NATIONAL PLANNING COUNCIL

POPULATION PROJECTIONS FOR CEYLON, 1956-1981

BY

S. SELVARATNAM, B. A. Hons. (CEYLON)

(Department of Census & Statistics, Colombo)

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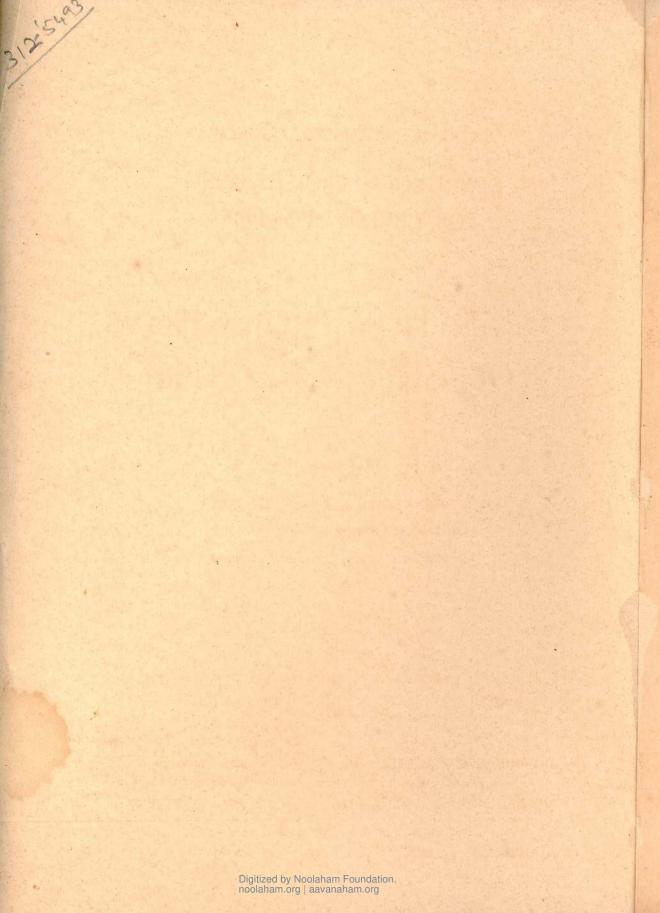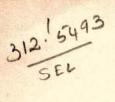(Department of Census & Statistics, Colombo)

FOREWORD

In February 1958, the Demographic Training and Research Centre, Bombay, undertook a study of future population trends in Ceylon at the request of the Planning Secretariat. This decision was the outcome of preliminary discussions with Mr. W. Parker Maudlin of the Research Centre where the broad requirements of the Planning Secretariat were outlined.

Population projections serve a dual purpose in relation to national planning. On the one hand they provide an important part of the data needed for estimating future requirements of several categories of goods and services ; on the other, they serve as a basis for measuring manpower resources. The population projections that have hitherto been available for Ceylon, though themselves of considerable use, do not provide the detail that is desirable for these purposes. The present study thus fills an important gap. On the basis of its estimates a further study, also part of the original request, is now being made by the Demographic Training and Research Centre on workforce projections for Ceylon.
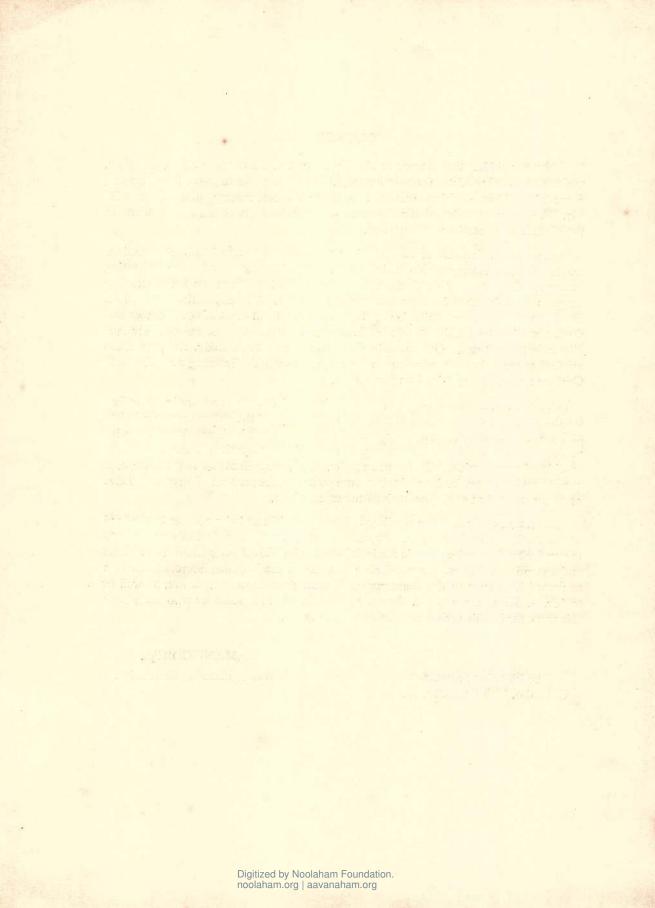
The results that emerge out of the population projections are naturally dependent on the specific assumptions that are made in respect of the future course of birth and death rates as well as other factors. The present work itself provides alternative projections on varying assumptions. Assumptions other than those used here would, of course, yield still different results. This underlines the importance of a regular review of projections of this nature so as to take account of new knowledge or assessments that affect the basis of the calculations.

The present study is being published since its usefulness is by no means confined to the work of this Secretariat. Population projections are in fact of direct use to forward planning and economic analysis in many individual fields in both the public and the private sectors. In publishing this report the Planning Secretariat wishes to record its thanks to the Demographic Training and Research Centre, as well as to Mr. S. Selvaratnam of the Department of Census and Statistics who undertook this work during his period of training at the Centre.

GAMANI COREA,
Director, Planning Secretariat.

The Planning Secretariat,
Colombo, 19th February, 1959.

PREFACE

In February 1958, the Director of the Planning Secretariat in Ceylon, enquired whether the Demographic Training and Research Centre, Bombay, would be willing to undertake a study of the population of Ceylon, which would include population projections for the period, 1956–1981, and an evaluation of the impact of population growth upon the economy of Ceylon, particularly in respect of the size and composition of the working force of the country. The Centre accepted the responsibility for such a project, and it was decided that I, then a United Nations Fellow at the Centre, should work on the study under the supervision of the Centre's staff.

This is the first report on the project and concerns itself with population projections for Ceylon for the period, 1956–1981. Plans for this part of the study were developed under the guidance of Mr. W. Parker Mauldin, Mr. Henry S. Shryock, Jr., United Nations experts at the Centre, and Mr. K. C. Zachariah, Demographer of the Centre. After the departure of Mr. Mauldin and Mr. Shryock, the projections were completed under the guidance of Mr. Zachariah and Mr. R. M. Sundrum, another United Nations expert. Miss Margaret Bright, also a United Nations expert, was very helpful by sketching the outline of the study and by offering comments on the draft of the report. I am deeply indebted to these five persons for the guidance and support received from them in carrying out this part of the work.

I wish also to acknowledge the many valuable suggestions which I received from other members of the staff and two of my research colleagues, Mr. V. R. Rao and Mr. K. S. Gnanasekaran, Indian Fellows at the Centre, and the great assistance I had from Miss A. Thomas and Mr. V. A. Dashpande, members of the technical staff at the Centre.

Finally I wish to thank Dr. K. C. K. E. Raja, Director of the Centre, for having willingly made available to me the necessary facilities for undertaking the project at the Centre and Mr. R. Raja Indra, Statistician, Registrar–General's Office, Colombo, for making available to me the details of his population projections, referred to in the text.

S. SELVARATNAM.

Demographic Training and Research Centre,
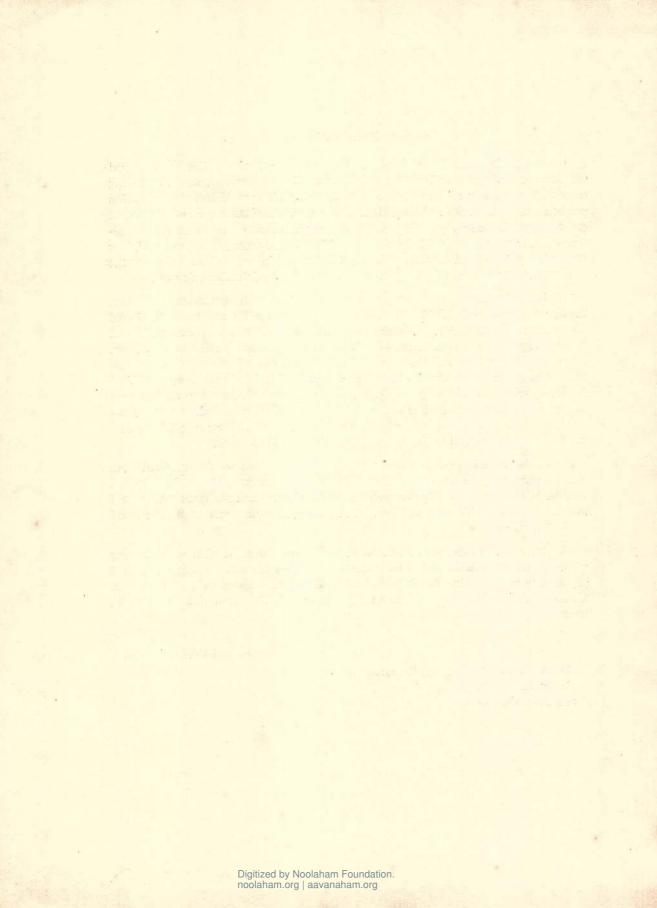Chembur, Bombay 38,
8th December, 1958.

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CHAPTER I

ACCURACY OF THE CENSUS AND REGISTRATION DATA

ONE of the important requirements of a population projection is a fairly accurate base or initial population. This base is usually either the population at the latest census or a recent population estimate. In the case of Ceylon, the last census of population was carried out in March 1953. These figures together with the vital statistics for the subsequent years were used to " build up " the population of the base year, 1956, from which the projections start.

When census data are used to " build up " the base population, these data should be tested for possible inaccuracy in age-reporting and under-enumeration. Necessary adjustments should then be made for incomplete enumeration at particular ages, for mis-statement of age or failure to report age. There are several methods for testing the accuracy of the age-distributions obtained in a census, and only a few of these have been applied in this study.

1. Digit Preference in Age-Reporting

The age distribution for Ceylon recorded at the 1953 census shows heaping at ages ending in certain digits. In order to find out the pattern of digit preference, the number of persons returned at each of the ages ending in 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9, between the ages 13 and 62 (both inclusive) were totalled separately for both males and females and the totals expressed as percentage of the total males and females between the ages 13 and 62 (both inclusive). This method shows the preference of the people not for a particular age but for a particular digit. The results of this test are given in Table 1.

Table 1

DIGIT PREFERENCE IN THE 1953 CENSUS OF CEYLON

Ages ending in	Percentage of Population between ages 13 and 62 with given terminal digits	
	Males	*Females*
0	15·09	17·46
1	5·22	4·57
2	10·34	9·38
3	9·51	8·85
4	8·62	8·38
5	16·14	17·23
6	9·45	9·33
7	7·09	6·77
8	12·56	12·60
9	5·98	5·43
Total	100·00	100·00

It is evident from Table 1 that there is a tendency both among the males and females to state their ages in digits ending in 0, 5, 8 or 2 with the digits 0 and 5 most commonly preferred. This digit preference, therefore, introduces a certain amount of error into the age statistics of the census.

2. Age-Ratio and Sex-Ratio Tests

A method adopted by the United Nations Secretariat for testing the accuracy of the age distributions is to compare the " sex-ratios " and " age-ratios " computed for successive five-year age groups as recorded at the census. The " sex-ratio " is defined as the number of males per 100 females in the same age class. " If the distributions are accurate or if errors for males are as frequent and of the same kind as those for females, sex-ratios will change very gradually from one age to another, as a result of sex differences in mortality and in rates of migration, but cannot very abruptly or fluctuate violently. The presence of marked variations in these age ratios testifies to errors which are not the same for the two sexes ".*

Table 2

SEX-RATIOS (MALES PER 100 FEMALES) IN QUINQUENNIAL AGE GROUPS, CEYLON, 1953

Age Group	Sex ratio	Difference from ratio for preceding group
0–4	101·54	—
5–9	102·64	+ 1·10
10–14	106·58	+ 3·94
15–19	107·37	+ 0·79
20–24	106·14	— 1·23
25–29	109·93	+ 3·79
30–34	121·16	+11·23
35–39	120·00	— 1·16
40–44	130·40	+10·40
45–49	132·96	+ 2·56
50–54	134·75	+ 1·79
55–59	136·73	+ 1·98
60–64	120·82	—15·91
65–69	122·22	+ 1·40
70–74	115·34	— 6·88
75 and over	108·64	— 6·70
All ages	111·48	

Table 2 shows there are marked fluctuations in the sex-ratios at various age groups, suggesting the presence of errors in the age-distributions. The number of males per 100 females increases from 101·54 in the ages 0–4 to 136·73 in the ages 55–59. This variation is much too great to be attributed to sex differentials in mortality or migration but must be explained largely in terms of mis-statement of age.

