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POPULATION PROJECTIONS OF THE LESS DEVELOPED REGIONS: 1980 – 2000

INTRODUCTION

During the recent past there have been several projections by different international bodies like the United Nations and the other specialised agencies and scholars like Frejka for individual countries and regions of the world. Different projections are obtained by assuming different variants in fertility and mortality decline, e.g., faster, moderately faster or relatively slower rate of decline of fertility or mortality. As is well known, future course of decline in mortality can be predicted more accurately than the future course of decline in fertility. Many of the extensive projections are based on the indicator N.R.R. and an N.R.R. = 1 at different periods in the future has been used in different projections. On the basis of these projection exercises the ultimate expected future size of the world population is also tried to be assessed though there has always been a debate as well as controversy as to the level at which world population will stabilise, if it will stabilise at all, or in technical terms it will attain ZPG and the time of such stabilisation. But one point that emerges from the various projections is that the role of the less developed regions (LDR) is very important in determining the future size and the age distribution of the world population. The more developed regions have already attained a low growth rate as a result of near balancing of their low fertility and low mortality. Moreover, the population of these regions in 1980 is less than 25 percent of the world's population. From this perspective the population projections of the less developed regions under different models and their implications assume greater importance now and are expected to assume even far greater importance in the future.

BASELINE POPULATION: 1980

The detailed projection is carried out by the component method. One of the important parts of the projection apparatus is the baseline population age ditribution and here a population scientist faces a very serious challenge. The age data of less developed regions are subject to errors of age misreporting, under-enumeration and the like and the magnitudes of these biases and errors vary from region to region. Even the total population figures of many of the less developed regions are far from reliable. The national censuses of different regions do not correspond to the same point of time and, above all, the age data of different regions are of different quality. As such we had to reconstruct the aggregated base population age distribution for the less developed regions by assuming stability of age distribution. We are fully aware of the limitations of such estimation procedure but under the present situation it seems to be quite reasonable. The method of reconstruction is discussed briefly in the following paragraphs.

The stable age distribution has the density function

$$c(a) = be^{-ra} \ p(a)$$

where b = birth rate

r = annual rate of increase

$p(a)$ = probability of survival from birth to age a

$c(a)\,da$ = proportion of the population at ages a to $a+da$.

In our reconstruction two key parameters are used, namely, e_0^0 and r. An examination of the data on life expectation at birth (e_0^0) for various countries of the less developed regions (World Population 1979) shows a reasonable value for e_0^0 as of 1980 around 55 years. This is corroborated from the figure given by the United Nations (1971). According to the United Nations estimate, the e_0^0 for the less developed regions during 1965-70 is 50 years. Assuming this corresponds to the midpoint and an increase in e_0^0 during the next 12-13 years to be 5 years, the best estimate for e_0^0 for the less developed regions in 1980 seems to be 55 years. Utilising the same source as metioned above the average annual rate of growth (per cent) has been taken as 2, e. g., $r = .02$ for 1980.

Now a look at the expectations of life at birth (e_0^0) for some of the less developed regions yields Table 1.

Out of these ten countries, in five countries female e_0^0 is in excess, in three countries in deficit and in the remaining two, e_0^0 is the same for the two sexes. It appears, for the LDR as a whole, the life expectancies at birth for the two sexes may reasonably be assumed to be the same.

Having determined the level of e_0^0, and the sex differentials in mortality, the next step is to choose an appropriate life table. Such a life table for combined sexes will be used in computing the stable age distribution in 1980 as well as in carrying out the projections by the well-known component method.

As occurs with the construction of many of the demographic models the obvious choice has been with the Coale Demeny West Model Life Tables. An examination of the Coale Demeny Life Tables shows that $e_0^0 = 55$ for both males and females corresponds approximately to a unit difference in the mortality level as between the two sexes in the model table. Thus the combined life table functions

TABLE 1

Life Expectancies at Birth (e_0^0) for Some of the Populous Developing Countries

Country	Year	e_0^0	
		Male	Female
China	1970-75	59.9	63.3
India	1961-70	46.4	44.7
Indonesia	1960	47.5	47.5
Brazil	1960-70	57.6	61.1
Bangladesh	1970-75	35.8	35.8
Pakistan	1962	53.7	48.8
Nigeria	1965-66	37.2	36.7
Mexico	1975	62.8	66.6
Philippines	1970-75	56.9	60.0
Thailand	1960	53.6	58.7

Note: Total population of these countries is about 72 per cent of the population of the less developed regions.

