S. Guha Roy

Population Estimates for India

INDIA, with a current population of over 700 million, ranks second in the world in population size. Even with moderate growth rate of around two percent, this large population base has immense population potential.

The importance of the knowledge of population trends for national planning and development is well known. Several attempts have been made to project the population of India with a view to formulating and implementing population policies and programmes. These estimates vary widely and refining operations continue.

In India, the major sources of demographic data, are the population censuses, the civil registration system, national sample surveys and sample registration scheme. Though the censuses and vital registration in the country extend over a full century, they remain severely defective. These sources provide raw demographic data like ore that will have to be worked over to extract the metal and get rid of the slag (Henry, 1972). On the other hand, the crude population statistics need intensive tests, like pathological or clinical treatment, for their proper evaluation.

Based on historical trends and current estimates, we made a short-run demographic projection for India. This is done for two reasons. In the first place, the working hypotheses for future trends are less likely to be fallible if the future estimates are made within the 'focal length' of the base data. A population estimate, longer-run in its perspectives, is merely academic, because a country's future demographic profile is dependent upon unpredictable factors and innovations affecting prospective trends in the components of growth. Secondly, a short-run projection syncronizing with a short term development planning, such as five-year plans adopted by India, is more illuminating than projection for a distant future. Moreover, a short-run projection of population provides a general framework for further projection at a later date when demographically relevant more information is available.

For our present purpose, the administrative divisions as existed at Census 1971 were adopted. The take-off point of the projection was 1st March, 1971. The state level estimates of population were also made to get disaggregated estimates as well as the sectorial growth patterns of the country. The usual graduation methods of adjustment of the base population at Census 1971 being unsatisfactory, we evolved a mathematical model to generate an approximately corrected age structure and estimated the 1971,1981 and 1986 population under consistent sets of estimated values of the components of growth. The estimates could be improved by iteration and the algebra underlying the techniques, developed and made more precise. But we were of the view that our practical approach to the problem and the final approximations we arrived at were good enough for the purpose in hand.

Components of Growth

The population of India may be taken as virtually closed but this is not true of the constituent states. For an understanding of the population dynamics of the country as a whole we would look only to fertility and mortality components. India has a long history of civil registration system, but it continued to be severely defective so that no firm estimates of vital rates from this source could be made. Several household surveys on the national scale have been undertaken by the National Sample Survey (NSS) Organisation to bridge the information gap on the components of growth. Because of gross underestimation due to large ascertainment errors, little substantive use could be made of the NSS vital statistics. The average decadal vital rates obtained from the age distribution of the population censuses are also not altogether acceptable because of the serious nature of age distortions.

The Sample Registration Scheme (SRS) initiated by Registrar General's Office in 1965 is believed to be the best available estimates of vital rates to date. The process combines the advantages of longitudinal registration and periodic retrospective sample surveys. Continuous recording of events is maintained by resident enumerators to be compared with the results of independent surveys conducted at regular intervals with a short reference period. An application of a simplified Chandrasekhar-Deming formula (Chandrasekhar and Deming, 1949) for estimation is made on the assumption that events missed and spurious reports by both the enumerations are insignificant. While the estimates provided by this scheme are as good as in any other closely supervised survey, the technique used is biased. The final estimates depend on the characteristics selected as criteria for matching, and residual uncertainty is associated with the matching procedure (Das Gupta and Guha Roy, 1976). These difficulties in utilizing the method are apparent in the underestimation of the SRS birth and death rates.

We, however, decided to accept the vital rate estimates of the Sample Registration Scheme as the first approximation for subsequent improvement. The birth and death rates estimated from the SRS are 36.9 and 14.9 respectively in 1971. Gross underenumeration is indicated and consistency criteria arc used to improve the estimates.

It is known that, rates of growth, during this century, though varying from year to year, had remained relatively steady at a low level for a major part and then started accelerating. For an independent estimate of growth of population of India, a quadratic exponential is fitted to the reported census populations of 1951, 1961 and 1971. Base (1971) population P(0) is subjected exponentially to a linear compound of a long-run constant growth » and acceleration parameter f is used to get *P(t),* the population in the tth year. In other words,

$$P(t) = P(0) \exp (ut + ft^2)$$

The fit can be made exact by using two equations for two unknowns. In fact, only two equations can be derived, namely,

$$P(1951) = P(1971) \exp (u (-20.083) + f (403.3269))$$

and

$$P(1961) = P(1971) \exp (u (-10.083) + f (101.6669))$$

taking into account that the reference dates for the 1951 and 1961 censuses are the same (March 1), while that of the 1971 census was April, 1. Therefore, there is only one solution for the value of u and f and, hence, the fitted values are identical with the observed ones. The current rate of population increase is given by

$$g = \frac{d}{dt} (ut + ft^2),$$

t being measured in years from the 1971 census available for curve fitting. Annual net migration being assumed insignificant, the above derivative need not be adjusted on this account to get the natural population growth rate. The theoretical curve was intended to describe the trends around 1971; generally it will not be valid in the long run.

With $P(1951) = 361$, $P(1961) = 439$ and $P(1971) = 548$, the resulting curve is

$$P(t) = P(1971) \exp (0.023211t + 0.00012095\, t^2).$$

It yields a plausible growth rate of 23.2 per 1,000 in 1971.

Going by the SRS records on birth (6) and death rates *(d),* we have

$$\frac{b}{r_b} - \frac{d}{r_d} = g$$

or

$$\frac{36.9}{r_b} - \frac{14.9}{r_d} = 23.2,$$

where r_b and r_d denote completeness of birth and death registration respectively. To get consistent solutions of reported vital rates from the above single equation, we used the birth rate of 41.0 per 1,000 around 1971. This estimate was obtained by reverse survival technique from the base 0-4 population (1971), adjusted by a transitional age structure model developed later. We used the United Nations Model Life Table at level 55 corresponding to prevalent value of about $_0e_0$ = 47.5 years. Our estimate of birth rate agrees with that given in the Acturial Reports, Census of India, which used the same technique of estimation after adjustment for under-enumeration of young children. We would not repeat the review of the previous estimates but refer to Robert Cassen and Tim Dyson (1976) who examined in detail the base line assumptions on fertility in previous projections for India (Ambannavar, 1975; Frejka, 1973; Government of India, 1974; Operations Research Group, undated; Raghavachari, 1974; Zachariah and Cuca, 1972) and concluded that the initial level assumed in the projections (crude birth rate ranges from 38.6-40.4 during 1965-71) was low. Pooling various estimates, he assumed that the crude birth rate for the period 1966-71 was in the region of 42. Our estimate of 41 lies in between those of previous projections and Cassen-Dyson.