* United Nations, Population Division, " Accuracy Tests for Census Age Distributions Tabulated in Five-Year and Ten-Year Groups ", *Population Bulletin*, No. 2, October 1952, New York, 1953, p. 60.

The "age-ratio" is defined as the number of persons in one age-group per 100 of the mean of the numbers of the two adjoining age groups. "In general, any considerable fluctuations of the age-ratios indicate inaccuracies in age-reporting or incomplete enumeration. Some real variations in these age ratios may be expected, however, mainly owing to variations in numbers of births in the past or to variations in past rates of migration or in an age distribution of migrants. Variations in age-ratios due to difference in age specific mortality rates can be neglected since almost throughout the entire scale of ages year to year changes in mortality rates are gradual and systematic".*

Table 3 gives the age-ratios for Ceylon computed for five-year age groups, by sex.

Table 3

AGE RATIOS (PERSONS IN EACH AGE GROUP AS PERCENTAGE OF ARITHMETIC MEAN OF TWO ADJACENT AGE GROUPS) FOR MALES AND FEMALES IN QUINQUENNIAL AGE GROUPS, CEYLON, 1953

Age group	Age Ratios	
	Males	Females
0–4	—	—
5–9	101·50	102·54
10–14	103·83	101·78
15–19	83·79	83·01
20–24	107·43	109·97
25–29	109·10	111·11
30–34	86·02	81·04
35–39	117·83	122·66
40–44	83·64	80·25
45–49	114·18	113·56
50–54	99·69	99·30
55–59	89·44	84·78
60–64	98·32	106·67
65–69	99·12	96·48
70–74	73·34	73·62
75 and over	—	—

If ages are reported accurately, the age-ratios should deviate very little from 100, ex cept at very old ages or, as stated earlier, due to sharp fluctuations in past birth ra tes. As is evident from Table 3 the age ratios show marked deviations from 100 in most cases, which reflects errors in the reported age distribution.

A summary measure of the degree of variability shown by the sex and age ratios is derived by computing a 'sex-ratio score' and an 'age-ratio score'. The 'sex-ratio score' is the mean difference between sex ratios for the successive age groups averaged irrespective of sign. The "age-ratio score" is "the mean deviation of the age-ratio from 100 per cent. irrespective of sign". With these two

* Ibid., p. 60.

scores it is possible to derive a joint-score by adding three times the sex-ratio score to the sum of the two age-ratio scores. The sex-ratio scores, age-ratio scores and the joint-scores for the four censuses 1891, 1921, 1946 and 1953 are presented in Table 4.

Table 4

RESULTS OF AGE-ACCURACY TESTS FOR SELECTED CENSUSES, CEYLON

Test Scores	Census Year			
	1891	1921	1946	1953
Sex-ratio score	32·0	22·0	9·6	4·4
Age-ratio score :				
Male	29·4	14·1	12·2	8·8
Female	49·0	17·4	11·3	11·0
Joint-score	174·4	97·5	52·3	33·0

Since a high score indicates greater inaccuracy in the age distribution than does a low score, it can be seen from Table 4 that errors in age distribution were more marked in earlier censuses. But compared to certain other countries of the world the 1953 census of population exhibits a high degree of inaccuracy in its age statistics, as is seen in table 5.

Table 5

TEST SCORES FOR CENSUS AGE DISTRIBUTION OF SELECTED COUNTRIES

Country	Year of Census	Sex-Ratio Score	Age Ratio Score		Joint Score
			Males	Females	
Ceylon	1953	4·4	8·8	11·0	33·0
Canada	1941	2·5	2·4	1·8	11·7
U. S. A.	1940	1·9	2·5	2·3	10·5
India	1931	5·2	6·1	6·2	27·9
Japan	1948	2·0	2·2	3·3	11·5
Thailand	1947	3·0	4·3	2·4	15·7
Denmark	1945	1·1	2·0	2·3	7·6
England and Wales	1931	2·2	2·2	1·4	10·2
Brazil	1940	3·9	7·0	8·5	27·2
Sweden	1945	1·2	2·1	1·9	7·6
Australia	1947	2·4	1·7	2·2	11·1

Source : United Nations, Population Division, " Accuracy Tests for Census Age Distributions Tabulated in Five-year and Ten-year Groups ". *Population Bulletin* No. 2, Oct. 1952, New York, 1953, pp. 75–76.

3. Under Enumeration at Young Ages

It is clear that the pattern of age distribution as obtained at the census of 1953 in Ceylon is substantially affected by errors in age reporting, especially at the ages 10 and above, as is seen from the sex and age-ratios for these groups. This does

not mean that the age distribution below 10 is free from error. In the censuses of many countries it has been noticed that there is an incomplete enumeration of children under 5 years of age and Ceylon is no exception to this. The following estimate shows that the number of persons 0–4 years as enumerated in the 1953 census is apparently less than should be expected on the basis of births and deaths occurring during the preceding five years.

Age 0–4 years	Number enumerated at the census March 1953	Number estimated from vital statistics	
		Uncorrected for under-registration	Corrected for 10% under-registration
Males	609,020	685,691	761,879
Females	599,809	667,738	741,933

It was therefore necessary that before the census data could be used as a basis of estimation or projection of future numbers, the age distribution derived from the census of 1953 should be smoothed to remove errors due to age mis-reporting and should be corrected for under-enumeration.

4.   Under-Registration of Births and Deaths

Statistics relating to births and deaths have been used to estimate the 0–4 and 5–9 age groups as at March, 1953, to " build up " the population of the base year, 1956, and to estimate the fertility and mortality rates at that time. It is therefore, necessary to examine the reliability of Ceylon's vital statistics. In Ceylon, the Registrar-General publishes annually the number of registered births by sex and the number of registered deaths by sex and age-groups. There is, however, always a lag between the event and its registration and the Registrar-General's Reports give only the number of births and deaths registered. In making use of the Registrar-General's figures, it was therefore assumed that the incidence of vital events and the lag in the registration remained constant from year to year so that vital occurences in any year will be approximately equal to vital registration in that year.

Another question that has to be examined relates to the completeness of the registration of vital events. Are all vital events registered or is there an under-registration of births and deaths ? Though the administrative machinery for the registration of vital events in Ceylon is relatively efficient and well co-ordinated, it cannot be claimed that the system ensures complete registration of all vital events. A sample check to assess the completeness of births and deaths registration was carried out in Ceylon in 1953 along with the verification of the census enumeration of that year. The results of this check showed that for Ceylon as a whole the percentage completeness of registration was 88·1 for births and 88·6 for deaths. However, this survey was subject to various sources of error.   " For instance, some

of the events that were not registered at the time of the survey might well be registered some times after, even though it meant that registration was effected a couple of months after the legally specified period "*. In the absence of any precise knowledge about the extent of under-registration, it was assumed, for purposes of our study, that there is a ten percent under-registration of births and deaths in Ceylon. Though this assumption is a little arbitrary, judging from available evidence, the assumption may be considered realistic. The figures relating to births and deaths published by the Registrar-General were corrected for 10 per cent. under-registration before they were used for our purpose. In the case of deaths, it was also assumed that the extent of under-registration was 10 per cent. in all age groups.

* Mrs. I. Kannangara, *Post Enumeration Survey*, 1953, Monograph No. I, Department of Census and Statistics, Colombo, 1953, p. 17.

ADJUSTMENT OF THE 1953 CENSUS DATA

AS mentioned in Chapater I, the errors in the data of the 1953 census indicated that the data have to be adjusted before they could be used to " build up " the population of the base year. The problem remained of deciding upon the best age-grouping and selecting a suitable graduation formula. While it is true that the errors in age-distribution caused by mis-statement of age cannot be entirely corrected by grouping, or by graduation alone, a proper grouping combined with suitable graduation will substantially improve the correctness of the age-distribution.

1. Choice of Age-grouping

The single year distribution is rendered practically useless for our purpose owing to the digitorial preference shown earlier and this makes the choice of a five-year group for primary tabulation very important. There were, however, five-possibilities with regard to five-year age-groupings, viz., 0–4, 1–5, 2–6, 3–7 and 4–8. As a basis for determining which of these five groupings seemed subject to the least error, the " sex-ratio score ", " the age-ratio score " and the " joint-score " were calculated for the five-year age-groupings outlined above. These scores are given below —

Age-groups	Joint-Score	Sex-Ratio Score	Age-Ratio Score	
			Males	Females
0–4	33·0	4·4	8·8	11·0
1–5	44·4	9·1	6·1	11·0
2–6	42·3	9·3	7·8	6·6
3–7	47·6	6·4	13·7	14·7
4–8	35·2	5·3	8·7	10·6

These figures seem to indicate that, when all scores are considdred, the 0–4 age-grouping appears to be the best and this grouping was, therefore, used to graduate the age-distributions of the 1953 census. This has got the additional advantage in that it is the grouping in which the final figures are to be given.

2. Graduation of Age-Distribution, 10-74 years

Two graduation formulae with different reducing powers were tested for their suitability for smoothing the 1953 census data. The first is the graduation formula recommended by the United Nations Secretariat for smoothing data with marked inaccuracies. This formual is derived from a simple parabola and could be used for smoothing all age-groups except the first two and the last two. " The formula employs five terms ; that is, in order to adjust the figure for one five-year age-group, data for the two preceding and the two following age-groups must also be inserted

in the formula. If the age statistics are tabulated by five-year groups upto age 85, smoothing can be effected by such a formula for all groups between the ages 10 and 75. The numbers at the youngest and the oldest ages have to be dealt with separately. The formula may be stated as follows :—

$$\Sigma = \frac{1}{16}(-S_{-2} + 4S_{-1} + 10S + 4S_1 - S_2)$$

where Σ is the adjusted number of persons in one five-year group, to be computed, S is the reported number of persons in the same five-year group, S_{-2} and S_{-1}, are reported numbers in the two preceding five-year groups and S_1 and S_2 are reported numbers in the two subsequent five-year groups ".[1]

In the second graduation formula the assumption is that the graduated value differs from the observed value by a fraction of the fourth difference *i.e.*,

$$\Sigma = S - \frac{1}{36}\triangle^4 S = \frac{1}{36}(-S_{-2} + 4S_{-1} + 30S + 4S_1 - S_2)$$

where notations are the same as in the United Nations formula. Compared to the United Nations formula, the second formula gives greater weight to the middle term and less to terms which are farther away.

The graduated values obtained by the two formulae are shown in Table 6.

Table 6

RECORDED AND GRADUATED AGE-SEX DISTRIBUTION OF POPULATION, 1953 CENSUS, CEYLON

Age-Group	Males			Females		
	Population according to Census 1953	Figures adjusted by U. N. formula	Figures adjusted by the second formula	Population according to Census 1953	Figures adjusted by U. N. formula	Figures adjusted by the second formula
0–4	609,020	—	—	599,809	—	—
5–9	550,022	—	—	535,892	—	—
10–14	474,739	462,564	469,328	445,447	436,473	441,236
15–19	364,432	387,669	374,760	339,412	361,974	347,773
20–24	395,165	383,385	389,929	372,307	359,403	366,350
25–29	371,205	361,085	366,707	337,666	326,560	332,785
30–34	285,303	306,292	294,631	235,482	259,094	245,976
35–39	292,138	270,143	282,363	243,452	220,358	233,188
40–44	210,565	229,666	219,055	161,475	179,401	169,442
45–49	211,357	199,588	206,126	158,959	149,145	154,597
50–54	159,664	161,458	160,461	118,490	119,281	118,841
55–59	108,944	111,920	110,267	79,681	83,698	81,466
60–64	83,958	82,640	83,372	69,490	66,384	68,109
65–69	61,848	61,623	61,748	50,603	51,515	51,008
70–74	40,841	40,463	40,673	35,410	35,025	35,239
75–79	22,771	—	—	21,707	—	—
80–84	15,519	—	—	13,457	—	—
85 and over	11,239	—	—	10,426	—	—

[1] United Nations, Department of Economic and Social Affairs, *Methods for Population Projections by Sex and Age*, Manual III, Population Studies No. 25, New York, 1956, p. 11.