Source: United Nations Demographic Yearbook, 1976, p. 414.

for the two sexes have been estimated by conjoining a female life table at level '*l*' with a male combined life table at level '*l* + *1*' assuming a sex ratio at birth of 1.06. Such a combined life table will be designated by CLT *(l, l + 1)*. It has been noted that a combined life table obtained as:

$$\frac{1.06 \text{ (male life table fuction at level 16)} + 1.00 \text{ (female life table function at level 15)}}{2.06}$$

yields a value of 54.55 for e_0^0. This life table has actually been taken for the construction of the base line stable age distribution. Of course for actual projection the combined life table as appropriate for any quinquennium has always been estimated by reading linearly between the two combined life tables with e_0^0 values bracketing the assumed value of e_0^0 under the particular model.

As a check to our calculation, the stable birth rate has been computed and has been found to be .0334. A stable birth rate of 33.4 per thousand per annum for the LDR in 1980 seems to be quite consistent and well within the range provided by different scholars. This strengthens the method of derivation of and gives confidence to the base line age distribution in 1980. According to the latest documentation the estimated total population for the less developed regions in 1979, is 3282965 thousand. With an exponential rate of growth of 2% per annum ($r = .02$) the estimated total population for 1980 comes out as 3282965 $e^{.02}$ = 33,493 (in 10^5 *s*). The base line stable age distribution for the less developed regions is shown in the following table.

TABLE 2

Stable Baseline Age Distribution of Less Developed Regions: 1980

Age group	Population	
	Number (in 10^5)	Percent
0 - 4	4,756	14.2
5 - 9	4,120	12.3
10 - 14	3,684	11.0
15 - 19	3,282	9.8
20 - 24	2,914	8.7
25 - 29	2,579	7.7
30 - 34	2,278	6.8
35 - 39	1,976	5.9
40 - 44	1,742	5.2
45 - 49	1,507	4.5
50 - 54	1,273	3.8
55 - 59	1,072	3.2
60 - 64	837	2.5
65 - 69	636	1.9
70 - 74	435	1.3
75 - 79	268	.8
80 +	134	.4
Total	33,493	100.0

METHODOLOGY OF PROJECTION

The following symbols have been used in this paper:

$P(a)$	=	population in the 5 year age group $(a, a+4)$
$P(a+)$	=	population at ages a and above
P	=	total population
$l(0)$	=	radix of the life table
$L(a)$	=	life table population in the 5 year age group $(a, a+4)$
$T(a)$	=	life table population at ages a and above
b	=	birth rate

A suffix 't' has been used to denote the point of reference. Thus $P(a, t)$ denotes the population in the 5 year age group $(a, a+4)$ at time 't'.

The projected populations at time $t+5$ for various age groups are obtained from the following equations:

$$P(a, t) \cdot \frac{L(a+5,\ t+2.5)}{L(a,\ t+2.5)} = P(a+5,\ t+5) \ldots\ldots\ldots\ldots [1]$$

$$P(75+, t) \cdot \frac{T(80, t+2.5)}{T(75, t+2.5)} = P(80+, t+5) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

$$\frac{P(t)\, b(t) + P(t+5)\, b(t+5)}{2} \cdot \frac{L(0, t+2.5)}{l(0, t+2.5)} = P(0, t+5) \ldots\ldots\ldots\ldots\ldots [3]$$

It should be noted that the survival ratios used for projecting the population at time 't' 5 years hence are taken from the appropriate life table based on the assumed value of e_0^0 at the midpoint of the quinquennium $(t, t+5)$, e.g., at the time point $t + 2.5$. The projection is carried out in 5-year age groups at intervals of 5 years for a twenty year period 1980-2000.