The completeness of birth reporting thus turns out to be 90 percent, which when substituted in the above equation yields a value of 85 per cent for completeness of death reporting. This gives a value of 17.8 per 1,000 for the death rate in 1971. One interesting point is that like some other cultures, deaths appear to be less completely reported than births in the registration system. There are irregular fluctuations in the level of reporting of the Sample Registration Scheme (SRS). It is known that SRS improved markedly in 1972 probably because a fertility survey was carried out simultaneously with the SRS operations and a more careful supervision was instituted. We may, therefore, stipulate an improved completeness of reporting of 95 per cent (cf. Registrar General, 1974) during 1972-75. However, due to budget cuts in later years, the high quality achieved during this period was probably not maintained in recent years.

Adding back the estimated amount of under-enumeration, the estimated birth rates for the years 1971,1972 and 1975 are :

	SRS Rates	rb	Rates Adjusted by r_b
1971	36.9	0.90	41.0
1972	36.6	0.95	38.5
1975	35.2	0.95	37.1

The following birth rates for India as estimated by different international agencies for the period around 1975 compare well with our estimate (Kirk, 1979) :

UN	*US Census Bureau*	*AID*	*World Bank*	*Population Council*	*Population Reference Bureau*	*Environmental Fund*	*World Watch*
36	36-37	35	36	36	34	40	36

There are clear indications that the birth rate, assumed to be invariant so far, had begun declining after 1971. The experience of the SRS confirmed such a trend for the period 1971-75. A negative exponential was fitted to the time series of adjusted birth rates in 1971, 1972 and 1975. Thus we have

$$b(t) = 4(0) \exp(-\beta t)$$

or

$$b(t) = 41{,}0 \exp(-0.012213t)$$

Continuing this trend, birth rates during the quinquennia 1971-75, 1976-80 and 1981-85 were respectively 40.1, 37.7 and 35.5 as compared to the corresponding figures of 39.4, 37.5 and 36.0 estimated in *F1M1* projection of Cassen and Dyson (1976). Because of the presence of contraceptors in the population, these rates fall short of natural fertility. As there was a short-fall of young adult females during the period, given the lower proportions observed in the ages 15-24 at the Census 1971, the birth rate would have been lower in any case.

Our next task is to split the births by sex. The sex ratio of the Indian population is biased towards males. The averse sex ratio seems to be the result of a higher female mortality due to neglect of females after birth (Registrar General and Census Commissioner, India, 1974). In the absence of any significant migration either way, sex differential in mortality is the only major factor in the imbalance in sex ratio. The SRS provided nearly a comprehensive and representative record of births and showed a high sex ratio at birth of 108 in 1960-69. Considering greater omission in counting of females compared with males in the social setting now obtaining in India, we, however, accepted a value of 107 for our purpose. The high sex ratio at birth was consistent with the adjusted population base of 1971 adopted for the forward estimates. Since the sex ratio at birth is a 'biological constant' which only meanders within a narrow margin of tolerance over time, we have assumed a constant value of 107 for the purpose of our short-term estimates.

In obtaining consistent solutions of vital rates, we have seen that the death rates estimated in the SRS were lower to the extent of 16 per cent. On the other hand, the technique of estimating contemporary level of mortality from survival ratios yielded by longitudinal comparison of age cohorts across census populations at 1961 and 1971, did not work owing to gross age reporting errors and biases. Estimating the level of mortality through the technique of age distribution of deaths would not similarly apply to the general population due to overstatement of age in the late and old age ranges and severe deficiency of the regular vital registration system.

We, therefore, used the United Nations model set of life tables at various levels (United Nations, 1956). We did not adhere formally to any particular level at all age groups but switched across the levels to give effect to the recent specific age pattern of mortality of India; it should be obvious that no specific mortality experience can be expected to cling to the very heterogenous averages of the model life tables.

The pooled age specific death rates in the SRS for 1970-72 period, centered on 1971, were adjusted to the consistent death rate of 17.8. In terms of life expectancy (for both sexes combined) this corresponds to 47.5 years (and UN level of 55), in our mortality base-assumption. This estimate is consistent with those of Cassen and Dyson (1976) who took male life expectation at 48 years, and the females, at 46 years. Though it is not expected that the death rate would go back to its earlier higher levels, the deceleration in mortality decline is nevertheless evident. Marvel of modern medicine helped decline sharply the death rate during last decades, but lack of improvement in nutritional level had arrested further decline in mortality, which tended to reach a plateau. We, therefore, assumed that the 1971 mortality as obtained above would prevail during the period 1971-75 and decline under normal conditions at half the rate assumed in the set of UN model tables, that is, by about two and a half levels during each quinquennium of 1976-80 and 1981-85- As the public health programme in the country is still at a low ebb, particularly in the major rural sector, this assumption about mortality trend seems plausible. The estimated age specific mortality as of 1971 and the pertinent survival factors corresponding to the projected mortality periods, given by UN model levels, are shown in Table 1.

Age Structure and Estimates of the Future

During the last decade, India did not experience any serious natural and man-made calamities that could disturb the demographic development of her large population. As in other countries of the subcontinent, census enumeration were,

TABLE 1(a)-AGE SPECIFIC DEATH RATES FOR 1971 (SRS AVERAGE 1970-72) AND ESTIMATED UN MODEL LEVELS (UNL) ALONG WITH THE SURVIVAL RATIOS

Males

Age (x)	*Mortality Experience for 1971*		*Survival Kates for the Quinquennia*			mX10 *for 1961*
	mx x 10[3]	*UNL*	*1971-75*	*1976-80*	*1981-85*	
0	133.0	69	0.8674	0.8755	0.8842	118.3
0- 4	52.6	55	0.9369	0.9407	0.9445	48.3
5- 9	4.8	53	0.9*01	0.9813	0.9825	4.3
10-14	2.0	71	0.9870	0.9879	0.9887	1.8
15-19	2.3	83	0.9862	09873	0.9884	2.0
20-24	3.0	85	0.9S47	0.9860	0.987	2.6
25-29	3.3	84		0.9848	0.9861	2.8
30-34	4.1	79	0.9786	0,9801	0.9816	3.6
35-39	5,3	74	0.9703	0.9722	0.9739	4.8
40-44	8.2	66	0.9533	0.9559	0.9583	7.4
45-49	11.7	63	0.9333	0.9365	0.9395	10.7
50-54	18.8	54	0.8947	0.89S9	0.9029	17.6
55-59	26.2	53	0.8547	0.8596	0,8642	24.7
60-64	41.2	46	0.7823	0.7886	0.7947	33.8
65-69	56.9	49	0.7087	0.7155	0.7220	54.1
70-74	83.4	50*	0.6054	0.6124	0.6194	80.0
75-79	122.9	50*	0.4757	0.4830	0.4903	118.2
80-84	182.5	50*	0.2768	0.2823	0.2878	176.1
S5+	284.1	50*				278.0

