero Population Growth*

GROWTH of human population depends on: age-sex structure of the population, marriage pattern, fertility, mortality and migration. These components of population change are affected by social, economic, cultural and political changes. On the other hand, size and composition of the population itself trigger off several changes in the society.

In India, population projections are made under the auspices of the Registrar General and Census Commissioner of India. Component Method¹ of population projection is used for projecting the national and state populations. The ratio method² and some of its variants are used for the rural/urban and sub-national (districts) projections.

In 1980, under the auspices of the Planning Commission, family planning targets were set for India and its States by Srinivasan *et al.*,³ with the objective of reaching "net reproduction rate" (NRR) of unity by the year 2001. This exercise provided the population for each state and India annually from 1980-81 to 2000-2001, along with percentage of couples to be protected and several other important demographic indicators. The targets are being revised by taking

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1. For details of the Component Method of projection, the **reader** may see any standard **text** book in Demography.

2. For an excellent exposition of the Ratio Method of population projection the **reader** may see *Projecting State and Local Population* by Pittenger, **Rallinger** Publishing Company, **Cambridge—Mass** (1976).

3. K- Srinivasan, T. K. Roy, and S. Ghogale, *Family Planning by States for India*, **Vol. II**, **IIPS**, 1980.

into consideration the 1981 census and recent Sample Registration Scheme's data.

Component method requires specification of the changes in the future years for each component, namely, fertility, mortality and migration. This is a difficult task, and the result is that the projected populations rarely agree with the actual populations when the corresponding census counts become available.

In this paper we present a simple mathematical procedure for population projection which virtually requires no demographic inputs. Brief outline of the procedure and the basic material required to get the estimated population in each census starting from the year 1981 is as follows.

The Procedure for the Population Projection

We define a parameter $R(i)$ which tend to unity as time, measured by "i", increases as follows:

$$R(i) = \frac{\text{Cumulated population upto the census "i"}}{\text{Cumulated population upto the census "(i-1)"}} \quad (1)$$

The parameter $R(i)$ can be easily computed for the country or any sub-group if the census counts from the earlier censuses are available.

Next, we define another parameter Est. $R(i)$ as follows:

$$\text{Est. } R(i) = 2 - \frac{1}{R(i-1)} \quad (2)$$

It can be shown that if $R(i) = \text{Est. } R(i)$, then there will be no growth of population between the censuses "(i-1)" and "i". Thus, $[R(i) - \text{Est. } R(i)]$ indicate the departure from zero population growth in the period (i-1) to i.

Now, given the magnitude of $[R(i) - \text{Est. } R(i)]$ in the last census, we can fix two future consecutive decades between which the difference should become zero. For example, let $[R(1981) - \text{Est. } R(1981)]$ be denoted by "a". Let us assume that after fifty years from 1981, that is, in the census 2021 and 2023 "a" will be zero. Further, let us assume that the decline in "a" will be arithmetic. Under these assumptions we have in Table 1, $R(i)$ and expected population for each census as follows:

In Table 1, $P_{71} =$ cumulated population upto 1971, $P_{81} =$ cumulated population upto 1981 etc. And $\bar{R}_i = [-1 + R(i)]$ for $i = 1971, 1981, \dots, 2031$. Further, $R(1981)$, Est. $R(1991)$, "a" and P_{81} are based on observed data, no estimations are involved. The only assumptions needed for projection are: (i) the year by which "a" will be equal to zero, and (ii) the decadal pattern in the decline in "a". Linear or curvilinear declines are usually assumed. In this paper we have assumed linear decline, for which or against which there is no data based evidence.

Table 2 shows the estimated population of each district for the census years 1981 to 2031.