The age-distribution of the 1946 census was also similarly smoothed by the two formulae. The smoothed values thus obtained for the two censuses were plotted on a graph separately for males and females and curves were drawn to find out which of the two formulae gave a better smoothing. It was found that the formula recommended by the United Nations Secretariat gave a better smoothing of the age-distributions of both censuses. Also there is no reason to believe that the smoothing by this formula was so drastic as to eliminate some of the real oscillations. It was therefore decided to use the United Nations formula for graduation.

The graduated five-year age-distribution of the 1953 census shows a relatively low frequency in the age-group 15-19 years for both males and females. This may be explained by the fact that the population in this group was born between 1934 and 1938, when coinciding with the malaria epidemic, there was a fall in the number of births as shown by the recorded vital statistics. If this was the main reason for the observed abnormality in 1953, a corresponding low frequency should have been noticed in the 1946 age-distribution at a lower age-group. But this was not so. The age-reporting at this particular age-group is, however, usually subject to quite large errors, as shown, for example, by the fact that the Indian censuses also show undulations in the age-distribution at these ages. It was therefore decided that, while the low frequency in the 15-19 age-group in 1953 may be genuine to some extent, it was desirable to smooth the distribution a little further. This was done by applying the following smoothing formula :—

$$\overline{W}_{15} = \tfrac{7}{8} W_{15} + \tfrac{1}{4} W_{20} - \tfrac{1}{8} W_{25}$$

$$\overline{W}_{20} = \tfrac{1}{4} W_{15} + \tfrac{1}{2} W_{20} + \tfrac{1}{4} W_{25}$$

$$\overline{W}_{25} = -\tfrac{1}{8} W_{15} + \tfrac{1}{4} W_{20} + \tfrac{7}{8} W_{25}$$

This ensures that $W_{15} + W_{20} + W_{25} = \overline{W}_{15} + \overline{W}_{20} + \overline{W}_{25}$. The smoothed values derived by the application of this formula are :

Age-Group	Males	Females
15–19	389,920	365,758
20–24	378,881	351,836
25–29	363,336	330,344

The age-distribution in the range 10 to 74 years as reported in the 1953 census was thus graduated to obtain a smooth regular series of values. The age-groups that remain to be considered are the 0–4 years, 5–9 years and 75 years and over.

3. Adjustment of Population Under 10 Years of Age

As has been mentioned earlier, in the censuses of many countries it has been found that children under five years of age are incompletely enumerated. This is the case in Ceylon also. It is customary, for purposes of population projections, to replace the census figures for this age-group by an independent estimate based on the number of births during the preceding five years for those countries which possess reliable vital statistics. The population in the age-group 0–4 years was estimated on the basis of births occuring during 1948 to 1953 and deaths among these births.

The United Nations Secretariat had recommended that the number of children aged 5–9 years as reported in a census could usually be accepted as accurate unless there are reasons to doubt their correctness. It is not difficult to see there is some under-enumeration in the age group 5–9 years. It was decided to make an estimate of this group also based on the births occurring between 1943 and 1948 and deaths among these births.

The total number of births between 21st March, 1948 and 20th March, 1953, was estimated to be 858,114 males and 828,521 females. Similarly the number of births between 21st March, 1943 and 20th March, 1948, was estimated to be 709,532 males and 682, 726 females.[1] The number of deaths attributable to the cohorts initially in the age-groups 0–4 years and 5–9 years was estimated as :

Age–group	Deaths attributable to cohorts at present in this age group	
	Males	Females
0–4	96,235	86,588
5–9	146,899	144,344

The number of survivors in the age–group 0–4 years and 5–9 years could, therefore, be obtained by subtracting from the number of births the estimated number of deaths among them.

Age–Group	Males			Females		
	Births	Deaths	Expected Survivors	Births	Deaths	Expected Survivors
0–4	858,114	96,235	761,879	828,521	86,558	741,933
5–9	709,532	146,899	562,633	686,726	144,344	542,382

4. Population at Ages 75 and Above

Examination of the census returns of a number of countries show that there is a tendency among the very old persons to over-state their age. Exaggeration of ages among those towards the upper extreme of life has been found to rise with the degree of illiteracy. In Ceylon, the 1953 census recorded 49,529 males and 45,590 females as being 75 years and above and together they formed only about 1·2 per cent. of the total population. Those who are above 75 years play no part in determining the future generation and this group gets depleted rapidly by deaths. Owing to these facts and because of their numerical insignificance, no attempt has been made in this study to test the accuracy of the age returns relating to this group. It was decided to accept the recorded figures pertaining to this group as correct.

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[1] Since the census was taken on 20th March, 1953, only those born between 21st March, 1948 and 20th March, 1953, would pass on to the 0–4 age-group as on 20th March, 1953. Similarly, only those born between 21st March, 1943 and 20th March, 1948, will come into 5–9 age-group as on 20th March, 1953. The number of births between 21st March, 1948 and 31st December, 1948, was estimated by multiplying the total births in 1948 by 286/366 and the number of births between 1st January, 1953 and 20th March, 1953, was estimated by multiplying the total number of births in 1953 by 79/365.

The death data was also adjusted for census date in the same manner as the birth figures. But not all the deaths reported among those of a particular age in an year could be attributed to the cohort initially in the age-groups ; part of the deaths must be attributed to the next younger cohort.

It was assumed that 70 per cent. of the deaths in a calender year among those aged 0 (as at last birth date) pertained to those who were born in that calender year. The corresponding percentages for ages 1, 2, 3, &c. (as at last brith date) are 60, 50, 50, &c., respectively.

5. Adjusted Age-Sex-Distribution of Population, 1953

The data on the age distribution of the population as recorded at the 1953 census has thus been adjusted for errors due to under-enumeration and mis-statement of age. The adjusted values that would be used for "building up" the base population are given in Table 7.

Table 7

ADJUSTED SEX-AGE DATA OF THE 1953 CENSUS OF CEYLON

Age-Group	Males		Females	
	Population according to census 1953	Figures adjusted for errors	Population according to census 1953	Figures adjusted for errors
0–4	609,020	761,879	599,809	741,933
5–9	550,022	562,633	535,892	542,382
10–14	474,739	462,564	445,447	436,473
15–19	364,432	389,920	339,412	365,758
20–24	395,165	378,881	372,307	351,836
25–29	371,205	363,336	337,666	330,344
30–34	285,303	306,292	235,482	259,094
35–39	292,138	270,143	243,452	220,358
40–44	210,565	229,669	161,475	179,401
45–49	211,357	199,588	158,959	149,145
50–54	159,664	161,458	118,490	119,281
55–59	108,944	111,920	79,681	83,698
60–64	83,958	82,640	69,490	66,384
65–69	61,848	61,623	50,603	51,515
70–74	40,841	40,463	35,410	35,025
75–79	22,771	22,771	21,707	21,707
80–84	15,519	15,519	13,457	13,457
85 and over	11,239	11,239	10,426	10,426
All ages	4,268,730	4,432,538	3,829,165	3,978,217

It can be seen that because of the various adjustments in the data, the totals of the adjusted figures do not tally with the initial figure of the total population. It is customary to "pro-rate" the adjusted figures to maintain consistency with published figures on total population. But in view of the fact that children below 10 years of age were under-enumerated at the census, and since there is no reason to believe that persons above 10 years are over-enumerated, it was decided to use the adjusted figures without any further manipulation. The adjusted totals may be taken as the best approximation to the number of people living in Ceylon as on 20th March, 1953.

POPULATION OF THE BASE YEAR, 1956

THE base time for the projection was 31st December, 1956, and the population of the base year was built up from adjusted figures of the 1953 census by making use of the data on births and deaths of the subsequent period.

1.   Utilization of Data on Births and Deaths by Age, 1953–1956

The published figures of the Registrar-General in respect of births and deaths were corrected for an assumed 10 per cent. under-registration.   The number of births and deaths between 21st March, 1953 and 31st December, 1953, was obtained by multiplying the births and deaths during the year by 286/365.   Since data on deaths by single years of age were not available a five-year age-grouping was used for purposes of bringing forward the population of 20th March, 1953 to 31st December, 1956. It will be seen that though the deaths relate to the cohorts in five-year age-groups, the period for which the deaths are needed is 3 and 286/365 or 3·78 years.   The cohort will be 3·78 years older at the end of this period, i.e., the cohort which is aged 0–4 years as on 20th March, 1953, will be 3·78 to 8·78 years old on 31st December, 1956.

Not all the deaths occurring in an age-group during the period are attributable to the cohort of that age-group at the beginning of the period ; part of the deaths belongs to the next younger cohort.   For our purpose it was assumed that the deaths attributable to a given cohort during this period was given by the following formula.[1]

$$0·621644 \, D_x + 0·378356 \, D_{x+5}$$

This formula implies uniform distribution of deaths in the five-year age-groups and also during every calender year of the period, 20th March, 1953 to 31st December, 1956.   The total number of deaths occuring among those aged 5 and over between 20th March, 1953 and 31st December, 1956, thus calculated are given in the tables in Appendix Tables 1 and 2.   The 0–4 age-group was treated separately.

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[1] The weights were obtained as follows.   Let us consider the cohort aged 5–9 years as on 20th March, 1953.   The people in this group would pass on to the 8·78–13·78 age-group as on 31st December, 1956.   Therefore total deaths among those in the cohort aged 5–9 years in 1953 will be all deaths among people between 8·78 and 10 years exact and approximately half the deaths among people 5 to 8·78 years and 10 to 13·78 years during the period.

$$i.e. \frac{1·22}{5} \, D_5 + \tfrac{1}{5} \times \tfrac{1}{2} (3·78 \, D_5 + 3·78 \, D_{10})$$

$$= ·622 \, D_5 + ·378 \, D_{10}$$

2. Estimates of Persons below 10 Years of Age

The survivors of the 0–4 age-group as on March, 1953, would have passed on to the 3·78 to 8·78 age-group as on 31st December, 1956. It would therefore be possible to obtain the numbers in the 3·78 to 8·78 age-group as on 31st December, 1956, by subtracting from the 0–4 age-group as on March, 1953, the number of deaths pertaining to this cohort between March, 1953 and December, 1956. The assumption of uniform distribution will not be correct in this age-group. A more accurate estimate of this group would be possible only if the number of deaths by single years among those aged 0–8 between 1953 and 1956 are available. The Registrar-General publishes death statistics by single years only for ages 0 to 4. For all other ages the information is published in five-year age-groups. It was, therefore, necessary to obtain the number of deaths by single years of age between 5 and 8 years by interpolation.[1]

As mentioned earlier, only a part of the deaths occuring in a given age-group during the period belongs to the cohort initially at that age-group ; the remainder is attributable to the next younger cohort. The number of deaths between 1953 and 1956 that should be attributed to those aged 0–4 in March, 1953, as they pass on to the 3·78 to 8·78 group as on 31st December, 1956, was estimated by using the separation fractions, ·7, ·6 and ·5 for ages 0, 1, 2 and above respectively.[2]

On this basis, the number of deaths between 20th March, 1953 and 31st December, 1956, attributable to the cohort initially in the 0–4 age-group as on March, 1953, as they pass on to the 3·78 to 8·78 age-group as on 31st December, 1956, was estimated to be 28,492 for males and 32,791 for females. The 3·78 to 8·78 age-groups as of 31st December, 1956, was obtained by subtracting from the population in the age-group 0–4 years as on 20th March, 1953, the estimated number of deaths in this cohort.

Age-group 0-4 years	Size of cohort 20th March, 1953	Deaths attributable to this cohort between 20th March, 1953 and 31st December, 1956	Size of 3·78-8·78 age-group as on 31st December, 1956
Males	761,879	28,492	733,387
Females	741,933	32,791	709,142

The total number of births between 1953 and 1956 and the number of deaths among those aged 0–4 during this period were used to estimate the 0 to 3·78 age-group as on 31st December, 1956. The number of registered births and deaths were corrected

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[1] The following interpolation formula was used for the purpose.

	D_5	D_{10}	
			When $D_x =$ Total deaths in age-groups x to $x + 4$
d_5	·28	—·08	$d_x =$ deaths at age x at last birth day
d_6	·24	—·04	
d_7	·20	·00	
d_8	·16	+·04	
d_9	·12	+·08	

[2] For details of method, see Appendix A.

for 10 per cent. under-registration. Though all births occuring between 20th March, 1953 and 31st December, 1956, would be included for the purpose not all the deaths in the age-group 0–4 during this period could be attributed to the initial cohort. The number of deaths attributable to births in each year was estimated by applying the separation fractions used earlier, viz., 0·7, 0·6 and 0·5 for ages 0, 1, 2 and above respectively.