*Estimated in order to obtain a consistent series,

TABLE 1(b)-AGE SPECIFIC DEATH **RATES FOR** 1971 (SRS **AVERAGE** 1970-72) AND ESTIMATED UN MODEL LEVELS (UNL) ALONG WITH THE SURVIVAL RATIOS

Females

Age (X)	*Mortality Experience for 1971*		*Survival Rates for the Quinquennia*			m_x, X10^3 for 1981
	m_x x 10^3	*UNL*	*2971-75*	*1976-80*	*1981-85*	
0	137.0	60	O.S594	0.8666	0.8739	124.7
0-4	59.2	45	0.9209	0.9254	0.9300	54.0
5- 9	5.3	50	0.9773	0.9787	0.9801	4-7
10-14	2.4	67	0.9852	0.9863	0.9873	2.1
15-19	3.4	69	0.9803	0.9818	0.9832	3.0
20-24	4.2	71	0.9778	0.9796	0.9813	3.8
25-29	4.8	70	0.9756	0.9774	0,9792	4.2
30-34	5.6	67	0.9716	0.9735	0.9754	4.9
35-39	5.9	67	0.9685	0.9706	0.9726	5.3
40-44	6.8	67	0.9624	0.9646	0.9666	6.1
45-49	9.4	63	0,9471	0.9498	0.9523	8.6
50-54	15.2	53	0.9146	0.9185	0.9222	14.1
55-59	20.2	54	0.8839	0.8883	0.8929	18.8
60-64	36.0	43	0.8049	0.8117	0.8180	33.4
65-69	49.3	47	0.7357	0.7429	0.7496	46.2
70-74	76.4	47*	0.6261	0.6342	0.6419	72.0
75-79	116.8	47*	0.4936	0.5023	0.5130	111.0
80-84	173.8	47*	0.2902	0.2966	0.3027	166.0
85+	276.8	47*				269.5

*Estimated in order to obtain a consistent series.

however, deficient; there were undercounts of infants and females and misstatements of age. Our purpose here is not to discuss the well-known nature of errors and biases in reporting ages, which are embedded in the culture, but we proceed to adjust the base population of 1971 census for irregularities in age distribution.

The usual general purpose graduation methods of wave cutting and running averages do smooth the reported age distribution but have little validity particularly in reported age ranges where undercount or large under or over statement of ages have occurred. "Mechanical smoothing processes work well only when deficits and excesses in persons reporting each age are balanced over fairly short intervals. When, as in the present instance, there are large displacements of reported age, disproportionate omissions or improper inclusions of persons in broad age groups, mechanical smoothing will yield an age distribution still strongly affected by the original errors". (Coalc and Hoover, 1959). To construct an approximate age structure, the theory of stable populations is often applied. But the use of stable models is not appropriate to India under transition of mortality (Das Gupta, *et al,* 1965).

In the situation prevailing in India, an approximate population model was evolved to generate corrected age structure consistent with the probable trend of mortality and the observed growth rates at successive censuses. The UN model mortality set before modification to conform to local pattern was used for convenience in view of the broad approximation involved.

The model supposes the growth survivor relationship between the successive ages of a closed population formation; fertility was assumed broadly invariant till 1971. The essence of the model is that suitably chosen stationary population (tL_x) is given the stimulus of actual growth (g) and survivorship (tp_x) to evolve an age structure to be fitted to the reported census population.

The Mathematical Model in Discrete Form

We consider a population which has been (i) closed to migration; (ii) growing at a constant decadal rate *g,* and (iii) whose mortality, as described by a life table, is subject to change over a quinquennium (e.g., 1966-70, 1961-65) or a decade (e.g., 1951-60, 1941-50, etc.). The fertility was assumed to have been broadly constant upto 1971.

Evidently the population under 5 at the end of 1970 will be survivors of the birth cohort of 1966-70, the 5-9 years olds will be the survivors of the births in 1961-65 and so on. Thus to find the size of the population in each age group requires (i) the calculation of the birth cohorts preceding 1971 and (ii) the calculation of the survivors at the end of 1970.

The input data used for this model are the average population growth rates (g_i), known at discrete intervals, and were taken from censuses. The values of

g were computed as:

$$g = \exp[(\ln P_2 - \ln P_1)/t] - 1$$

where P_2 is the population enumerated at the end of the period, P_1 that at the beginning and t is the length of the intercensal period (e.g., t =10.083 for 1961-71). These values arc shown as follows :

1961-71	*1951-61*	*1931-51*	*1921-31*	*1911-21*	*1901-11*	*Pre-1901*
22.2	19.8	13.0	10.6	—0.4	5.7	2.1
g_6	g_5	g_4	g_3	g_2	g_1	g_0

A single value for the growth rate during 1931-51 was taken as it changed only slightly in this period. The decade 1911-21 experienced severe epidemics resulting in a negative growth.

The mortality patterns for the different periods were described by United Nations Model Life Tables, and the levels (UNL) broadly considered (Ministry of Health and Family Planning, 1972-73) were as given below :

	1966-70	*1961-65*	*1951-60*	*1941-50*	*1931-40*	*Pre-1931*
UNL	55	50	45	35	25	10
$^oe_0$	47.5	45.0	42.5	37.5	32.5	25.0

Since in 1968 (mid-year of 1966-70) there were $^{55}_{5}L_0$ population on the average (as per the life table assumed) and since this number was growing at the rate of g_6 (according to census decadal growth rate), we have

(1) Size of the cohort (1966-70) at the end of 1970

$$= {}^{55}_{5}L_0/(1+g_6)^{2.5} = {}^{55}_{5}L_0\, e^{-2.5g_6}$$

Similarly the average size of the birth cohort in 1963 (mid-year of 1961-65) was $^{50}_{5}L_0$ (as per the life table of the previous quinquennium) and this was growing again at the rate of g_6 (the cohort being in the same decade 1961-71), so that (without mortality assumption for the time being)

(2) Size of the cohort (1961-65) at the end of 1970

$$= {}^{50}_{5}L_0/(1+g_6)^{7.5} = {}^{50}_{5}L_0\, e^{-7.5g_6}$$

Again, the average size of the birth cohort (1956-60) in 1958 was $^{45}_{5}L_0$ (according to the life table for the period 1951-60) and this cohort passed through two decades, 1951-61 and 1961-71, with growth rates of g_5 and g_6 respectively. Now, the time difference between 1958 and 1970 is 12.5 years, which should be apportioned between the two decades. After 1958 there were 2.5 years that fell in 1951-61 decade, and 10 years in 1961-71 decade. Thus we get