TABLE 1

Year	:	1981	1991	2001	2011	2021	2031
$R(i) - \text{Est. } R(i)$:	a	$a - \frac{a}{5}$	$a - \frac{2a}{5}$	$a - \frac{3a}{5}$	$a - \frac{4a}{5}$	0
$R(i)$:	$R(1981)$	$\left[\begin{array}{c} \text{Est. } R(91) \\ + \\ 4a/5 \end{array} \right]$	$\left[\begin{array}{c} \text{Est. } R(2001) \\ + \\ 3a/5 \end{array} \right]$	$\left[\begin{array}{c} \text{Est. } R(2011) \\ + \\ 2a/5 \end{array} \right]$	$\left[\begin{array}{c} \text{Est. } R(2021) \\ + \\ a/5 \end{array} \right]$	$\text{Est. } R(2031)$
Expected population	:	$P_{71} \bar{R}(81)$	$P_{81} \bar{R}(91)$	$P_{91} \bar{R}(2001)$	$P_{2010} \bar{R}(2011)$	$P_{2011} \bar{R}(2021)$	$P_{2021} \bar{R}(2031)$

TABLE 2—ESTIMATED POPULATION OF THE DISTRICTS OF
ANDHRA PRADESH

<i>District</i>	<i>1981</i>	<i>1991</i>	<i>2001</i>	<i>2011</i>	<i>2021</i>	<i>2031</i>
1. Srikakulam	1,943,749	2,102,685	2,242,024	2,349,187	2,410,258	2,410,258
2. Vijayanagaram	1,802,947	2,002,305	2,177,803	2,313,790	2,313,530	2,313,530
3. Vishakapatnam	2,563,438	3,077,527	3,552,472	3,937,888	4,168,738	4,168,738
4. E. Godavari	3,700,084	4,292,151	4,852,061	5,263,971	5,519,127	5,519,127
5. W. Godavari	2,865,786	3,345,251	3,786,066	4,141,243	4,352,329	4,352,329
6. Krishna	3,050,485	3,601,582	4,114,417	4,532,094	4,782,673	4,782,673
7. Guntur	3,451,343	4,043,991	4,589,512	5,029,636	5,291,585	5,291,585
8. Prakasam	2,302,014	2,666,452	2,995,376	3,256,294	3,409,384	3,409,384
9. Nellore	2,004,914	2,367,415	2,697,031	2,960,630	3,116,499	3,116,499
10. Chittoor	2,729,174	3,173,884	3,578,411	3,901,456	4,092,068	4,092,068
11. Cuddapah	1,917,736	2,244,397	2,540,754	2,777,087	2,916,437	2,916,437
12. Anantpur	2,545,850	2,963,335	3,345,258	3,651,658	3,833,122	3,833,122
13. Kurnool	2,382,501	2,770,809	3,126,045	3,411,011	3,579,758	3,579,758
14. Mahbubnagar	2,456,110	3,125,401	3,757,962	4,284,351	4,607,218	4,607,218
15. Rangareddy	1,567,304	2,048,158	2,523,897	2,935,611	3,196,458	3,196,458
16. Hyderabad	2,279,387	2,905,252	3,520,803	4,049,270	4,381,420	4,381,420
17. Medak	1,805,404	2,132,004	2,430,629	2,670,588	2,812,859	2,812,859
18. Nizamabad	1,673,375	2,032,744	2,370,474	2,648,650	2,817,360	2,817,360
19. Adilabad	1,626,688	1,963,447	2,279,007	2,538,124	2,694,825	2,694,825
20. Karimnagar	2,433,399	2,891,819	3,314,251	3,655,940	3,859,915	3,859,915
21. Warangal	2,297,699	2,718,333	3,108,606	3,425,812	3,615,837	3,615,837
22. Khammam	1,739,515	2,118,604	2,483,495	2,787,251	2,974,525	2,974,525
23. Nalgonda	2,264,736	2,700,123	3,102,126	3,427,927	3,622,762	3,622,762
Andhra Pradesh	53,403,627	63,213,656	72,247,483	79,547,530	83,900,521	83,900,521

In this approach, projection is done independently for each district and the state. So for the years 1991 to 2031 the district population total may not agree with the corresponding year's state population. For example, sum of the district populations in 2021 is 84,368,687 whereas the estimated state population is 83,900,521. Pro-rata adjustments can be made, if necessary.

Results and Discussions

We define an indicator $[R(i) - \text{Est. } R(i)]$ which estimates the extent of departure from zero population growth in the intercensal period $(i - 1)$ to i . Table 3 shows the indicator for Andhra Pradesh between 1911-1921 and 1971-1981.

TABLE 3—DEPARTURE FROM ZERO POPULATION GROWTH IN EACH PERIOD

	1921	1931	1941	1951	1961	1971	1981
$[R(i) - \text{Est. } R(i)]$	-.000662	.044938	.035821	.033731	.033682	.041652	.044200

Mean $[R(i) - \text{Est. } R(i)]$ from 1921 to 1981 = .033337.