FUTURE COURSE OF MOVEMENTS OF FERTILITY AND MORTALITY

Fertility :

Population projections can be carried out through different indices of fertility like general fertility rate, age specific fertility rates, gross reproduction rate and the crude birth rate. As most of the national population policies aim at reducing the crude birth rate (CBR) to different levels according to different targets here in our projection assumed levels of future CBR have been used. Three different models have been set according to the different levels of CBR to be attained in 2000. A linear path of decline has been assumed in all the models. The assumptions regarding the future course of movements in CBR are in accordance with the national population policies being adopted and pursued at present and likely to be pursued in the near future. The assumed levels of CBR for different models are shown below.

Model		1980	1985	1990	1995	2000
High fertility	F_1	33	32	31	30	29
Medium fertility	F_2	33	31	29	27	25
Low fertility	F_3	33	30	27	24	21

Mortality :

Expectations of life at birth have been taken as the main indicators of various projections. Looking at the trend in current mortality in the less developed regions and the course movements of mortality during the recent past, two different courses of trends in e_0^0 have been assumed for our projections. In one model (medium mortality assumption) life expectancy at birth has been assumed to increase at a moderate rate of 2.5 points per decade whereas provision has been made for a faster rate of increase, namely an increase of 5 points per decade in the second model (low mortality assumption). Here again in both the models linear path of increase has been assumed. The expectations of life at birth for different years under the two models are shown below:

Model		1980	1985	1990	1995	2000
Medium mortality	M_2	55	56.25	57.5	58.75	60
Low mortality	M_3	55	57.5	60.0	62.5	65

The survival factors appropriate for any quinquennium have been computed from the Coale Demeny West Model Combined Life Tables corresponding to the assumed value of e_0^0 for the midpoint of the quinquennium. For clarity, the method has been illustrated below for 1980-1985 under medium mortality assumption.

Average e_0^0 for 1980-1985 : $\frac{55 + 56.25}{2} = 55.625$

e_0^0 for the combined life table at female level 15 and male level 16 = 54.556

e_0^0 for the combined life table at female level 16 and male level 17 = 56.975

By linear interpolation .558 CLT (15, 16) + .442 CLT (16, 17) is the final combined life table corresponding to $e_0^0 = 55.625$.

RESULTS OF PROJECTIONS

Each of the three sets of fertility assumptions is combined with each of the two sets of mortality assumptions and altogether six sets of projections are obtained. It is apparent that out of the six sets all are not equally likely. Some fertility decline may be more likely than the others and similar is the situation with mortality. For the less developed regions as a whole, though with modernisation we expect a positive relationship between the pace of decline in fertility and the pace of decline in mortality, the relationship may not be the same for all the individual regions from the qualitative as well as from the quantitative point of view.

Tables below show the projected populations for the six sets along with the resulting exponential rates of growth (per cent) under different projections.

DISCUSSION

The salient points that emerge from the above tables are noted below:

a) The size of the population of the less developed regions in 2000 will range from 4,561 million (F_3 M_2) to 5,043 million (F_1 M_3) according to the as-