The estimated numbers at ages 0, 1, 2 and 3 as at 31st December 1956, were as follows :—

Age	Number of males	Number of females
0 and less than 1	174,564	169,808
1 and less than 2	168,480	164,584
2 and less than 3	153,640	150,319
3 and less than 4	161,726	155,939
Total	658,410	640,650

The 0–3·78 age-group obtained by adding to the total of those aged 0, 1, 2 and 286/366 of those aged 3 (last birth day). In this manner the 0–3·78 group as on 31st December, 1956, was estimated to be 623,406 males and 606,899 females.

3. Population as at 31st December, 1956

The estimated population as at 31st December, 1956, obtained by the method discussed earlier, is given in Appendix, Table 3. It would be seen that the method adopted to estimate the population as at 31st December, 1956, does not give the population according to the conventional five-year groups, viz., 0–4, 5–9, &c. It was therefore necessary to redistribute the population into the conventional five-year groupings. This was done by fitting a second degree parabola to three consecutive values of five-year group totals. The following interpolation formula was used :—

$$U_x = U_o + \binom{x}{1} \triangle U_o + \binom{x}{2} \triangle^2 U_o + \binom{x}{3} \triangle^3 U_o$$

where U_x is the cumulative age-frequency, i.e., U_x = total population aged x and above.

The number of persons in the 0–4 age-group was obtained by an independent estimate based on the births and deaths occuring during the preceding five years. The number of persons in the 5–9 age-group was estimated as follows : From the total number in the 0–8·78 group the number of persons in the 0–4 age group (obtained on basis of births and deaths) was subtracted and the balance would fall into the 5–8·78 age-group. What remains to be estimated is the number of persons between 8·78 to 9 years (last birth day). This was done by the formula given above.

Thus the number of persons in five-year age-groups between the ages 0 and 79 as at 31st December, 1956, was obtained. The difference between the total estimated population and the total number between 0 to 79 was taken as the number in the 80 and over group.

It has to be noted that migration was not taken into account in these estimates as it was assumed that migration played a very insignificant role in population increase during this period. Table 8 gives the estimated population of the base year, 31st December, 1956, by sex and five-year age-groups.

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Table 8.

ESTIMATED POPULATION OF CEYLON AS AT 31ST DECEMBER, 1956, BY SEX AND CONVENTIONAL FIVE-YEAR AGE-GROUPS

</div>

Age-group	Males	Females
0–4	812,274	790,693
5–9	690,325	668,855
10–14	531,308	508,374
15–19	436,683	411,095
20–24	384,648	358,786
25–29	375,412	345,895
30–34	343,950	304,965
35–39	293,953	245,116
40–44	254,872	205,170
45–49	217,808	168,136
50–54	185,195	138,294
55–59	140,774	104,622
60–64	96,355	74,128
65–69	68,804	56,393
70–74	46,826	39,532
75–79	26,643	23,752
80 & over	16,212	11,485
Total	4,922,041	4,453,291

MORTALITY

1. Mortality Trends in Ceylon

AN examination of the past death rates shows that at the beginning of the century Ceylon had a high death rate. The death rates have fluctuated violently around a level of about 30 per thousand. By the early twenties the crude death rate was 28·9. During the post-war years Ceylon's mortality rates showed a steep decline The crude death rate which was 20·2 in 1946 suddenly dropped to 14·3 in 1947. It has continued to decline and in 1956 was only 9·8 per 1,000 population. The expectation of life at birth rose from about 43 years to 52 years between 1946 and 1947, a gain achieved by most western countries over a period of fifty years. By 1956, the expectation of life at birth was estimated by the Registrar-General's Department to be nearly 60 years.

Perhaps one of the most important factors in the decline of mortality in Ceylon is the sharp drop in maternal deaths and infantile mortality. The maternal death rate which was 20.1 in 1938 dropped to 10·6 in 1947 and further to 3·8 in 1956. The infant death rate which was 182 per 1,000 life births between 1935 and 1939 came down to 101 in 1947 and to 67 in 1956. Along with the fall in maternal mortality and infant mortality rates, a decline has also occurred in other segments of the population as well.

This rapid decline in mortality in Ceylon during the post-war years coincided with the great D. D. T. campaign and a wide-spread use of new drugs and antibiotics to control endemic diseases, an extension of medical services and health education and the development of environmental sanitation. " There is little indication that these phenomenal changes have been caused by improving levels of living. Through 1953, per-capita food consumption may well have been below pre-war levels and, at best, was not much higher. In addition, urban over-crowding is reported to have been increasing, as a result of internal migration. Almost certainly, therefore, the main determinants of Ceylon's mortality movements since the war are not to be found in overall economic development, but rather in change of a public health and medical nature. The fight against malaria since 1946 has probably been the most important single factor ; however other health activities have also been significant."[1]

2. Assumptions Regarding Future Course of Mortality

The question that has to be examined, thereiore, is whether the mortality rates will continue to decline further, or whether they will remain at the present level for some

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[1] George J. Stolnitz, " Comparison between some recent mortality trends in under-developed areas and historical trends in the west ", in Milbank Memorial Fund, *Trends and Differentials in Mortality*, New York, 1956, p, 29.

years to come or whether there will be a rise in the future. There is some reason to believe that there will be no deterioration in the present rates of decline since the new drugs and at least the present medical and sanitary services will be available. Regarding the prospects of future declines in mortality. Dr. Sarkar is of the opinion that Ceylon has already reached the limit of what can be achieved by efficient organisation of measures external to the community, and not requiring willing and active participation of the people. According to him, the next phase of the progress in health conditions of the people would require the co-operation of the masses and, secondly, large investments of funds for water supply, sewage and drainage, housing and other schemes, which can only be financed by economic developments and a rise in the national income, and carried through by education and other measures, amounting to a veritable social transformation.

At the present, the prospects of socio-economic development in future appears to be favourable in Ceylon. All plans and expenditure of the Government are towards this end and, therefore, a rise in the levels of living may perhaps be expected. A rise in the standard of living, together with the maintenance of at least the present level of medical and sanitary services would help to reduce further the mortality rates in Ceylon. Therefore, for purposes of our study, it has been assumed that the mortality rate will decline further during the next twenty-five years.

3. Projection of Mortality Rates

In the method adopted by us for projecting the mortality rates, a balance was struck between international experience and Ceylon's experience since 1947. The international experience as given by Arthur A. Campbell in a recent U. S. Bureau of Census' publication is utilized for this purpose. This analysis was undertaken by him because it was found that the pre-war pattern of mortality decline was no longer applicable to the experience of many countries since 1946. " The need to formulate a new method of projecting age-specific death rates arose from the fact that the methods in use, which depended largely on mortality experience observed before World War II, did not provide for reductions in mortality sufficient to keep pace with the declines that have occurred in the post-war period. It was obvious that in most countries for which there were adequate mortality data, there had been a sharp break with pre-war trends. It no longer seemed appropriate to assume that future declines in mortality would be at as slow a rate as had been observed in the early part of the twentieth century. There was a need for a method which would take into account accelerated decline in death rates if projections of population to future dates were to represent reasonable expectations."[1] It may be noted that in Campbell's method the mortality rates of Ceylon from 1947 to 1952 has been taken into consideration.

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[1] Arthur A. Campbell,—*A Method of Projecting Mortality Rates Based on Post-War International Experience*. U. S. Department of Commerce, Bureau of the Census, Washington 1958, p. 1.

Examining the mortality decline in the post-war period, Campbell concluded that :

(a) at least in certain countries the post-war decline in mortality was much more rapid than the pre-war experience ; e.g., Ceylon, Malaya, Japan, Rumania, etc.

(b) the decline in mortality was more prounced among females.

(c) the decline was not uniform in all age-groups ; it was more pronounced in the middle ages.

Campbell examined the height-slope relationship, i.e., the relationship between mortality levels for various ages and their rates of decline and suggested that the following exponential function be used to extrapolate the mortality rates :

$$m_{x,t} = (m_{x,o} - m_{x,\infty})\, e^{-bxt} + m_{x,\infty}$$ when $m_{x,t}$ represents the central death

rate for age x at a time t years after the base year which is designated as o. The symbol $mx_{x,o}$ represents the central death rate for age x observed during the base year. The symbol $m_{x,\infty}$ represents the ultimate value assumed for the death rate at age x ; the symbol b_x represents a constant, specific for age x to be determined ; and t represents the number of years for which the projection is desired.

The values of b calculated by Campbell are based on the decline in mortality in several countries including Ceylon for the period 1947–52. However, for this study, it was felt that greater weight should be given to Ceylon's recent experience in mortality decline. The b coefficients for Ceylon (i.e. the rate of decline of age-specific mortality rates) were calculated by applying the least square method to Ceylon's annual data for the years 1948 to 1956, and the values were plotted on a graph. It was found on examination of the graph that there was a relatively smaller decline in mortality in the younger age-groups. On the whole, the relative rate of decrease (the rate of decline as shown by Ceylon's rates divided by the rates given by Campbell) increased with age. It was, however, felt that in the future the decline in mortality in Ceylon will be greater in the younger age groups and that in the higher ages will be at a slower rate. It is worth noting that the recorded age specific death rates for Ceylon in the higher age-groups (above 40) are already as low or even lower than the corresponding rates in a number of advanced countries for both sexes.

Since Campbell's method reflects international experience, the inter-relationship of b as given by Campbell between sexes and among different age-groups may be taken to be applicable to Ceylon during the next twenty-five years, but the values of b need adjustment. In other words, while the shape of the curve obtained by plotting b_x against x (on logarithmic paper) may be retained, its actual level needs to be adjusted taking into account Ceylon's recent experience. In the central age-groups the rate of decline obtained from Ceylon's experience was about two-thirds of that given by Campbell. The rates of decline used for mortality projections were obtained by multiplying the b coefficients as given by Campbell by 2/3 in all age-groups for

both sexes. This assumes that Ceylon's experience in the future will conform to international experience as far as interrelationship of the b coefficients for different ages is concerned.

The age-specific death rates for 1956 were used as the basis of mortality projections. The published figures of the Registrar-General relating to the number of registered deaths were in the first instance corrected for an assumed 10 per cent. under-registration. The population as at 1st July, 1956, was estimated on the basis of the 1953 census adjusted figures and the estimated population as at 31st December, 1956.

The values of $m_{x,t}$ for different values of t were computed by using the formula—

$$m_{x,t} = (m_{x,o} - m_{x,\infty}) e^{-bxt} + m_{x,\infty}$$

where $m_{x,o}$ are the death rates corresponding to 1956, $m_{x,\infty}$ the values given by Campbell and b_x two-thirds of the value given by Campbell. The mortality rates for any quinquennium was taken to be the value as at the mid-point of the quinquennium (e.g. 1959·5 for 1956/61). The projected mortality rates were used to construct the life tables for every five-year period and obtain the survival ratios to be used in the population projections. The projected mortality and survival rates are given in Appendix Tables 4 and 5 respectively.

FERTILITY

PERHAPS the most important and the most difficult task in making population projections is the formulation of realistic assumptions as to future trends in fertility. This is particularly so for Ceylon, because it does not seem plausible to assume that western experience will be applicable to Ceylon in the future. It has already been seen that Ceylon's demographic experience in the recent period in the matter of mortality decline has been very different from the way in which a corresponding reduction in death rates was achieved in the west. This suggests that in regard to fertility also, a somewhat different pattern may occur in the future. We can, however, expect that in Ceylon, the decline in mortality which has occurred and which we expect to continue will increase population pressure for the economy as a whole and for individual families, so that it is unlikely that fertility levels will rise in the future. On the other hand, although the means are now available for the direct control of fertility, knowledge about these means is not widely disseminated in Ceylon. Moreover, there may be resistence to their acceptance, owing to the existing social customs and attitudes which are generally conducive to high fertility. Many forces are at work some of which may tend to increase fertility while others may decrease it. It is only by appreciating all these factors that one could have a fairly accurate view of the past or the possible future trends in fertility.

1. Fertility Trends in Ceylon

Ceylon is one of the countries of the world which have been experiencing a high fertility for a long time. In the past the tendency has been for people, especially women, to get married at an early age. Also a high percentage of the persons in the marriageable ages have been married. Further, in a country where the bulk of the people are engaged in agriculture, children especially males, are considered to be an asset, for even a six-year old can become a member of the family labour force and help on the farm with any of the innumerable chores of unmechanized agriculture.

Whatever may have been the factors that were conducive to high fertility rates in the past, it is rather difficult to say what the future course of fertility in Ceylon will be. Many forces are at work, some of which would tend to increase fertility while others will tend to decrease it. It is therefore difficult to assess the overall effect.