(3) Size of the cohort (1956-60,1 at the end of 1970

$$= {}^{45}_{5}L_0/(1+g_6)^{10}(1+g_5)^{2.5}$$
$$= {}^{45}_{5}L_0\, e^{-10g_6}\, e^{-2.5g_5}$$

and so on. The population alive at the end of 1970 can be now easily calculated, using appropriate survival factors, $_b$ Thus,

$$\text{Persons at age 0-4} = {}^{55}_{5}L_0 \times e^{-2.5g_6}$$

$$\text{Persons at age 5-9} = {}^{50}_{5}L_0 \times e^{-7.5g_6} \times {}^{55}_{5}p_0$$

$$(\text{where } {}^{55}_{5}p_0 = {}^{55}_{5}L_5/{}^{55}_{5}L_0)$$

$$\text{Persons at age 10-14} = {}^{45}_{5}L_0 \times e^{-10g_6} \times e^{-2.5g_5} \times {}^{50}_{5}p_0 \times {}^{55}_{5}p_5$$

The approximate **age** structure **model** could thus be built up in this **manner.** The model assumes that an estimate of true age structure of **the** population in 1971 may be obtained by **inflating** the $_5L_x$ **values derived** from a series of **model** life tables at different levels according to a few broadly consistent **changes** in growth and mortality. **The complete** presentation for the quinquennial age groups are **given** below ;

0- 4 : ${}^{55}_{5}L_0\,(1+g_6)^{-2.5}$

5- 9 : ${}^{50}_{5}L_0\,(1+g_6)^{-7.5}$

10-14 : ${}^{45}_{5}L_0\,(1+g_6)^{-10}\,(1+g_5)^{-2.5}$

15-19 : ${}^{45}_{5}L_5\,(1+g_6)^{-10}\,(1+g_5)^{-7.5}$

20-24 : ${}^{35}_{5}L_0\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-2.5}$

25-29 : ${}^{35}_{5}L_5\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-7.5}$

30-34 : ${}^{25}_{5}L_0\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-12.5}$

35-39 : ${}^{25}_{5}L_5\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-17.5}$

40-44 : ${}^{10}_{5}L_0\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-2.5}$

45-49 : ${}^{10}_{5}L_5\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-7.5}$

50-54 : ${}^{10}_{5}L_{10}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-2.5}$

55-59 : ${}^{10}_{5}L_{15}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-7.5}$

60-64 : ${}_5^{10}L_{20}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-2.5}$

65-69 : ${}_5^{10}L_{25}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-7.5}$

70-74 : ${}_5^{10}L_{30}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-10}\,(1+g_0)^{-2.5}$

75-79 : ${}_5^{10}L_{35}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-10}\,(1+g_0)^{-7.5}$

80-84 : ${}_5^{10}L_{40}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-10}\,(1+g_0)^{-12.5}$

85+ : ${}_5^{10}L_{45}\,(1+g_6)^{-10}\,(1+g_5)^{-10}\,(1+g_4)^{-20}\,(1+g_3)^{-10}\,(1+g_2)^{-10}\,(1+g_1)^{-10}\,(1+g_0)^{-17.5}$

The population alive at the end of 1971 can be obtained by subjecting the above experiences to the following survival factors (p_x) in corresponding ages :

5- 9 : ${}_5^{55}p_0$

10-14 : ${}_5^{50}p_0 \times {}_5^{55}p_5$

15-19 : ${}_5^{50}p_5 \times {}_5^{55}p_{10}$

20-24 : ${}_5^{45}p_0 \times {}_5^{45}p_5 \times {}_5^{50}p_{10} \times {}_5^{55}p_{15}$

25-29 : ${}_5^{45}p_5 \times {}_5^{45}p_{10} \times {}_5^{50}p_{15} \times {}_5^{55}p_{20}$

30-34 : ${}_5^{35}p_0 \times {}_5^{35}p_5 \times {}_5^{45}p_{10} \times {}_5^{45}p_{15} \times {}_5^{50}p_{20} \times {}_5^{55}p_{25}$

35-39 : ${}_5^{35}p_5 \times {}_5^{35}p_{10} \times {}_5^{45}p_{15} \times {}_5^{45}p_{20} \times {}_5^{50}p_{25} \times {}_5^{55}p_{30}$

40-44 : ${}_5^{25}p_0 \times {}_5^{25}p_5 \times {}_5^{35}p_{10} \times {}_5^{35}p_{15} \times {}_5^{45}p_{20} \times {}_5^{45}p_{25} \times {}_5^{50}p_{30} \times {}_5^{55}p_{35}$

45-49 : ${}_5^{25}p_5 \times {}_5^{25}p_{10} \times {}_5^{35}p_{15} \times {}_5^{35}p_{20} \times {}_5^{45}p_{25} \times {}_5^{45}p_{30} \times {}_5^{50}p_{35} \times {}_5^{55}p_{40}$

50-54 : ${}_5^{25}p_{10} \times {}_5^{25}p_{15} \times {}_5^{35}p_{20} \times {}_5^{35}p_{25} \times {}_5^{45}p_{30} \times {}_5^{45}p_{35} \times {}_5^{50}p_{40} \times {}_5^{55}p_{45}$

55-59 : ${}_5^{25}p_{15} \times {}_5^{25}p_{20} \times {}_5^{35}p_{25} \times {}_5^{35}p_{30} \times {}_5^{45}p_{35} \times {}_5^{45}p_{40} \times {}_5^{50}p_{45} \times {}_5^{55}p_{50}$

60-64 : ${}_5^{25}p_{20} \times {}_5^{25}p_{25} \times {}_5^{35}p_{30} \times {}_5^{35}p_{35} \times {}_5^{45}p_{40} \times {}_5^{45}p_{45} \times {}_5^{50}p_{50} \times {}_5^{55}p_{55}$

65-69 : ${}_5^{25}p_{25} \times {}_5^{25}p_{30} \times {}_5^{35}p_{35} \times {}_5^{35}p_{40} \times {}_5^{45}p_{45} \times {}_5^{45}p_{50} \times {}_5^{50}p_{55} \times {}_5^{55}p_{60}$

70-74 : ${}_5^{25}p_{30} \times {}_5^{25}p_{35} \times {}_5^{35}p_{40} \times {}_5^{35}p_{45} \times {}_5^{45}p_{50} \times {}_5^{45}p_{55} \times {}_5^{50}p_{60} \times {}_5^{55}p_{65}$