TABLE 3

Projected Population (in 10^5) of Less Developed Regions, 1985-2000

Age group	1985	1990	1995	2000	1985	1990	1995	2000
		F_1M_2				F_1M_3		
0-4	5,118	5,519	5,932	6,356	5,144	5,604	6,107	6,644
5-9	4,596	4,963	5,369	5,789	4,604	5,011	5,492	6,017
10-14	4,070	4,545	4,913	5,319	4,072	4,559	4,971	5,458
15-19	3,636	4,021	4,495	4,863	3,638	4,029	4,519	4,936
20-24	3,222	3,574	3,958	4,430	3,224	3,583	3,978	4,472
25-29	2,849	3,155	3,506	3,888	2,851	3,164	3,528	3,927
30-34	2,514	2,783	3,087	3,436	2,517	2,792	3,109	3,478
35-39	2,212	2,446	2,713	3,016	2,214	2,456	2,735	3,056
40-44	1,907	2,140	2,371	2,636	1,909	2,148	2,394	2,676
45-49	1,666	1,829	2,057	2,284	1,668	1,837	2,077	2,325
50-54	1,420	1,574	1,733	1,954	1,422	1,582	1,752	1,991
55-59	1,172	1,312	1,458	1,611	1,174	1,319	1,477	1,646
60-64	951	1,044	1,173	1,309	953	1,052	1,191	1,344
65-69	701	800	883	997	703	808	901	1,030
70-74	487	540	620	688	488	546	636	717
75-79	289	326	364	421	290	330	375	444
80 +	168	193	222	253	169	197	232	273
Total	36,978	40,764	44,854	49,250	37,040	41,017	45,474	50,434
Exponential rate of growth (% per annum)	1.98	1.95	1.91	1.87	2.01	2.04	2.06	2.07
		F_2M_2				F_2M_3		
0-4	5,030	5,220	5,357	5,431	5,055	5,301	5,514	5,673
5-9	4,596	4,878	5,078	5,228	4,604	4,924	5,195	5,432
10-14	4,070	4,545	4,828	5,031	4,072	4,559	4,885	5,163
15-19	3,636	4,021	4,495	4,779	3,638	4,029	4,519	4,850
20-24	3,222	3,574	3,958	4,430	3,224	3,583	3,978	4,472
25-29	2,849	3,155	3,506	3,888	2,851	3,164	3,528	3,927
30-34	2,514	2,783	3,087	3,436	2,517	2,792	3,109	3,478
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50-54	1,420	1,574	1,733	1,954	1,422	1,582	1,752	1,991
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60-64	951	1,044	1,173	1,309	953	1,052	1,191	1,344
65-69	701	800	883	997	703	808	901	1,030
70-74	487	540	620	688	488	546	636	717
75-79	289	326	364	421	290	330	375	444
80 +	168	193	222	253	169	197	232	273
Total	36,890	40,380	43,903	47,392	36,951	40,627	44,498	48,497
Exponential rate of growth (% per annum)	1.93	1.81	1.67	1.53	1.96	1.89	1.82	1.72
		F_3M_2				F_3M_3		
0-4	4,941	4,926	4,800	4,558	4,966	5,001	4,939	4,758
5-9	4,596	4,792	4,792	4,684	4,604	4,838	4,901	4,866
10-14	4,070	4,545	4,743	4,748	4,072	4,559	4,800	4,870
15-19	3,636	4,021	4,495	4,695	3,638	4,029	4,519	4,766
20-24	3,222	3,574	3,958	4,430	3,224	3,583	3,978	4,472
25-29	2,849	3,155	3,506	3,888	2,851	3,164	3,528	3,927
30-34	2,514	2,783	3,087	3,436	2,517	2,792	3,109	3,478
35-39	2,212	2,446	2,713	3,016	2,214	2,456	2,735	3,056
40-44	1,907	2,140	2,371	2,636	1,909	2,148	2,394	2,676
45-49	1,666	1,829	2,057	2,284	1,668	1,837	2,077	2,325
50-54	1,420	1,574	1,733	1,954	1,422	1,582	1,752	1,991
55-59	1,172	1,312	1,458	1,611	1,174	1,319	1,477	1,646
60-64	941	1,044	1,173	1,309	953	1052	1,191	1,344
65-69	701	800	883	997	703	808	901	1,030
70-74	487	540	620	688	488	546	636	717
75-79	289	326	364	421	290	330	375	444
80 +	168	193	222	253	169	197	232	273
Total	36,801	40,000	42,975	45,608	36,862	40,241	43,544	46,639
Exponential rate of growth (% per annum)	1.88	1.67	1.43	1.19	1.92	1.75	1.58	1.37

sumed levels of fertility and mortality in the future. The relatively low figure of 4,561 million will be attained with the projection incorporating relatively slower increase in e_0^0 or, in other words, slower mortality decline, and relatively faster rate of fertility decline. But in societies gradually progressing towards modernisation and industrialisation, this sort of fertility mortality combination seems to be less likely though it cannot be totally discarded either. On the other hand, the theoretically more likely combinations like F_3 M_3 and F_2 M_2 will result in 4,664 and 4,739 million population respectively in 2000. Following theory, the projected population under the F_3 M_2 will be the minimum and under F_1 M_3 will be the maximum, the differences in the total population between the two sets being 24, 102, 250 and 483 millions in 1985, 1990, 1995 and 2000 respectively.