It has been observed by Dr. N. K. Sarkar that there has been a systematic rise in the age at first marriage. " The spread of female education, and the increasing economic opportunity that may be made available to women may lead not only to

a rise in the age of marriage but also to fewer marriages."[1]   A study of a one per cent. sample of the 1953 census households reveals that as age at marriage rises, the number of children ever born decreases.   "In Ceylon, where little or no family planning is practised by the population, an early marriage results in a larger family size than does a late marriage."[2]   This is a factor which may lead to a decline in fertility.

Improvement in medical and health services may also be expected to have an effect on fertility.   With an increase in the number of healthy men and women, and decrease in maternal deaths, chances of conception are increased, pregnancy wastage is reduced, and more mothers go through the full reproductive period. These would lead to an increase in fertility.   In this connection it may be mentioned that fertility appears to have increased in the former malarial districts of Ceylon after the successful control of malaria.   "But perhaps the most significant trend in fertility has developed after 1946 in the 'ex-malarial' regions, where the spectacular drop in death-rates has been followed by an almost equally spectacular rise in the birth rate ".[3]

According to the results on completed fertility based on the 1953 census data, it was found that " the rural mother had on the average 1·09 children more than the urban mother " and according to the study based on the 1946 census data it was found that " among the urban areas fertility declined on the whole as towns grew bigger and, presumably, more urbanised during this century."

It may also be assumed that a reduction in fertility may be achieved by governmental efforts to spread the practice of family planning.   Towards the end of 1957, the government which hitherto had no definite policy on family planning, decided to lend its active support to such a programme.   In this matter it accepted an offer for assistance from Sweden.   At the beginning, all family planning activities will be in collaboration with the Family Planning Association of Ceylon.

Any reduction in fertility as a result of these efforts will, of course, depend on the intensity with which such activities are undertaken by the government and the extent to which means are found to make family planning acceptable to the people.   It is, of course, too early to anticipate the effects which governmental support for family planning may have on the general fertility level in Ceylon.   Nonetheless, if undertaken seriously, governmental sponsorship for such a programme could increase the motivation for fertility control among the population at a much more rapid rate than if this motivation had to await the improvement of social and economic conditions.

2.   Assumptions Regarding Future Course of Fertility

The developments mentioned in Section 1 were taken into consideration in making assumptions regarding the future course of fertility in Ceylon.   On balance, it was

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[1.]   N. K. Sarkar, *The Demography of Ceylon*, Ceylon Government Press, Colombo, 1957, p. 235.
[2.]   S. Kumaraswamy, *Fertility Trends in Ceylon*, Monograph No. 8, Department of Census and Statistics, Colombo, 1956, p. 15.
[3.]   R. Raja Indra, *Fertility Trends in Ceylon*, Monograph No. 3, Department of Census and Statistics, Colombo, 1954, p. 4.

considered safe to assume that the range of possibilities extended from constant to a slightly decreasing fertility. For purposes of our study, three assumptions regarding future fertility trends in Ceylon were made :—

(a) On the ' high ' side, it was assumed that the fertility rate of 1956 would remain constant up to 1981.

(b) In the medium projection it was assumed that each specific fertility rate of 1956 would remain constant up to 1961 but thereafter would decrease by 5 per cent. per quinquennium up to 1981.

(c) For the ' low ' projection, it was assumed that each specific fertility rate of 1956 would remain constant up to 1961 but thereafter decrease by 10 per cent. per quinquennium up to 1981.

3. Projection of Fertility Rates.

Available from the Registrar-General's Report on Vital Statistics were figures relating to the number of births registered in 1956 classified by age of mother, and the birth rates per 1,000 women in specified age-groups. The following adjust-ments in these data were made to obtain the specific birth rates for 1956 :

(a) The number of births registered were corrected for an assumed 10 per cent. under-registration.

(b) The female population of mid-year 1956 was estimated on the basis of the adjusted 1953 census figures and our estimated population as at 31st December, 1956.

The specific birth rates thus computed are given in Table 9.

Table 9

AGE SPECIFIC BIRTH RATES OF CEYLON, 1956

Age of mother	Number of births 1956*	Number of women Mid-year 1956	Specific birth rates (per 1,000 women)
10–14	222	498,872	·45
15–19	28,780	405,104	71·04
20–24	103,561	357,868	289·38
25–29	111,359	343,840	323·87
30–34	66,267	298,903	221·70
35–39	41,956	241,844	173·48
40–44	7,929	201,765	39·30
45–49	1,112	165,626	6·71

* Corrected for 10 per cent. under-registration.

The number of births during each five-year period under the three assumptions was estimated by the following formula :—

$$[2\cdot5 + 4\cdot25\,a]\ \sum_{x}\ \omega^{\circ}_{x}\, f^{\circ}_{x} + [2\cdot5 + 8\cdot25\,a]\ \sum_{x}\ \omega^{\circ}_{x}\, f^{\circ}_{x}$$

where ω°_{x} is the number of women in the age-group x to x + 4 at the beginning of the five-year period, and ω^{5}_{x} is the corresponding number at the end of the five year period. f°_{x} is the specific fertility rate for age-group x to x + 4 at the beginning of the five-year period and a_x is the assumed rate of decrease per year in the same age-group.[1]

The Registrar-General's Report on Vital Statistics published only the distribution of total births by age of mother and not by sex. The number of male and female births was obtained by multiplying the total births by the sex-ratio at birth in 1956, viz., ·509 males per ·491 females. It was assumed that the sex-ratio for each age group was the same as the overall sex ratio. It was also assumed that the same sex-ratio would apply to births for all the years up to 1981.

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[1] For details see Appendix B.

MIGRATION

In Ceylon, migration played an important part in the growth of the population in the second half of the 19th century and the beginning of the 20th century. Migration into Ceylon began somewhere in 1830 with the opening up of the coffee plantations. Most of the migrants were indentured labourers from South India. Up to 1900, with the rise and fall of the plantation industries, the rate of flow of migration has also been varying. After 1900, this rate has declined greatly.

In recent years there has been a tightening in the immigration policy of the Government. A completely new national policy for the control of migration and the framework for its implementation came into being after the enforcement of the Immigrants and Emigrants Act, No. 20 of 1948 as amended by Act, No. 16 of 1955. This act introduced far reaching changes in migration policy. The Temporary Residence Permits were replaced by visas and provisions were made to combat illicit immigration. Most of the non-nationals have since been repatriated. The future of the Indian estate labourers is still not decided and their stay in the Island or their exit will depend largely on political developments which cannot be easily predicted.

For purposes of our study, it was assumed that there would be no migratory changes in future and that even if migration occurs, its magnitude would not be so great as to bring about significant changes in population growth.

POPULATION PROJECTIONS

1. Method of Projection

THE assumptions made in Chapters IV, V and VI about future trends in mortality, fertility and migration are used to project the estimate population as on 31st December, 1956, to the next twenty-five years by the component method*. The assumptions regarding the various components may be summarised as follows :—

(*a*) Mortality : An orderly decline along an exponential curve of the 1956 specific death rates till the end of the projection period.

(*b*) Fertility : (i) Constant from 1956 to 1981.

(ii) Constant from 1956 to 1961 and thereafter 5 per cent. decline every quinquennium.

(iii) Constant from 1956 to 1961 and thereafter 10 per cent. decline every quinquennium.

(*c*) Migration : Nil.

The combination of these assumptions would therefore result in three different projections which we have termed the " high ", " medium " and " low " projections. The results of these projections are given in Tables 11, 12 and 13.

Apart from the projections mentioned above, we have also prepared another set of projections using the values of b (or rates of decline of age-specific mortality) derived by Campbell on the basis of the post-war decline in mortality experienced in many countries, mostly of the west. For these projections, certain simplifying computational devices suggested by Campbell were used, viz., the projection of survival ratios instead of mortality rates. The results of these projections are presented in Appendix Tables 6, 7 and 8.

2. Projected Population

The results of the population projections based on declining mortality and the three different assumptions of fertility are given in Tables 11, 12 and 13. The figures in the tables have been rounded to the nearest thousands. A summary of the results are given in Table 10.

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* For details of the method, *see* United Nations, Department of Economic and Social Affairs *Methods for Population Projections by Sex and Age.* Manual III, Population Studies No. 25, New York, 1956, pp. 2–3.

Table 10
PROJECTED TOTAL POPULATION OF CEYLON, 1956–1981

Projection \ Year	Projected Total Population (in 000's)					
	1956	1961	1966	1971	1976	1981
High	9,375	10,873	12,647	14,809	17,476	20,701
Medium	9,375	10,873	12,594	14,573	16,877	19,508
Low	9,375	10,873	12,541	14,342	16,312	18,424

Table II
POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND)
HIGH PROJECTION : CONSTANT FERTILITY AND DECLINING MORTALITY

Ages \ Year	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	905,000	1,050,000	1,261,000	1,535,000	1,840,000
5– 9	690,000	789,000	886,000	1,033,000	1,246,000	1,520,000
10–14	531,000	685,000	784,000	882,000	1,030,000	1,242,000
15–19	437,000	529,000	682,000	782,000	880,000	1,027,000
20–24	385,000	434,000	526,000	679,000	779,000	877,000
25–29	375,000	381,000	430,000	522,000	676,000	776,000
30–34	344,000	371,000	378,000	427,000	519,000	672,000
35–39	294,000	339,000	367,000	374,000	423,000	515,000
40–44	255,000	289,000	334,000	362,000	369,000	419,000
45–49	218,000	248,000	282,000	326,000	355,000	362,000
50–54	185,000	210,000	240,000	273,000	316,000	345,000
55–59	141,000	175,000	199,000	228,000	260,000	302,000
60–64	96,000	129,000	161,000	183,000	211,000	241,000
65–69	69,000	83,000	112,000	141,000	161,000	185,000
70–74	47,000	54,000	66,000	90,000	113,000	130,000
75–79	27,000	33,000	39,000	48,000	65,000	82,000
80 and over	16,000	24,000	32,000	39,000	48,000	64,000
All ages	4,922,000	5,678,000	6,568,000	7,650,000	8,986,000	10,599,000
Females						
0– 4	791,000	878,000	1,018,000	1,222,000	1,487,000	1,783,000
5– 9	667,000	765,000	857,000	1,000,000	1,207,000	1,473,000
10–14	508,000	661,000	760,000	853,000	997,000	1,204,000
15–19	411,000	505,000	658,000	758,000	852,000	996,000
20–24	359,000	407,000	502,000	656,000	756,000	850,000
25–29	346,000	353,000	403,000	499,000	653,000	753,000
30–34	305,000	340,000	350,000	400,000	496,000	650,000
35–39	245,000	299,000	336,000	346,000	397,000	493,000
40–44	205,000	240,000	294,000	331,000	342,000	393,000
45–49	168,000	200,000	235,000	289,000	326,000	337,000
50–54	138,000	163,000	194,000	226,000	282,000	319,000
55–59	105,000	132,000	156,000	192,000	218,000	273,000
60–64	74,000	97,000	123,000	144,000	180,000	205,000
65–69	56,000	65,000	86,000	109,000	128,000	162,000
70–74	40,000	45,000	52,000	69,000	89,000	105,000
75–79	24,000	27,000	31,000	37,000	48,000	63,000
80 & over	11,000	18,000	24,000	28,000	32,000	43,000
All ages	4,453,000	5,195,000	6,079,000	7,159,000	8,490,000	10,102,000
Both sexes	9,375,000	10,873,000	12,647,000	14,809,000	17,476,000	20,701,000

Table 12

POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND)