75-79 : ${}_5^{25}p_{35} \times {}_5^{25}p_{40} \times {}_5^{35}p_{45} \times {}_5^{35}p_{50} \times {}_5^{45}p_{55} \times {}_5^{45}p_{60} \times {}_5^{50}p_{65} \times {}_5^{55}p_{70}$

80-84 : ${}_5^{25}p_{40} \times {}_5^{25}p_{45} \times {}_5^{35}p_{50} \times {}_5^{35}p_{55} \times {}_5^{45}p_{60} \times {}_5^{45}p_{65} \times {}_5^{50}p_{70} \times {}_5^{55}p_{75}$

85+ : $\frac{{}^{25}T_{55}}{{}^{25}T_{45}} \times \frac{{}^{35}T_{65}}{{}^{35}T_{55}} \times \frac{{}^{45}T_{75}}{{}^{45}T_{65}} \times \frac{{}^{50}T_{80}}{{}^{50}T_{75}} \times \frac{{}^{55}T_{85}}{{}^{55}T_{80}}$

where the life table function T_x is obtained as usual by cumulation of L_x — function starting with L_{85+}.

The age structure model thus developed was fitted to the reported 1971 Census male population. A different procedure had to be used to adjust underenumeration in the initial age group 0-4. The age distribution was adjusted by fitting the model to the reported population aged five and over and then the fitted distribution was extended below those ages by pro-rating. When the male population reported at Census 1971 had been distributed according to the age structure model, the female population suffering from even worse irregularities of reporting, was estimated with reference to the finally adjusted male distribution. For this purpose, smoothed regression functions were derived from the reported male and female populations by age group. A quadratic regression was found appropriate (Das Gupta and Guha Roy, 1976); the ratio of the female population F_x to the male population M_x worked out for census 1971 was as follows :

$$F_x/M_x = 0.94688204 + 0.00025716x - 0.00002835x^2.$$

The finally adjusted male and female base populations at the Census 1971 are shown in Table 2.

The aggregate population at Census 1971 was not adjusted for shifting the reference date from April to the usual census month of March, but to take at least a token account of underenumeration, revealed in 1971 post-enumeration check, the published census total was made to refer to March.

At this stage, we tested the mutual consistency of the adjusted base population and the estimated components of growth (Das Gupta, *et al.*, 1965). Following the usual procedure for the sex-age component projection, the adjusted population thus obtained was survived by five-year intervals to the census anniversary months in 1976, 1981 and 1986, by application of the five-year sex-age specific improving survival factors shown in Table 1. As the period of projection was short and the sex-age structure of the population was changing very slowly, the quinquennial birth rates estimated earlier were applied to the average quinquennial female population aged 15-44 to estimate the emerging births. The average was worked out in the manner as described by Ajit Das Gupta and others (1969). The aggregate births were than split into males and females in accordance with the steady sex ratio at birth established above, and survived in a similar manner.

Adjusted base population of India at Census 1971 and estimated populations in 1981 and 1986 are shown in Table 2. The corresponding estimates of birth, death and growth rates, consistent with the assumptions underlying the projections, are also shown at the base of the same table. The Planning Commission's expert committee on population projection gave a revised estimate of 657.3 million population in 1981 (Ministry of Health and Family Planning, 1972-73).

TABLE 2—ADJUSTED BASE POPULATION OF INDIA AT CENSUS 1971 AND ESTIMATED POPULATIONS (000) IN 1981 AND 1986

Age Group	*Adjusted Base Population 1971*			*Current Estimates 1981*			*1986*		
		Females	*Total*	*Males*	*Females*	*Total*	*Males*	*Females*	*Total*
0- 4	48253	45658	93911	52492	48559	101051	57601	53206	110807
5- 9	39907	37785	77692	47690	43008	9069S	40579	45160	94739
10-14	33856	32026	65882	44363	41151	85514	46855	42152	89007
0-14	122016	115469	237485	144545	132718	277263	154035	140518	294553
15-19	29392	27733	57130	38640	36421	75061	43861	40628	84489
20-24	24788	23301	48089	32992	30978	63970	3S191	35810	74001
25-29	21584	20180	41764	23581	26637	55218	32573	30398	62971
30-34	18085	16791	34876	24038	22269	46307	28184	26083	54267
35-39	15421	14196	29617	20803	19166	39969	23595	21721	45316
40-44	12233	11146	23379	17206	15835	33041	20260	18640	38900
15-44		113352			151306			173280	
45-49	9941	8951	18892	14303	13262	27565	16489	15306	31795
50-54	8435	7492	15927	10921	10188	21109	13438	12629	26067
55-59	7170	6271	13441	8340	7786	16126	9861	9396	19257
15-59	147049	136066	283115	195824	182542	378366	226452	210611	437063
60+	14872	1247S	27350	17280	16008	33288	18933	18230	37163
Total	283937	264013	547950	357649	331268	688917	399420	369359	768779
Birth rate			41.0			36.4			34.2
Death rate			17.8			14.8			13.9
Growth rate			23.2			21.6			20.3

The other projections made by the Office of the Registrar General (1974) estimated (high fertility assumption) 677.5 and 753.6 million populations in 1981 and 1986, compared to our estimates of 688.9 (Census 1981 reports 685.2 million) and 768.8 million respectively. Our aggregate estimates were higher than their projections, because we did not take into account the performance statistics of family planning programmes- The excess margin of our projected population may provide alternative estimates of probable demographic impact of the programme.

Application of the Model to Census 1981

A few results of 1981 census being available, it may be of interest to fit the transitional age structure model to the latest reported population as well. The model was constructed for 1981 under similar assumptions about past paths of growths and mortality rates as for 1971, and the population growth rate for 1971-81 was similarly calculated as 22.8 per cent (designated as g_7); the mortality patterns during 1971-75 and 1976-80 were assumed to be described respectively by UN model life tables of levels 60 and 65. Thus the population ${}_5P_x$ from age x to $x + 5$ at the end of 1980 is given by

$$
\begin{aligned}
{}_5P_0 &= {}^{65}_{5}L_0 \, e^{-2.5g_7} \\
{}_5P_5 &= {}^{60}_{5}L_0 \, e^{-7.5g_7} \, ({}^{65}_{5}L_5/{}^{65}_{5}L_0) \\
{}_5P_{10} &= {}^{65}_{5}L_0 \, e^{-(10g_7+2.5g_6)} \, ({}^{60}_{5}L_5/{}^{60}_{5}L_0) \, ({}^{65}_{5}L_{10}/{}^{65}_{5}L_5)
\end{aligned}
$$

and so on, the symbols having the same significance as mentioned earlier,

The age structure model thus being built up was fitted to the 1981 census population in the same manner as in 1971. Table 3 shows the per cent age distributions of the enumerated population (5 per cent sample) of 1981, the projected 1981 population derived earlier from 1971 adjusted population and the population distribution of the transitional age structure model of 1981. While the model distributions broadly agree, the census distribution shows the usual undercnumeration in the initial age group 0-4.