b) In conformity with demographic theory and Ansley Coale's numerous writings on the effect of fertility and mortality on the population age structure, the age distributions under different projections depict a very interesting picture.

We are all familiar with the marked effect of fertility on the age distribution of a population and the impact of various combinations of fertility and mortality on the age structure can be seen from Table 4 showing the projected populations in broad age groups. Whereas with F_3 M_2 the population aged 0-4 in 2000 is actually smaller than that in 1980 and by about 4 per cent and that under F_3 M_3 remains more or less at the same level, and a large part of the population increase in these two models is observed to be in the middle and in the older age groups, the population aged 0-4 under F_1 M_3 in 2000 shows a substantial increase of about 40 per cent over 1980.

c) For the future growth rate, with high fertility it remains at a level of around 2 per cent per annum showing a tendency of slight increase or decrease according to the assumptions made regarding the rate of decline in mortality. The faster rate of decline in r resulting in the lowest value of r is observed to be with F_3 M_2. While according to this model the exponential rate of growth during the quinquennium 1995-2000 will attain a figure of as low as 1.19 per cent per annum, from theoretical point of view the model F_3 M_3 seems to be more likely unless there is some drastic change in the fertility mortality interrelationship in the LDR of the world in the near future. Thus there is more likelihood of the LDR attaining a population size of 4,664 million by the end of the present century coupled with a growth rate of about 1.37 per cent per annum during 1995-2000.

Finally let us look at the possibilities of ZPG. According to the report from the United Nations population Development Forum released on July 14, 1981 "The world's population will stop growing in 130 years when there could be 14.2 billion people or two and a half times more than now. But the maximum number could be as low as eight billion depending on the effectiveness of the birth control programmes". Here we have undertaken a simple though, to some extent, hypothetical mathematical exercise. These types of exercises are not always totally useless as they appear to be primafacie. As has been argued the projection under F_3 M_3 seems

TABLE 4

Projected Population (in 10^5) of Less Developed Regions by Broad Age Groups, 1985-2000

Age group	1985	1990	1995	2000	1985	1990	1995	2000
		$F_1 M_2$				$F_1 M_3$		
0 - 4	5,118	5,519	5,932	6,356	5,144	5,604	6,107	6,644
5 - 14	8,666	9,508	10,282	11,108	8,676	9,570	10,463	11,475
15 - 64	21,549	23,878	26,551	29,427	21,570	23,962	26,760	29,851
65 +	1,645	1,859	2,089	2,359	1,650	1,881	2,144	2,464
		$F_2 M_2$				$F_2 M_2$		
0 - 4	5,030	5,220	5,357	5,431	5,055	5,301	5,514	5,673
5 - 14	8,666	9,423	9,906	10,259	8,676	9,483	10,080	10,595
15 - 64	21,549	23,878	26,551	29,343	21,570	23,962	26,760	29,765
65 +	1,645	1,859	2,089	2,359	1,650	1,881	2,144	2,464
		$F_3 M_3$				$F_3 M_3$		
0 - 4	4,941	4,926	4,800	4,558	4,966	5,001	4,939	4,758
5 - 14	8,666	9,337	9,535	9,432	8,676	9,397	9,701	9,736
15 - 64	21,549	23,878	26,551	29,259	21,570	23,962	26,760	29,681
65 +	1,645	1,859	2,089	2,359	1,650	1,881	2,144	2,464

to be the most plausible amongst the six sets presented here, and the growth rates observed under this model decline monotonically from the start attaining a value of 1.37 per cent during 1995-2000. For fitting a growth curve, along with the projected populations for 1985-2000 populations for 1975 (World Population,1979) and 1980 are also considered. A little trial and error shows that a simple logistic:

$$P_t = \frac{71{,}757}{1 + e^{\frac{1.70658 - t}{5.30467}}}$$

(P_t = fitted population in 10^5 at time t,
origin = 1975,
unit of time = 5 years).

gives a very good fit to the projected population data for the less developed regions under $F_3\, M_3$. The projected values along with the fitted ones are shown below.