MEDIUM PROJECTION : DECLINING FERTILITY AND DECLINING MORTALITY

Ages / Year	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	905,000	1,023,000	1,167,000	1,350,000	1,536,000
5 –9	690,000	789,000	886,000	1,007,000	1,153,000	1,336,000
10–14	531,000	685,000	784,000	882,000	1,003,000	1,150,000
15–19	437,000	529,000	682,000	782,000	880,000	1,001,000
20–24	385,000	434,000	526,000	679,000	779,000	877,000
25–29	375,000	381,000	430,000	522,000	676,000	776,000
30–34	344,000	371,000	378,000	427,000	519,000	672,000
35–39	294,000	339,000	367,000	374,000	423,000	515,000
40–44	255,000	289,000	334,000	362,000	369,000	419,000
45–49	218,000	248,000	282,000	326,000	355,000	362,000
50–54	185,000	210,000	240,000	273,000	316,000	345,000
55–59	141,000	175,000	199,000	228,000	260,000	302,000
60–64	96,000	129,000	161,000	183,000	211,000	241,000
65–69	69,000	83,000	112,000	141,000	161,000	185,000
70–74	47,000	54,000	66,000	90,000	113,000	130,000
75–79	27,000	33,000	39,000	48,000	65,000	82,000
80 & over	16,000	24,000	32,000	39,000	48,000	64,000
All ages	4,922,000	5,678,000	6,541,000	7,530,000	8,681,000	9,993,000
Females						
0– 4	791,000	878,000	992,000	1,131,000	1,308,000	1,488,000
5– 9	667,000	765,000	857,000	975,000	1,117,000	1,295,000
10–14	508,000	661,000	760,000	853,000	972,000	1,115,000
15–19	411,000	505,000	658,000	758,000	852,000	971,000
20–24	359,000	407,000	502,000	656,000	756,000	850,000
25–29	346,000	353,000	403,000	499,000	653,000	753,000
30–34	305,000	340,000	350,000	400,000	496,000	650,000
35–39	245,000	299,000	336,000	346,000	397,000	493,000
40–44	205,000	240,000	294,000	331,000	342,000	393,000
45–49	168,000	200,000	235,000	289,000	326,000	337,000
50–54	138,000	163,000	194,000	226,000	282,000	319,000
55–59	105,000	132,000	156,000	192,000	218,000	273,000
60–64	74,000	97,000	123,000	144,000	180,000	205,000
65–69	56,000	65,000	86,000	109,000	128,000	162,000
70–74	40,000	45,000	52,000	69,000	89,000	105,000
75–79	24,000	27,000	31,000	37,000	48,000	63,000
80 & over	11,000	18,000	24,000	28,000	32,000	43,000
All ages	4,453,000	5,195,000	6,053,000	7,043,000	8,196,000	9,515,000
Both sexes	9,375,000	10,873,000	12,594,000	14,573,000	16,877,000	19,508,000

Table 13

POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND)

LOW PROJECTION : DECLINING FERTILITY AND DECLINING MORTALITY

Ages \ Year	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	905,000	996,000	1,077,000	1,179,000	1,270,000
5– 9	690,000	789,000	886,000	980,000	1,063,000	1,168,000
10–14	531,000	685,000	784,000	882,000	977,000	1,060,000
15–19	437,000	529,000	682,000	782,000	880,000	975,000
20–24	385,000	434,000	526,000	679,000	779,000	877,000
25–29	375,000	381,000	430,000	522,000	676,000	776,000
30–34	344,000	371,000	378,000	427,000	519,000	672,000
35–39	294,000	339,000	367,000	374,000	423,000	515,000
40–44	255,000	289,000	334,000	362,000	369,000	419,000
45–49	218,000	248,000	282,000	326,000	355,000	362,000
50–54	185,000	210,000	240,000	273,000	316,000	345,000
55–59	141,000	175,000	199,000	228,000	260,000	302,000
60–64	96,000	129,000	161,000	183,000	211,000	241,000
65–69	69,000	83,000	112,000	141,000	161,000	185,000
70–74	47,000	54,000	66,000	90,000	113,000	130,000
75–79	27,000	33,000	39,000	48,000	65,000	82,000
80 & over	16,000	24,000	32,000	39,000	48,000	64,000
All ages	4,922,000	5,678,000	6,514,000	7,413,000	8,394,000	9,443,000
Females						
0– 4	791,000	878,000	966,000	1,043,000	1,143,000	1,230,000
5– 9	667,000	765,000	857,000	949,000	1,030,000	1,132,000
10–14	508,000	661,000	760,000	853,000	946,000	1,028,000
15–19	411,000	505,000	658,000	758,000	852,000	945,000
20–24	359,000	407,000	502,000	656,000	756,000	850,000
25–29	346,000	353,000	403,000	499,000	653,000	753,000
30–34	305,000	340,000	350,000	400,000	496,000	650,000
35–39	245,000	299,000	336,000	346,000	397,000	493,000
40–44	205,000	240,000	294,000	331,000	342,000	393,000
45–49	168,000	200,000	235,000	289,000	326,000	337,000
50–54	138,000	163,000	194,000	226,000	282,000	319,000
55–59	105,000	132,000	156,000	192,000	218,000	273,000
60–64	74,000	97,000	123,000	144,000	180,000	205,000
65–69	56,000	65,000	86,000	109,000	128,000	162,000
70–74	40,000	45,000	52,000	69,000	89,000	105,000
75–79	24,000	27,000	31,000	37,000	48,000	63,000
80 & over	11,000	18,000	24,000	28,000	32,000	43,000
All ages	4,453,000	5,195,000	6,027,000	6,929,000	7,918,000	8,981,000
Both sexes	9,375,000	10,873,000	12,541,000	14,342,000	16,312,000	18,424,000

According to the ' high ' assumption, based on constant fertility and declining mortality, the population of Ceylon which was estimated to be nearly 9·4 millions in 1956 will have more than doubled itself by 1981. The ' low ' assumption of declining mortality and ten per cent. decrease in fertility after 1961 will give a total population of 18·5 millions in 1981. This will be almost double the 1956 level of 9·4 millions. The medium projection will result in a total population of 19·5 millions by 1981—an increase of 108·1 per cent. over the 1956 level.

It has to be noted that because of the nature of fertility and mortality assumptions made, the total population under medium and low assumptions is the same as that of high projection for the years 1956 and 1961. Beginning from 1966 there is a difference in the total population estimated under the three projections, caused by a change in the numbers in younger age groups. The change in the numbers in the younger age groups is entirely due to the different fertility assumptions and not due to mortality which is assumed to be the same for all projections.

Assuming that the percentage of under-enumeration at the proposed censuses of 1961, 1971 and 1981 will be the same as at the census of 1953, it would be interesting to find out what the population to be enumerated at future censuses would be. Since the last census was taken on 20th March, estimates are given for that date in 1961, 1971 and 1981. The estimates by sex for these years are presented in Table 14.

Table 14

ESTIMATES OF ENUMERATED POPULATION IN FUTURE CENSUSES OF CEYLON

(AS OF 20TH MARCH)

Year	Males	Females	Total
1961	5,347,168	4,881,360	10,228,528
1971	7,198,025	6,720,700	13,918,725
1981	9,950,300	9,465,830	19,416,130

3. Vital Rates Implied in the Present Projections

The crude rates of the population during the period covered by our projections are shown in Table 15. These rates have been calculated by dividing the average number of births and deaths during each five-year interval by the average population of the period. The difference between birth rates and death rates is not exactly equal to the growth rates given in Table 18, because the birth and death rates are obtained by dividing by the average population, while the growth rates given in Table 18 are obtained on the assumption of geometric growth.

Table 15 shows a rapid decline in death rates so that by 1976–81 there will be a death rate of 5·3 according to the ' high ' projection and 5·4 according to the

'medium' and 'low' projections. The birth rates as implied in the 'high' projection would have slightly increased while these rates for the 'medium' and 'low' projections show a very rapid decline by 1976–81.

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Table 15

BIRTH RATES, DEATH RATES AND RATES OF NATURAL INCREASE, CEYLON, 1956–1981

</div>

Period / Projections	High	Medium	Low
	Birth Rates		
1956/61	37·4	38·0	38·0
1961/66	37·4	36·5	35·6
1966/71	37·9	35·5	33·6
1971/76	38·9	35·1	31·5
1976/81	39·1	34·3	29·7
	Death Rates		
1956/61	8·3	8·3	8·3
1961/66	7·2	7·2	7·1
1966/71	6·4	6·3	6·2
1971/76	5·8	5·8	5·7
1976/81	5·3	5·4	5·4
	Rates of Natural Increase		
1955/61	29·1	29·7	29·7
1961/66	30·2	29·3	28·5
1966/71	31·5	29·2	27·4
1971/76	33·1	29·3	25·8
1976/81	33·8	28·9	24·3

The expectations of life at birth for five year intervals for the period covered by the projections are given in Table 16. The figures relate to the middle of each of the five-year intervals.

Table 16

EXPECTATION OF LIFE AT BIRTH, CEYLON, 1956–1981

	1956/61	1961/66	1966/71	1971/76	1976/81
Males	63·21	65·78	67·70	69·17	70·29
Females	62·54	65·98	68·44	70·03	71·69

The table shows that our projections imply an increase in expectation of life at a rate of ·35 years for males and ·46 years for females for every calender year. While the expectation of life figures according to our projections for the middle of the period 1976–81 are at the same level as the United States level at present, the death rate is about half the corresponding rate for that country. This is largely due to the effect of the difference in age-structure of the two populations.

4. Comparison with Previous Projections

Apart from our own study, there are three other studies which give an estimate of the future total population of Ceylon :

(a) Dr. N. K. Sarkar has made two projections for Ceylon. The first, the mathematical projection, assumes that the rate of growth of population during the period 1921–1946 will remain constant in the future. The second, a component projection, assumes a decline in mortality and constant fertility. The two projections have been made for a twenty-five year period beginning from 1951.[1]

(b) The Registrar-General's Department, Ceylon, has prepared two projections— 'high' and 'low'—by the component method for a fifteen year period beginning from 1955. The 'high' projection was prepared on the assumption of increasing fertility and declining mortality. The 'low' projection assumed that mortality rates would remain constant while fertility would decline.[2]

(c) The United Nations Population Division has prepared a population projection for Ceylon, among other countries, assuming constant fertility and declining mortality. The population is projected over a twenty-year period starting from 1955.[3]

In all these studies it was assumed that migration would play no part in the future growth of population in Ceylon. The results of the present projection for the total population are compared with some of the other projections mentioned above in Table 17.

[1] Dr. N. K. Sarkar, *The Demography of Ceylon*, Ceylon, Government Press, Colombo, 1957, pp. 237–239.

[2] Department of Census and Statistics—*Statistical Abstract of Ceylon*, 1957, Colombo, 1957, pp. 30–31.

[3] United Nations, Department of Economic and Social Affairs, *The Future Growth of World Population*. Population Studies No. 28, New York, 1958, p. 74.

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Table 17

SUMMARY OF VARIOUS POPULATION PROJECTIONS FOR CEYLON,
TOTAL POPULATION

Year	Total Population (in 000's)			
	Dr. Sakar[1] (As at 1st July)	Registrar General[2] (As at 1st July)	United Nations (As at 1st July)	Present study[3] (as at 31st December)
1955		8,723	8,680	
1956	8,960			9,375
1960		10,045	9,850	
1961	9,813			10,873
1965		11,600	11,100	
1966	10,688			12,594
1970		13,471	12,600	
1971	11,546			14,573
1975			14,100	
1976	12,560			16,877
1980				
1981				19,508

[1] Component Projection (Projection No. 2)   [2] High Projection   [3] Medium Projection.

To facilitate comparison among these projections, we may study the annual average rates of growth implied in each case. These rates have been calculated by the compound interest formula and are shown in Table 18.

Table 18

ANNUAL RATE OF POPULATION GROWTH, CEYLON

Period	Projections			
	Dr. Sarkar	Registrar-General	United Nations	Present Study
1950–1955				
1951–1956	1·79			
1955–1960		2·86	2·56	
1956–1961	1·84			3·01
1960–1965		2·92	2·42	
1961–1966	1·72			2·98
1965–1970		3·04	2·57	
1966–1971	1·56			2·96
1970–1975			2·29	
1971–1976	1·70			2·98
1975–1980				
1976–1981				2·94

It can be seen that our projections give the highest estimate of future population growth. The explanation may be clear from the difference in the assumptions. Dr. Sarkar's projections, published in 1956, utilize the mortality trends in Ceylon from 1910 to 1946, but the period 1910 to 1946 has been a period of much slow decline in mortality than the period after 1946 which is used as the basis of our projections. Therefore, Dr. Sarkar's estimate shows a slower rate of population growth.

Though the Registrar-General's projections were based on declining mortality, the rate of decline assumed was slower than the rate of decline assumed by us. According to the Registrar-General's estimates, the expectation of life at birth in 1970 was assumed to be $65 \cdot 68$, whereas our estimates give a life expectation at birth of $67 \cdot 7$ for males and $68 \cdot 4$ for females for the middle of the period 1966–1971. Hence, the Registrar-General's estimates show a slower rate of population growth.