For deriving a new set of projections for 1986 and 1991 from the adjusted 1981 base, we assumed, as before, that mortality would decline at half the rate considered in the set of UN model tables and birth rates during the quinquennia 1981-85 and 1986-90 would be 35,5 and 33.3 on the basis of the trend implied by a negative exponential fitted earlier. The sex ratio at birth was assumed to be 107 males per 100 females for this short-run projection. The results of projection are shown in Table 4. It appears that, in either the 1971 or 1981 base projections, no important differences in population sizes can be seen, an observation valid also for the population age structure.

As against our present population estimates (taking both bases at 1971 and

TABLE 3—REPORTED, PROTECTED (BASED ON ADJUSTED 1971 CENSUS) AND TRANSITIONAL MODEL AGE STRUCTURES (%) FOR 1981

Age Group	*Reported Census 1981**	*Transitional Model for 1981*** *1971 base*	*1981 base*
0- 4	12.6	14.7	14.9
5- 9	14.1	13.2	13.7
10-14	12.9	12.4	12.2
15-19	9.7	10.9	10.4
20-24	8.6	9.3	8.8
25-29	7.6	8.0	7.7
30-34	6.4	6.7	6.5
35-39	5.8	5.8	5.7
40-44	5.1	4.8	4.8
45-49	4.4	4.0	4.0
50-54	3.8	3.1	3.2
55-59	2.5	2.3	2.5
60+	6.5	4.8	5.6

•Based on unsmoothed age data (5%) for 1981 census (excluding Assam and data for unknown age).

"Includes Assam

Reported population age distribution (%), and transitional model age structure (%) for 1981 : both sexes.

1981) of about 397-399 million males and 369 million females in 1986, the Expert Committee on Population Projection (Cited in Ministry of Health and Family Welfare, 1978-79) estimated 380 million males and 355 million females for the same year. The earlier projections were lower, firstly from an apparent underestimation of base population, and secondly from assumption of too optimistic target of reducing the birth rates to 26.0-29.5 and 21-27 during the quinquennia 1981-85 and 1986-91.

TABLE 4(a)—PROJECTIONS OF 19S6 AND 1991 POPULATIONS FROM THE ADJUSTED BASE POPULATION OF INDIA AT CENSUS 1981

(a) Males

Age Group	*Adjusted Base population, 1981 (000)*	*Survival Rates 1981-85* P_b = .8842	*Survivors, 1986*	*Survival Rates, 1986-90* P_b = .8935	*Survivors, 1991*
0- 4	52902	.9445	58879	.9482	62133
5- 9	48994	.9825	49966	.9836	55829
10-14	43745	.9887	48137	.9895	49147
15-19	37010	.9884	43251	.9895	47632
20-24	31070	.9873	36581	.9886	42797
25-29	27303	,9861	30675	.9874	36164
30-34	23126	.9816	26923	.9830	30288
35-39	20250	,9739	22700	,9756	26465
40-44	16978	.9583	19721	.9544	22146
45-49	14356	.9395	16270	.9424	18822
50-54	11144	.9029	13487	.9068	15333
55-59	8683	.8642	10062	.8687	12230
GO-64	6935	.7947	7504	.8000	8741
65-69	5324	.7220	5511	.7279	6003
70-74	3584	.6194	3844	.6264	4011
75-79	2036	.4903	2220	.4976	2408
80-84	907	.2878	998	.2933	1105
85+	53		261		293
Total	354400		396990		441547

TABLE 4 (b)—PROJECTIONS OF 1986 AND 1991 POPULATIONS FROM THE ADJUSTED BASE POPULATION OF INDIA AT CENSUS 1981

(b) Females

Age Group	Adjusted Base Popl., 1981 (000)	Survival Rates 1981-85	Survivors, 1986	Survival Rates, 1986-90	Survivors, 1991
		P_b = .8739		Pi = .8810	
0- 4	49306	.9300	54386	.9342	57256
5- 9	45428	.9801	45855	.9814	50807
10-14	40417	.9873	44524	.9884	45002
15-19	34199	.9832	39904	.9846	44008
20-24	29120	.9813	33624	.9829	39289
25-29	25198	.9792	28575	.9809	33049
30-34	21337	.9754	24674	.9773	28029
35-39	18643	.9726	20812	.9745	24114
40-44	15715	.9666	18132	.9687	20281
45-49	13216	.9523	15190	.9548	17564
50-54	10477	.9222	12586	.9259	14503
55-59	8295	.8929	9662	.8973	11653
60-64	6802	.8180	7407	.8241	8670
65-69	5395	.7496	5564	.7563	6104
70-74	3820	.6419	4044	.6495	4208
75-79	2267	.5130	2452	.5188	2627
80-84	1079	.5027	1163	.3083	1272
85+	66		327		355
Total	330780		368881		408795

Implications of the Projection

According to our projection, the proportion of the aggregate population below age 15 is expected to decline from 43.3 per cent in 1971 (41.0 per cent in 1981) to 37.7 per cent in 1991. It will be appreciated that under the assumed future course, the moderate fall in fertility makes its effect felt in the pre-adult age range. On the other hand, the proportion of working age (15-59) population will increase by a little over 5 points during the 20 years (1971-79). The proportion of old age (60+) population, which would increase by about 19 million from 1971 to 1991 as per our projection, is likely to follow the same trend mostly due to the decline in fertility. With the changes in the age structure as indicated by the projection, the reproductive stock of the population would increase somewhat. This is the female population aged 15-44 whose proportion in the total population would increase from 20.7 per cent in 1971 to 22,2 per cent in 1991, adding about 75 million females in the reproductive age group over the period.

Another important consideration of the implication of the projection is the child dependency ratio (P_{0-14}/P_{15-59}). This ratio, which was about 84 per cent in 1971 and 77 per cent in 1981, will probably drop to 66 per cent in 1991. While in 1971 one 'worker' had to shoulder the burden of about one dependent (both young and old), in 1991 every four 'workers' will have three dependents to support.