Standard deviation of $[R(i) - \text{Est. } R(i)]$ from 1921 to 1981 = .015727.

From Table 3 it can be seen that there was a decline of population between the censuses 1911 and 1921. The gain in the population growth was remarkable in the period 1921 to 1931. For the next 30 years, that is, upto 1951, the growth was fairly stable and positive and the growth between 1971-1981 was again high. The national plan objective is to reach zero growth as soon as possible. The NRR projection by Srinivasan *et al.*³ assumes that NRR will be unity by the year 2001, and zero growth will be attained subsequently. Bourgeois Pichat and Taleb⁴, in a very interesting paper, have shown that it will take about 30 more years to reach zero population growth after NRR becomes equal to unity. Taking that as guidance it has been assumed that between the censuses 2021 and 2031 the growth will be zero. In other words, between 2021 and 2031, $[R(i) - \text{Est. } R(i)]$ will become zero. Further, if we assume that the fall in $[R(i) - \text{Est. } R(i)]$ will be linear, then we get the estimated populations as shown in Table 4.

The estimated population in 1991, namely, 63,213,656 (from Table 4, row no. 3) differs from that estimated by Srinivasan *et al.*, at 60,305,335, by about 4.8 per cent. When the latter figure is adjusted on the basis of 1981 census count, the difference will be still smaller. This is a very interesting situation.

3. *op. cit.*, p. 2.

4. Pichat J Bourgeois and A. Taleb, "Zero Population Growth for Developing Countries in the Year 2000", *Population-5*, 1970.

TABLE 4—FUTURE POPULATION OF ANDHRA PRADESH

	1981	1991	2001	2011	2021	2031
[R—Est. R]	.0442*	.03536	.02652	.01768	.00884	0
R	1.23838*	1.227853	1.212090	1.192659	1.170377	1.145575
Estimated Population	53,403,820*	63,213,656	72,247,483	79,547,530	83,900,521	83,900,521

*The entries are **census** based and not estimates.

The two methods of projection have nothing in common, yet the estimated populations do not differ much. Similar tests were made for a few other States also. In each case the estimated population through this simple procedure was close to the projected populations on the basis of Linear change in NRR. It will be shown in the text that estimated couple protection rates also agree with those required for the NRR projection. It, therefore, appears that the quality of the projection is not poor.

Now, let us examine its feasibility and the implications. From the point of feasibility, it appears, that it may be difficult to attain such a pronounced decline due to the following two reasons ;

(i) In terms of the standard deviation (.015727, given in Table 3) the decadal rate of decline in $[R(i) - \text{Est. } R(i)]$, at .00884 per decade is equivalent to a decline of 0.56209. From probability point of view this amount of decrease in $[R(i) - \text{Est. } R(i)]$ or higher decline has a chance of less than 30 per cent. It therefore, appears that the chance of having higher $R(1991)$, and therefore, higher population than that given in Table 4, row 3 in 1991 is more than 70 per cent,

(ii) Corresponding to a population of 63,213,656 in 1991, the annual geometric growth between 1981-1991 will be 17.01 per 1000 population, whereas the corresponding growth in 1971-81 was 20.71 per 1000. Thus, between the two decades the average annual decline in the growth rate should be by 3.7 points per 1000 population. To achieve this, the birth rate will have to decline by a little more than 3.7 points in the decades 1971-81 and 1981-91. Reduction in birth rate is achieved mainly through birth control. For India as a whole, the females in 15-49 formed 23.034 per cent of the total population in 1981. For Andhra Pradesh, the same percentage should be a little higher. So, in terms of couple protection requirement, to achieve a population of 63,213,656 in 1991, additional percentage of women to be protected between 1981 and 1991 will be marginally smaller than $(3.7/0.23034)$ or 16.06 per cent. In the NRR projection the protection rate in 1980-81 was about 29 per cent, thus the couple protection rate in 1990-1991 will be a little lower than $(29 + 16)$ or 45 per cent.