Year	1975	1980	1985	1990	1995	2000
Projected	30,156	33,493	36,862	40,241	43,544	46,639
Fitted	30,156	33,492	36,870	40,231	43,516	46,672

Using logistic model, it is interesting to note, that the population of the LDR will stabilise at 7,2 billion around the middle of 22nd century.

If we add to this another 2 billion of population for the more developed regions which have been worked out by different agencies and for which variations have not been observed to be very much according to the different sets of projections, the ultimate figure at which world population will stabilise comes out to be around 9 billion. Let us all hope that the world population will stabilise at least at the level of 9 billion around 2150.

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SUMMARY

In this paper the population projections for the less developed regions (1980-2000) have been worked out under different combinations of fertility and mortality. Six sets of projections have been presented.

The base population has been constructed by using stable population model. In this reconstruction two paramenters – the life expectancy at birth (e_0^0) and intrinsic rate of growth *(r)* have been used. As for fertility, three sets of assumptions have been made according to the different levels of CBR to be attained by 2000. Regarding future trend in mortality, two sets of assumptions based on the movement of e_0^0 and model life tables have been made.

Finally a simple logistic has been fitted to the projected populations obtained by the medium variant projection and has been found to be satisfactory. According to this model, the population of the LDR is expected to stabilise at about 7 billion around the middle of the 22nd century.

RIASSUNTO

Il lavoro si occupa di previsioni della popolazione delle regioni meno sviluppate, ottenute combinando diverse ipotesi evolutive sulla fecondità e la mortalità. Vengono illustrati i risultati di sei di tali combinazioni previsive.

La popolazione di base è stata ricostruita ricorrendo al modello della popolazione stabile, prescelto in base a due parametri: la speranza di vita alla nascita (e_0^0) e il saggio intrinseco di incremento (r).

In quanto alla fecondità, sono stati adottati tre tipi di ipotesi secondo il livello del tasso generico di natalità (CBR) previsto per il 2000. Riguardo al trend futuro della mortalità, le due serie di ipotesi si basano invece sull'evoluzione di e_0^0 e su tavole tipo di mortalità.

Infine, una logistica semplice è stata adattata alle popolazioni previste in base alla combinazione di ipotesi denominata "variante media" con risultati soddisfacenti. Secondo questo modello, la popolazione dei paesi meno sviluppati dovrebbe raggiungere i 7 miliardi intorno alla metà del ventiduesimo secolo.

RESUME

Dans ce travail on a fait des prévisions de la population des régions sous-développées (1980-2000) sous des combinaisons différentes de fécondité et de mortalité. Ici, six de ces prévisions ont été présentées.

La population de base a été construite en employant le modèle de population stable. Dans cette reconstruction, deux paramètres: l'éspérance de vie à la naissance (e_0^0) et le taux intrinsèque d'accroissement (r), ont été utilisés. Quant à la fécondité, on a adopté trois types d'hypothèses selon le niveau du taux de natalité (CBR) à atteindre d'ici l'an 2000. Pour ce qui concerne la tendance de la mortalité, deux ensembles d'hypothèses basées sur le mouvement de e_0^0 et les tableaux modèles de vie ont été pris.

Finalement, une courbe logistique simple a été prise pour la population projetée, obtenue par la méthode de projections appelée "medium variant projection" et qui se montre satisfaisante. Selon ce modèle, il est probable que la population des régions les moins développées se stabilise autour de 7 milliards autour de la moitié du vingt-deuxième siècle.