Mathematical Projection of State Populations

The transitional age structure model, successfully applied to the national population, could not be used for the populations of the constituent States of India; the demographic disturbances were apparently too large in some of these States (e.g., Assam) to be cured by this technique. The State populations are not closed like the country as a whole and the magnitude of internal migration was not precisely known. In such a situation, the quadratic exponential growth curves, used earlier for independent estimates of population, were fitted to the reported populations of the States and Union Territories at censuses 1961, 1971 and 1981 (for Assam the official estimate for 1981 was used) and the trends were extrapolated to 1986 and 1991. While the disaggregated State population extrapolations are not acceptable as their population estimates, the extrapolated values were used as relative weights to prorate them to Indian aggregated estimates just made above.

With t measured in years from 1971, the resulting curves for different units were derived as follows :

Males

States/Union Territories	Estimating Equations $P(t) = P(0) \exp(ut + ft^2)$
1. Andhra Pradesh	$22009 \exp(.019907t + .000086t^2)$
2. Assam	$7714 \exp(.029572t + .000124t^2)$
3. Bihar	$28847 \exp(.021582t + .000037t^2)$
4. Gujarat	$13803 \exp(.024841t - .000099t^2)$
5. Haryana	$5377 \exp(.026056t - .000170t^2)$
6. Himachal Pradesh	$1767 \exp(.020130t + .000059t^2)$
7. Jammu and Kashmir	$2459 \exp(.023952t - .000182t^2)$
8. Karnataka	$14972 \exp(.022484t + .000086t^2)$
9. Kerala	$10588 \exp(.020012t - .000339t^2)$
10. Madhya Pradesh	$21455 \exp(.024105t - .000147t^2)$
11. Maharashtra	$26116 \exp(.022931t - .000141t^2)$
12. Orissa	$11041 \exp(.020609t - .000220t^2)$
13. Punjab	$7266 \exp(.019323t + .000044t^2)$
14. Rajasthan	$13485 \exp(.025981t + .000176t^2)$
15. Tamil Nadu	$20828 \exp(.018331t - .000232t^2)$
16. Uttar Pradesh	$47016 \exp(.021008t + .000152t^2)$
17. West Bengal	$23436 \exp(.021341t - .000159t^2)$
18. Other States	$2140 \exp(.030400t - .000056t^2)$
19. Union Territories	$3623 \exp(.038709t - .000045t^2)$

Females

States/Union Territories	*Estimating Equations* $P(t) = P(0) \exp(ut + ft^2)$
1. Andhra Pradesh	$21494 \exp(.019601t + .000100t^2)$
2. Assam	$6911 \exp(.031334t + .000004t^2)$
3. Bihar	$27506 \exp(.019183t + .000209t^2)$
4. Gujarat	$12895 \exp(.024970t - .000028t^2)$
5. Haryana	$4660 \exp(.026584t - .000104t^2)$
6. Himachal Pradesh	$1693 \exp(.021924t + .000028t^2)$
7. Jammu and Kashmir	$2158 \exp(.028107t + .000237t^2)$
8. Karnataka	$14327 \exp(.022692t + .000129t^2)$
9. Kerala	$10759 \exp(.020620t \quad .000223t^2)$
10. Madhya Pradesh	$20199 \exp(.023484t - .000089t^2)$
11. Maharashtra	$24296 \exp(.023105t - .000064t^2)$
12. Orissa	$10904 \exp(.019665t - .000182t^2)$
13. Punjab	$6285 \exp(.021174t + .000101t^2)$
14. Rajasthan	$12281 \exp(.026704* + .000217t^2)$
15. Tamil Nadu	$20371 \exp(.017631t - .000162t^2)$
16. Uttar Pradesh	$41325 \exp(.019762* + .000359t^2)$
17. West Bengal	$20876 \exp(.023192* - .000117t^2)$
18. Other States	$2017 \exp(.029920t + .000015t^2)$
19. Union Territories	$3051 \exp(.038370t + .000047t^2)$

The "Other States" comprise smaller units like Manipur, Meghalaya, Nagaland, Tripura and Sikkim.

The growth rates (Table 5) estimated from the quadratic exponential could be expected to be substantially higher or lower than the actual growth rates in view

TABLE 5-QUADRATIC EXPONENTIAL GROWTH RATES (NOT ADJUSTED FOR MIGRATION) FOR STATES AND UNION TERRITORIES (U. T.)

States/U. T.	Growth Rates(%)					
	Males			Females		
	1981	1986	1991	1981	1986	1991
1. Andhra Pradesh	2.16	2.25	2.33	2.16	2.26	2.36
2. Assam	3.20	3.33	3.45	3,13	3.13	3.13
3. Bihar	2.23	2.27	2.31	2.33	2.54	2.75
4. Gujarat	2.29	2.19	2.09	2.44	2.41	2.39
5. Haryana	2.27	2.10	1.93	2.45	2.35	2.24
6, Himachal Pradesh	2.13	2.19	2.25	2.25	2.28	2.30
7. Jammu and Kashmir	2.03	1.85	1.67	3.28	3.52	3.75
8. Karnataka	2.41	2.50	2.59	2.52	2.6S	2.78
9. Kerala	1.33	0.99	0.65	1.62	1.40	1.17
10. Madhya Pradesh	2.12	1.97	1.82	2.17	2.08	1.99
11. Maharashtra	2.01	1.87	1.73	2.18	2.12	2.06
12. Orissa	1.62	1.40	1.18	1.61	1.42	1.24
13. Punjab	2.02	2.06	2.11	2.32	2.42	2.52
14. Rajasthan	2.95	3.12	3.30	3.10	3.32	3.53
15. Tamil Nadu	1.37	1.14	0.91	1.44	1.28	1.12
16. Uttar Pradesh	2.40	2.55	2.71	2.69	3.05	3.41
17. West Bengal	1 82	1.66	1.50	2,09	1.97	1.85
18. Other States	3.15	2.87	2.82	3.02	3.04	3.05
19. Union Territories	3.78	3.74	3.69	3.93	3.98	4.02
India	1.76	1.60	1.44	1.90	1.82	1.75

*Growth rate = $ut + 2ft$, u being the constant growth and f the acceleration parameter of the net in- or out-migration among the constituent States. These estimates can be varied and migration modules algebraically added to the growth estimates, once reliable internal migration data become available. These growth rates with a very few exceptions, are higher for females than for males. The estimated populations of the States in 1986 and 1991 are shown in Table 6.