**TABLE 5-FUTURE POPULATION OF SOME OF THE DISTRICT OF
ANDHRA PRADESH**

	1981	1991	2001	2077	2021	2031
<i>Srtkakulam</i>						
<i>R - Est. R</i>	.01593	.012744	.009558	.006372	.003186	0
<i>R</i>		1,168,554	1,153,800	1,139,670	1,125,739	1,111,695
Estimated popn.		2,102,685	2,242,024	2,349,187	2,410,258	2,410,258
<i>Vijayanagaram</i>						
<i>R - Est. R</i>	.02163	.017304	.012978	.008652	.004326	0
<i>R</i>		1,173,804	1,161,047	1,147,306	1,128,434	1,113,816
Estimated popn.		2,002,305	2,177,803	2,312,790	2,313,530	2,313,530
<i>Vishakapatnam</i>						
<i>R - Est. R</i>	.04841	.038728	.029046	.019364	.009682	0
<i>R</i>		1,231,848	1,217,258	1,197,845	1,174,850	1,148,827
Estimated popn.		3,077,527	3,552,479	3,937,888	4,168,738	4,168,738
<i>E. Godavari</i>						
<i>R - Est. R</i>	.03723	.029784	.022338	.014892	.007446	0
<i>R</i>		1,215,924	1,199,918	1,181,502	1,161,066	1,138,722
Estimated popn.		4,292,151	4,832,061	5,263,971	5,519,127	6,519,127
<i>W. Godavari</i>						
<i>R - Est. R</i>	.04047	.032376	.024282	.016188	.008094	0
<i>R</i>		1,225,896	1,208,552	1,188,752	1,166,875	1,143,010
Estimated popn.		3,345,251	3,786,066	4,141,243	4,352,329	4,352,323
<i>Hyderabad</i>						
<i>R - Est. R</i>	.08386	.067088	.050316	.033544	.016772	0
<i>R</i>		1,311,438	1,287,794	1,257,022	1,221,241	1,181,161
Estimated popn.		2,905,252	3,520,803	4,049,270	4,381,420	4,381,420

This again, is close to the estimated requirement of couple protection by 1991 at 45.79 per cent worked out by Srinivasan *et al.*⁵ An increase of couple protection by about 16 points in the 10 years 1981-91, though not impossible, is difficult to achieve through a sterilization programme alone.

If the objective is to reach zero population growth in the decade 2021-2031, the couple protection rate will have to increase by 14.2 percentage point in each of the decades covering 1981 to 2031.

From (i) and (ii) discussed above, it appears that the goal of reaching $NRR = 1$ and zero population growth by the year 2031 is not easy but certainly not impossible to achieve.

Let us now examine the likely population in some of the districts of Andhra Pradesh. Table 5 presents the estimated figures. Table 2 provides estimated populations for all the districts of Andhra Pradesh.

From Table 5, it appears that the task of reaching zero population growth by 2031 is relatively easy for the Srikakulam district because $[R(1981) - Est. R(1981)]$ is already small (.01593) and further reducing it to zero by 2031, may not be difficult. There must be several other districts in the State (which had 23 districts on 1981 census date) where the indicator was small in 1981, for example $[R(1981) - Est. R(1981)]$ had the values .02163, .03723, .03475, .03728, .03814, .03870 and .03850 in the seven districts — Vijayanagaram, East Godavari, Prakasam, Chittoor, Cuddapah, Anantpur and Kurnool respectively. In these areas decline to zero value by the year 2031 should not pose serious problems. The highest value of $[R(1981) - Est. R(1981)]$ was for the district Rangareddy and the next high value of .08385 was for Hyderabad. The districts Mahbubnagar, Nizamabad, and Khammam had values .06964, .05592 and .06260 respectively. In these districts the decline to zero $[R(2031) - Est. R(2031)]$ may be difficult to achieve. For example, for Hyderabad the decadal growth has to be brought down from 1.350113 to 1.274576 between 1971-81 and 1981-91. For this type of decline in the population growth, the rate of increase in the couple protection will be high. There will be some moderation in the required rate of increase of couple protection between 1981 and 2031 due to decline in the rate of in-migration to Hyderabad city. For Hyderabad, the likely population in 2031 will be 4,381,420 or 2,102,033 more than the enumerated population of 2,279,387 in 1981. In the same period, the population of the State will go up by nearly 30 million persons. The task of achieving planned population growth may be difficult but does not appear to be impossible.

5. *OP cit.*, p. 2, col- 14.