In the case of the United Nations projections, Ceylon was included in the group of countries of Central South Asia, i.e. India, Pakistan, Ceylon, Afghanistan, Bhutan and Nepal. Though the vital rates for Ceylon have been reliably recorded at considerably lower figures, the effect of this factor on the population growth of Central South Asia was expected to be offset by some other countries of that region where fertility and mortality are both at high levels. The same assumptions were used for all the countries in this region and this has yielded estimates of the future population of Ceylon lower than the present estimates. For the individual countries of this region, the estimates are based on the assumption of constant fertility during the twenty-five years following 1950 and an increase in the expectation of life at the rate of a half year for each calender year. This assumption approximates to the increase in expectation of life implied in our projection, except for the fact that for the Central South Asian region, the expectation of life at birth for the base year 1950 is assumed to be 30 years. This is rather a low level for Ceylon and partly explains the slow rate of population growth indicated by the United Nations projections.

SUMMARY

THE primary requirement of a population projection is a good base population by age and sex, and this is usually obtained from the latest census or a recent population estimate. In this study, the population of the base year 1956 has been ' built up ' from the figures of the 1953 census making use of the data on births and deaths occurring between the two years.

The data of the 1953 census was tested for inaccuracies in age-reporting and under-enumeration at young ages. Three tests—the digit preference test, age and sex-ratio tests—were applied to the data. The results of these tests showed that the data had to be smoothed before it could be used to ' build up ' the population of the base year.

Two graduation formulae were tested for their suitability to smooth the age distribution of the 1953 census. It was found that the formula recommended by the United Nation Secretariat gave a better smoothing of the age distribution and hence this formula was used for graduating the population between the ages 10 and 74. The 0–4 age-grouping was considered to be the best for use in the graduation. The number of persons in the 0–4 and 5–9 age groups as at the Census of 1953 was replaced by independent estimates based on births and deaths occurring during the preceding ten years as it was found that there was under-enumeration of persons in these age groups. No adjustments were made in respect of the population 75 years and over as at March, 1953.

The adjusted population of March, 1953, was carried forward to 31st December. 1956, by making use of the data on births and deaths for the intervening period, The numbers of registered births and deaths were corrected for an assumed 10 per cent. under-registration.

During the post-war years, there was a rapid decline in mortality in Ceylon due chiefly to the expansion and intensification of medical and health services and development of environmental sanitation. Further decline in mortality could be expected as a result of economic developments which would lead to a rise in the standard of living of the people. It was therefore assumed for purposes of this study that there would be further decline in mortality in future. The age specific mortality rates were projected from 1956 to 1981 based on a method developed by Arthur A. Campbell.

After taking into consideration the recent developments in the various factors affecting fertility, three assumptions regarding the future course of fertility were made. On the ' high ' side it was assumed that fertility rates of 1956 would remain constant up to 1981. For the ' medium ' projection it was assumed that the fertility rates of 1956 would remain constant up to 1961 and thereafter decline by 5 per cent. every quinquennium, while for the ' low ' projection it was assumed that there would be a decline by 10 per cent. every quinquennium after 1961.

It was assumed that there would be no migratory changes in the future.

The population of Ceylon was projected from 1956 to 1981 by the component method. As a result of the combination of the one mortality and three fertility assumptions, three projections, high, medium and low, were prepared. The results of these projections and the rate of growth implied by them have been compared with three other population projections for Ceylon. On the basis of the various assumptions made, the population of Ceylon by 1981 is estimated to be 20·7 millions according to the high projection, 19·5 millions according to the medium projection, and 18·4 millions according to the low projection.

Method of Estimating Deaths between 21st March, 1953 and 31st December, 1956, among those who were 0–4 as on 20th March, 1953

The number of deaths between 1953 and 1956 that should be attributed to those aged 0–4 in March, 1953, as they pass on to the 3·78 to 8·78 age group as on 31st December, 1956, was estimated as follows :

Year Age	1953	1954	1955	1956	Total
0	$+ \cdot364932\ D_0$				
1	$+ D_1$	$+ \cdot486576\ D_1$			
2	$+ D_2$	$+ D_2$	$+ \cdot60822\ D_2$		
3	$+ D_3$	$+ D_3$	$+ D_3$	$+ \cdot60822\ D_3$	
4	$+ D_4$	$+ D_4$	$+ D_4$	$+ D_4$	
5	$+ \cdot39178\ D_5$	$+ D_5$	$+ D_5$	$+ D_5$	
6		$+ \cdot39178\ D_6$	$+ D_6$	$+ D_6$	
7			$+ \cdot39178\ D_7$	$+ D_7$	
8				$+ \cdot39178\ D_8$	
Total	A	B	C	D	A+B+C+D

The number of deaths between 21st March and 31st December, is obtained by multiplying all the deaths in the year by 286/365 or ·78356. On the assumption of uniform distribution, the deaths in 1956 at age 3 among those who were born before 20th March, 1953, will be all deaths between the ages 3·78 and 4 (exact) and half the number of deaths between the ages 3 and 3·78 (exact).

$$i.\ e. \qquad \cdot21644\ D_3{}^{56} + \tfrac{1}{2} \times \cdot78356\ D_3{}^{56}$$
$$= \cdot60822\ D_3{}^{56}$$

Similarly only ·39178 of the deaths in 1956 at age 8 will be among those who were born before 20th March, 1953. The same coefficients can be used for deaths in 1955 also. In the case of deaths in 1953 and 1954, the assumption of uniform distribution cannot be maintained. The coefficients, ·364932 and ·486576 are obtained by multiplying ·3 (component of separation fraction at age 0) and ·4 (component of separation fraction at age 1) by $\dfrac{\cdot60822}{\cdot5}$ or 1·21644.

It may be noted that this is not an exact formula. In addition to the possible error in the weights, there is yet another source of error for the years 1954–56. For instance, in calculating the total deaths for 1956, a part of the deaths among those aged 2 years ought to have been included while a part of the deaths among those aged 7 years should have been omitted. It was assumed that these two fractions will cancel out.

METHOD OF PROJECTING BIRTHS, 1956–1981

THE number of births during each five year period under the three fertility assumptions was estimated by the following formula :

$$[2 \cdot 5 + 4 \cdot 25a] \sum_x w_x^o f_x^o + [2 \cdot 5 + 8 \cdot 25a] \sum_x w_x^s f_x^o$$

The formula was derived as follows :

Let w_x^o be the number of women in the age-group x to x + 4 at the beginning of the five-year period and w_x^s be the corresponding number at the end of the five-year period. Similarly let f_x^o be the specific fertility rate for women in the age group x to x + 4 at the beginning of the five-year period. On the assumption of a linear change, the number of women w_x^t in the age group x to x + 4 and their specific fertility rates f_x^t, at any time t years after the beginning of the five-year period can be expressed as

$$w_x^t = w_x^o + \frac{w_x^s - w_x^o}{5} t$$

$$f_x^t = f_x^o + \frac{f_x^s - f_x^o}{5} t$$

In our projections of high, medium and low, we have assumed that $f_x^s = k f_x^o$ where k = 1·0, 0·95 and 0·90. The number of births in the year $t = \sum_x w_x^t f_x^t$ and the total number of births during the five-year period will be given by

$$\sum_t \sum_x w_x^t f_x^t = \sum_t \sum_x \left\{ \frac{w_x^o + w_x^s + w_x^o}{5} t \right\} f_x^o (1 + at)$$

$$\text{where } a = \frac{k - 1}{5}$$

The summation extends over $t = \frac{1}{2}, 1\frac{1}{2}, 2\frac{1}{2}, 3\frac{1}{2}$ and $4\frac{1}{2}$

and x = 10, 15, 20, 25, 30, 35, 40 and 45.

Summing the above equation with respect to t and substituting 12·5 and 41·25 for $\sum t$ and $\sum t^2$ (respectively and simplyfying, we can express the total number of births in the five-year period by the following formula :

$$\sum w_x^o f_x^o (2 \cdot 5 + 4 \cdot 25a) + \sum w_x^s f_x^o (2 \cdot 5 + 8 \cdot 25a)$$

The values of a for the high, medium and low projections are 0, − 0·01 and − 0·02 respectively.

Table 1

DEATHS IN CEYLON 1953–56 ATTRIBUTABLE TO MALE COHORTS OF GIVEN
AGES ON 20TH MARCH, 1953

Age group	Total number of reported deaths* 1953–56	Deaths attributable to cohort initially in this age group	Size of cohorts as of March 20, 1953	Size of cohorts estimated as of 31st December, 1956 (4) – (3)	Age of cohorts as of 31st, December, 1956
(1)	(2)	(3)	(4)	(5)	(6)
5– 9	7,189	5,458	562,633	557,175	8·78 – 13·78
10–14	2,615	2,529	462,564	460,035	13·78 – 18·78
15–19	2,388	2,758	389,920	387,162	18·78 – 23·78
20–24	3,365	3,502	378,881	375,379	23·78 – 28·78
25–29	3,728	3,574	363,336	359,762	28·78 – 33·78
30–34	3,321	3,777	306,292	302,515	33·78 – 38·78
35–39	4,526	4,405	270,143	265,738	38·78 – 43·78
40–44	4,207	4,926	229,669	224,743	43·78 – 48·78
45–49	6,108	6,110	199,588	193,478	48·78 – 53·78
50–54	6,114	6,536	161,458	154,922	53·78 – 58·78
55–59	7,230	7,472	111,920	104,448	58·78 – 63·78
60–64	7,870	8,369	82,640	74,271	63·78 – 68·78
65–69	9,189	9,373	61,623	52,250	68·78 – 73·78
70–74	9,676	9,034	40,463	31,429	73·78 – 78·78
75–79	7,979	8,270	22,771	14,501	78·78 – 83·78
80–84	8,749	10,690	15,519	4,829	83·78 – 88·78
85 & over	13,879	8,628	11,239	2,611	88·78 & over

* Corrected for 10 per cent under-registration.

Table 2

DEATHS IN CEYLON, 1953–56 ATTRIBUTABLE TO FEMALE COHORTS OF GIVEN AGES ON 20TH MARCH, 1953

Age group	Total number of reported deaths* 1953–56	Deaths attributable to cohort initially in this age group	Size of cohorts as of March 20, 1953	Size of cohorts estimated as of 31st December, 1956	Age of cohort as of 31st, December, 1956
1	2	3	4	5	6
5– 9	8,487	6,276	542,382	536,106	8·78 – 13·78
10–14	2,644	2,752	436,473	433,721	13·78 – 18·78
15–19	2,930	3,754	365,758	362,004	18·78 – 23·78
20–24	5,107	5,294	351,836	346,542	23·78 – 28·78
25–29	5,600	5,174	330,344	325,170	28·78 – 33·78
30–34	4,474	4,753	259,094	254,341	33·78 – 38·78
35–39	5,211	4,547	220,358	215,811	38·78 – 43·78
40–44	3,457	3,738	179,401	175,663	43·78 – 48·78
45–49	4,200	4,147	149,145	144,998	48·78 – 53·78
50–54	4,059	4,219	119,281	115,062	53·78 – 58·78
55–59	4,482	4,857	83,698	78,841	58·78 – 63·78
60–64	5,473	6,075	66,384	60,309	63·78 – 68·78
65–69	7,063	7,522	51,515	43,993	68·78 – 73·78
70–74	8,277	7,931	35,025	27,094	73·78 – 78·78
75–79	7,363	7,714	21,707	13,993	78·78 – 83·78
80–84	8,292	10,878	13,457	2,579	83·78 – 88·78
85 & over	15,126	9,403	10,426	1,023	88·78 & over

* Corrected for 10 per cent under-registration.