TABLE 6—ESTIMATED POPULATION OF THE STATES AND UNION TERRITORIES (U. T.) : 1986 AND 1991

	States/U. T.	*Census 1981 Population (million)*		*Estimated Population (million)*			
				1986		*1991*	
		Males	*Females*	*Males*	*Females*	*Males*	*Females*
1.	Andhra Pradesh	27.11	26.44	30.57	29.14	34.00	32.29
2.	Assam	10.47*	9.43	12.31	11.07	14.57	12.67
3.	Bihar	35.93	33.98	40.49	38.00	45.48	42.52
4.	Gujarat	17.55	16.54	19.85	18.44	22.08	20.44
5.	Haryana	6.91	6.01	7.54	6.64	8.39	7.36
6.	Himachal Pradesh	2.17	2.11	2.38	2.21	2.65	2.45
7.	Jammu and Kashmir	3.17	2.82	3,57	3.32	3.53	4.09
S.	Karnataka	18.92	18.22	21.44	20.66	24.28	22.89
9.	Kerala	12.53	12.92	13.50	13.65	13.69	14.31
10.	Madhya Pradesh	26.89	25.29	30.17	28.04 -	33.12	30.25
11.	Maharashtra	32.41	30.37	36.13	33.57	39.30	36.38
12.	Orissa	13.31	13.06	14.29	14.02	15.45	14.72
13.	Punjab	8.94	7.85	9.93	8.85	11.04	9.81
14.	Rajasthan	17.85	16.41	20.64	19.18	24.28	22.08
15.	Tamil Nadu	24.49	23.92	26.20	25.45	27.38	26.57
16.	Uttar Pradesh	SS.S2	52.04	67.09	59.39	76.39	69-09
17,	West Bengal	28.56	26.07	31.36	28.40	34.00	30.66
18.	Other States	3.04	2.86	3.18	3.32	3.97	3.68
19.	Union Territories	5.32	4.49	6.35	5.53	7.95	6.54
	India	354.40	330.78	396.99		441.55	408.80

*Official estimate (No census could be taken in Assam in 1981).

The shifts in the geographic distribution of the national population result from the effects of the variations in population growth rates. These variations across regions or States occur due to differences in the components of growth, namely, births, deaths and migrations. It, however, takes a longer time period than has been considered here to find any changing distribution of population among the States. Thus Uttar Pradesh, Bihar, Maharashtra, West Bengal, Andhra Pradesh, Madhya Pradesh and Tamil Nadu remain the most populous States of India and maintain a fairly constant share of country's population of about 67.0 per cent in 1971 and 66.0 per cent, 65.8 per cent and 65.6 per cent in 1981, 1986 and 1991 respectively. However, there has been an indication that some population redistribution among the States may take place before the turn of the century, On the basis of the present estimation, Andhra Pradesh and Madhya Pradesh, which have now smaller aggregate population than West Bengal, are likely to exceed Bengal's population around 2001 due to their higher growth rates potential. Similarly, Rajasthan will be more populous State than Karnataka in the next decade if the present trend continues.

The change in the share (per cent) of zonal populations (excluding Union Territories) to total can be seen as follows :

Zone*	1971	1981	1986	1991
South	24.7	24.0	23.6	23.0
West	14.1	14.1	14.1	13.9
Central	23.7	23.8	24,1	24.6
East	25.9	25.8	25.6	25.6
North	10.5	10.8	11.1	11.3

*South : Andhra Pradesh, Karnataka, Kerala, Tamil Nadu
West : Gujarat, Maharashtra
Central : Madhya Pradesb, Uttar Pradesh
East : Assam, Bihar, Orissa, West Bengal, Manipur, Meghalaya, Nagaland, Tripura, Sikkim.
North : Haryana, Punjab, Himachal Pradesh, Rajasthan, Jammu and Kashmir

Regional redistribution of population being a long-run process, the time pattern of shifts of population from one zone to another would not be fully reflected over a short period (1971-91) considered. It is, however, indicated that the South zone will have a steady decline in its share of national population, while the North and Central zones will experience a steady increase in their population share. The East and West zones, after a somewhat static positions initially, show a slow decline in the proportions of the country's population. These changes arc mostly the results of changing rates of natural increase and net migration due mainly to regional differential in economic opportunities.

Acknowledgements

In India, late Professor Ajit Dasgupta was a pioneer in population projections. It is likely, as his research associate, that his thought can be found to permeate this work. Discussions with Robert Ratherford (East-West Population Institute, Hawaii) have been extremely useful. I am also thankful to Prasanta Kumar Swar for assisting me in the typing work.

References

1. Ambannavar, J. P. 1975, *Population,* Delhi Macmillan Co. of India, Chapter 2.
2. Cassen, R. and Dyson, T., 1976, New population projections for India, *Population and Development Review,* 2(1), 101-136.
3. Chandrasekhar, C. and Deming, W. E., 1949, On a method of estimating birth and death rates, and the extent of registration, *Jour. of the Am. Stat. Assn.,* XLIV, 101-115.
4. Coale, A. J. and Hoover, E. M., 1959, *Population Growth and Economic Development in Low-income Countries : A Case Study of India's Prospects,* Bombay, Oxford University Press, p. 343.
5. Dasgupta, A., Chatachanapibel, S., Chalothorn, T. and Siripak, W., 1965, Population perspective of Thailand, *Sankhya,* B27.
6. Dasgupta, A. and Guha Roy, S., 1976, Population estimates for Bangladesh : The use of a specific transitional population model, *Population Studies,* 30(1), 15-33.
7. Dasgupta, A., Hamilton, C., Heath, K. and Ramkay, J., 1969, Trinidad and Tobago 1965-80, Student, Labour Force, Pensioner Estimates, CSO Research Paper 6, Port of Spain.
8. Frejka, T., 1973, *Reference Tables to the Future of Population Growth,* New York, the Population Council.
9. Government of India, 1974, *The Fifth Five Year Plan,* New Delhi, Planning Commission, Chapter 1, pp. 1-2.
10. Henry, L., 1976, *Population : Analysis and Models,* Great Britain, Edward Arnold Ltd.
11. Kirk, D., 1979, World population and birth rates : Agreements and disagreements, *Population and Development Review,* 5(3), 394.
12. Ministry of Health and Family Planning, India, 1972-73, *Year Book.*
13. Operations Research Group, Baroda, Population of India—A Projection 1971-2011, mimeo, undated.
14. Raghavachari, S., 1974, Population projections, 1976-2001. In : A. Bose, P. B. Desai, A. Mitra and J. N. Sharma (eds.), *Population in India's Development 1947-2000,* Delhi, Vikas Publishing House.
15. Registrar General and Census Commissioner, India, 1974, *The Population of India,* Delhi, The Sunlight Printers, pp. 48-51.
16. United Nations, 1956, Methods of population projections by age and sex, *Population Studies,* No. 25, New York.
17. Zachariah, K. C. and Cuca, R., 1972, *Population Projections for Bank Member Countries 1910-2000,* Population and Human Resources Division, Development Economics Department, International Bank for Reconstruction and Development.