Table 3

ESTIMATED POPULATION OF CEYLON AS AT 31ST DECEMBER, 1956

Age Group	No. of Males	No. of Females
0 – 3·78	623,406	606,899
3·78 – 8·78	733,387	709,142
8·78 – 13·78	557,175	536,106
13·78 – 18·78	460,035	433,721
18·78 – 23·78	387,162	362,004
23·78 – 28·78	375,379	346,542
28·78 – 33·78	359,762	325,170
33·78 – 38·78	302,515	254,341
38·78 – 43·78	265,738	215,811
43·78 – 48·78	224,743	175,663
48·78 – 53·78	193,478	144,998
53·78 – 58·78	154,922	115,062
58·78 – 63·78	104,448	78,841
63·78 – 68·78	74,271	60,309
68·78 – 73·78	52,250	43,993
73·78 – 78·78	31,429	27,094
78·78 – 83·78	14,501	13,993
83·78 – 88·78	4,829	2,579
88·78 and over	2,611	1,023
Total	4,922,041	4,453,291

Table 4

(PROJECTED AGE-SPECIFIC DEATH RATES (PER 1,000), CEYLON, 1956–1979

Age group	Age-Specific Death rates 1st July, 1956	Projected Age-Specific Death Rates				
		1st July, 1959	1st July, 1964	1st July, 1969	1st July, 1974	1st July 1979
		Males				
0	77·08	67·82	53·10	42·30	34·37	28·57
1– 4	11·97	10·24	7·56	5·66	4·31	3·36
5– 9	2·80	2·34	1·70	1·26	·97	·77
10–14	1·29	1·08	·79	·61	·49	·42
15–19	1·38	1·17	·88	·69	·58	·51
20–24	2·08	1·77	1·32	1·04	·87	·76
25–29	2·54	2·19	1·70	1·38	1·18	1·05
30–34	2·41	2·17	1·80	1·55	1·39	1·28
35–39	3·97	3·55	2·92	2·48	2·14	1·95
40–44	4·22	3·95	3·52	3·20	2·96	2·78
45–49	7·39	6·94	6·20	5·61	5·16	4·80
50–54	8·77	8·48	7·97	7·56	7·22	6·93
55–59	14·76	14·34	13·58	12·93	12·38	11·90
60–64	22·04	21·62	20·84	20·16	19·55	19·01
65–69	37·86	37·26	36·14	35·11	34·18	33·32
70–74	57·43	56·84	55·71	54·66	53·68	52·77
75 and over	193·43	191·32	187·26	183·39	179·71	176·22
		Females				
0	63·87	56·15	43·84	34·77	28·08	23·15
1– 4	14·65	12·38	8·88	6·44	4·72	3·51
5– 9	3·50	2·85	1·90	1·29	·90	·65
10–14	1·41	1·12	·72	·49	·35	·27
15–19	1·81	1·42	·89	·59	·42	·33
20–24	3·51	2·71	1·66	1·06	·73	·54
25–29	3·99	3·16	2·03	1·38	·99	·77
30–34	3·94	3·24	2·26	1·65	1·28	1·05
35–39	5·51	4·66	3·41	2·58	2·03	1·67
40–44	4·37	3·92	3·23	2·74	2·34	2·14
45–49	6·76	6·21	5·31	4·62	4·09	3·69
50–54	7·65	7·28	6·64	6·12	5·69	4·74
55–59	11·75	11·34	10·60	9·98	9·44	8·99
60–64	19·37	18·85	17·90	17·07	16·33	15·68
65–69	35·95	35·14	33·65	32·28	31·04	29·92
70–74	60·18	59·15	57·20	55·40	55·35	52·17
75 and over	230·54	227·39	221·33	215·56	210·07	204·85

Table 5

PROJECTED SURVIVAL RATIOS FOR 5-YEAR AGE GROUPS, CEYLON, 1959–1979

	Projected Survival Ratios				
Age groups	1st July, 1959	1st July, 1964	1st July, 1969	1st July, 1974	1st July, 1979
Males					
5 years of births	·92246	·93927	.95181	·96113	·96795
0– 4	·97139	·97879	·98399	·98764	·99021
5– 9	·99184	·99410	·99558	·99655	·99720
10–14	·99478	·99612	·99696	·99749	·99780
15–19	·99275	·99458	·99574	·99642	·99688
20–24	·99002	·99240	·99393	·99487	·99548
25–29	·98935	·99144	·99282	·99368	·99427
30–34	·98590	·98838	·99009	·99134	·99208
35–39	·98173	·98432	·98619	·98762	·98851
40–44	·97341	·97625	·97736	·98017	·98150
45–49	·96265	·96570	·96925	·97008	·97165
50–54	·94570	·94865	·95111	·95319	·95499
55–59	·91558	·91914	·92221	·92488	·92724
60–64	·86562	·86962	·87331	·87664	·87970
65–69	·79177	·79627	·80054	·80447	·80814
70–74	·71036	·71401	·71738	·72065	·72233
75–79	·62435	·62610	·62765	·62946	·63356
80 and over	·47029	·46872	·46709	·46620	·47358
Females					
5 years of birth	·92706	·94388	·95629	·96547	·97219
0– 4	·96696	·97645	·98296	·98748	·99059
5– 9	·99059	·99379	·99577	·99704	·99782
10–14	·99430	·99639	·99756	·99825	·99862
15–19	·98976	·99369	·99593	·99718	·99786
20–24	·98518	·99070	·99387	·99570	·99674
25–29	·98432	·98948	·99257	·99444	·99555
30–34	·98030	·98585	·98947	·99178	·99326
35–39	·97890	·98369	·98697	·98920	·99071
40–44	·97539	·97920	·98206	·98419	·98565
45–49	·96712	·97090	·96075	·97623	·97966
50–54	·95575	·95897	·98842	·96391	·96738
55–59	·92943	·93331	·92369	·93957	·94198
60–64	·87677	·88207	·88686	·89142	·89509
65–69	·79280	·79966	·80605	·80925	·81738
70–74	·68977	·69696	·70416	·70010	·71705
75–79	·57668	·58951	·59070	·57674	·60382
80 and over	·40197	·41117	·41130	·38964	·42055

Table 6

POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND)

HIGH PROJECTION : CONSTANT FERTILITY AND DECLINING MORTALITY

Ages	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	916,000	1,067,000	1,282,000	1,560,000	1,873,000
5– 9	690,000	789,000	899,000	1,054,000	1,272,000	1,550,000
10–14	531,000	685,000	785,000	896,000	1,051,000	1,269,000
15–19	437,000	529,000	682,000	783,000	894,000	1,048,000
20–24	385,000	434,000	526,000	680,000	780,000	892,000
25–29	375,000	381,000	431,000	524,000	677,000	777,000
30–34	344,000	371,000	378,000	428,000	521,000	674,000
35–39	294,000	339,000	368,000	375,000	425,000	517,000
40–44	255,000	289,000	335,000	363,000	371,000	421,000
45–49	218,000	248,000	282,000	328,000	357,000	365,000
50–54	185,000	210,000	240,000	274,000	319,000	347,000
55–59	141,000	175,000	199,000	229,000	262,000	306,000
60–64	96,000	129,000	161,000	184,000	213,000	244,000
65–69	69,000	84,000	113,000	142,000	163,000	188,000
70 and over	90,000	109,000	133,000	172,000	220,000	267,000
All ages	4,922,000	5,688,000	6,599,000	7,714,000	9,085,000	10,738,000
Females						
0– 4	791,000	889,000	1,035,000	1,243,000	1,512,000	1,815,000
5– 9	667,000	764,000	871,000	1,022,000	1,233,000	1,504,000
10–14	508,000	661,000	760,000	868,000	1,020,000	1,232,000
15–19	411,000	505,000	659,000	759,000	867,000	1,019,000
20–24	359,000	408,000	503,000	657,000	757,000	866,000
25–29	346,000	354,000	405,000	501,000	655,000	756,000
30–34	305,000	341,000	351,000	403,000	499,000	653,000
35–39	245,000	300,000	337,000	349,000	400,000	497,000
40–44	205,000	240,000	295,000	334,000	345,000	397,000
45–49	168,000	200,000	236,000	291,000	229,000	341,000
50–54	138,000	163,000	195,000	230,000	285,000	323,000
55–59	105,000	132,000	156,000	188,000	223,000	276,000
60–64	74,000	97,000	124,000	147,000	177,000	211,000
65–69	56,000	65,000	86,000	110,000	132,000	160,000
70 and over	75,000	89,000	106,000	134,000	172,000	214,000
All ages	4,453,000	5,208,000	6,119,000	7,236,000	8,606,000	10,264,000
Both sexes	9,375,000	10,896,000	12,718,000	14,950,000	17,691,000	21,002,000

APPENDIX

Table 7

POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND)

MEDIUM PROJECTION : DECLINING FERTILITY AND DECLINING MORTALITY

Ages \ Year	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	916,000	1,039,000	1,187,000	1,369,000	1,563,000
5– 9	690,000	789,000	899,000	1,027,000	1,177,000	1,361,000
10–14	531,000	685,000	785,000	896,000	1,024,000	1,175,000
15–19	437,000	529,000	682,000	783,000	894,000	1,023,000
20–24	385,000	434,000	526,000	680,000	780,000	892,000
25–29	375,000	381,000	431,000	524,000	677,000	777,000
30–34	344,000	371,000	378,000	428,000	521,000	674,000
35–39	294,000	339,000	368,000	375,000	425,000	517,000
40–44	255,000	289,000	335,000	363,000	371,000	421,000
45–49	218,000	248,000	282,000	328,000	357,000	365,000
50–54	185,000	210,000	240,000	274,000	319,000	347,000
55–59	141,000	175,000	199,000	229,000	262,000	306,000
60–64	96,000	129,000	161,000	184,000	213,000	244,000
65–69	69,000	84,000	113,000	142,000	163,000	188,000
70 and over	90,000	109,000	133,000	172,000	220,000	267,000
All ages	4,922,000	5,688,000	6,571,000	7,592,000	8,772,000	10,120,000
Females						
0– 4	791,000	889,000	1,008,000	1,151,000	1,327,000	1,514,000
5– 9	667,000	764,000	871,000	996,000	1,142,000	1,320,000
10–14	508,000	661,000	760,000	868,000	994,000	1,140,000
15–19	411,000	505,000	659,000	759,000	867,000	993,000
20–24	359,000	408,000	503,000	657,000	757,000	866,000
25–29	346,000	354,000	405,000	501,000	655,000	756,000
30–34	305,000	341,000	351,000	403,000	499,000	653,000
35–39	245,000	300,000	337,000	349,000	400,000	497,000
40–44	205,000	240,000	295,000	334,000	345,000	397,000
45–49	168,000	200,000	236,000	291,000	329,000	341,000
50–54	138,000	163,000	195,000	230,000	285,000	323,000
55–59	105,000	132,000	156,000	188,000	223,000	276,000
60–64	74,000	97,000	124,000	147,000	177,000	211,000
65–69	56,000	65,000	86,000	110,000	132,000	160,000
70 and over	75,000	89,000	106,000	134,000	172,000	214,000
All ages	4,453,000	5,208,000	6,092,000	7,118,000	8,304,000	9,661,000
Both sexes	9,375,000	10,896,000	12,663,000	14,710,000	17,076,000	19,781,000

Table 8

POPULATION OF CEYLON BY AGE 1956–1981 (AS AT 31ST DECEMBER) (ROUNDED TO THE NEAREST THOUSAND) LOW PROJECTION

Ages	1956	1961	1966	1971	1976	1981
Males						
0– 4	812,000	916,000	1,012,000	1,095,000	1,196,000	1,290,000
5– 9	690,000	789,000	899,000	1,000,000	1,086,000	1,189,000
10–14	531,000	685,000	785,000	896,000	997,000	1,083,000
15–19	437,000	529,000	682,000	783,000	894,000	996,000
20–24	385,000	434,000	526,000	680,000	780,000	892,000
25–29	375,000	381,000	431,000	524,000	677,000	777,000
30–34	344,000	371,000	378,000	428,000	521,000	674,000
35–39	294,000	339,000	368,000	375,000	425,000	517,000
40–44	255,000	289,000	335,000	363,000	371,000	421,000
45–49	218,000	248,000	282,000	328,000	357,000	365,000
50–54	185,000	210,000	240,000	274,000	319,000	347,000
55–59	141,000	175,000	199,000	229,000	262,000	306,000
60–64	96,000	129,000	161,000	184,000	213,000	244,000
65–69	69,000	84,000	113,000	142,000	163,000	188,000
70 and over	90,000	109,000	133,000	172,000	220,000	267,000
All ages	4,922,000	5,688,000	6,544,000	7,473,000	8,481,000	9,556,000
Females						
0– 4	791,000	889,000	982,000	1,061,000	1,159,000	1,250,000
5– 9	667,000	764,000	871,000	969,000	1,053,000	1,153,000
10–14	508,000	661,000	760,000	868,000	968,000	1,051,000
15–19	411,000	505,000	659,000	759,000	867,000	967,000
20–24	359,000	408,000	503,000	657,000	757,000	866,000
25–29	346,000	354,000	405,000	501,000	655,000	756,000
30–34	305,000	341,000	351,000	403,000	499,000	653,000
35–39	245,000	300,000	337,000	349,000	400,000	497,000
40–44	205,000	240,000	295,000	334,000	345,000	397,000
45–49	168,000	200,000	236,000	291,000	329,000	341,000
50–54	138,000	163,000	195,000	230,000	285,000	323,000
55–59	105,000	132,000	156,000	188,000	223,000	276,000
60–64	74,000	97,000	124,000	147,000	177,000	211,000
65–69	56,000	65,000	86,000	110,000	132,000	160,000
70 and over	75,000	89,000	106,000	134,000	172,000	214,000
All ages	4,453,000	5,208,000	6,066,000	7,001,000	8,021,000	9,115,000
Both sexes	9,375,000	10,896,000	12,610,000	14,474,000	16,502,000	18,671,000

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