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World Population Projections for the 21st Century*

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1. Introduction and Proposition

Up to the mid-18th century, it was still an open question as to whether the world population had grown or diminished since the olden days. It was not until demography developed along with regular censuses being carried out in a number of different European countries during the 18th century that a clearer picture emerged. It is now thought probable that the population of the world around the time of the birth of Christ lay between 200 and 400 million. Today (1995), there are estimated to be 5.7 billion people, i.e. about twenty times as many, living on the planet Earth.

In the first one-and-a-half milennia A.D., world population growth was extraordinarily slow. The average annual rate during that period was well below 0.1%. As industrialization got under way around 1750, the growth in the world's population took a considerable leap, yet still remained well below 1% until the end of the 19th century. The 20th century, though, will go down in population history as the century which brought a unique acceleration in growth. In other words, not only the world population has grown markedly but also the growth rate as such, so the pace of that growth has hotted up (see *Figure 5*, lower graph). This phenomenon of increasing growth rates is referred to as *hypergeometric population growth*. The rate grew from 0.5% in 1900 to 0.8% in 1950 and then to 2.1% in the early 1970s. If the world population figure for 1975 - when the Earth had 4.07 billion inhabitants - were to have continued growing steadily

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at that same rate for 100 years, that would have meant a world population of 32 billion in 2075. The rate of world population growth has in fact fallen off from its early-1970s peak of 2.1% to reach approximately 1.5-1.6% at present (1995). However, in spite of that decline the *absolute* population figure is still increasing - the in-built momentum is rather like that of a supertanker which, even as it is slowing down, can still travel some miles before it is brought to a stand. The present rate of increase in absolute terms is approx. 90-100 million each year, or approx. 1 billion per decade (see *Figures 24* and *25*). The time needed by the world population to increase by another billion has shortened from 121 years in 1805 to just 11 years in present times (see *Table 1*).

Public interest in the issue of world population growth is largely concentrated upon the double question of how long the population will continue to grow (i.e., up to which year) and what level it will have reached by that time, likely to be in the late 21st or early 22nd century. As long as the number of live births per woman, defined as the *total fertility rate* (TFR), remains above 2.13 (the *replacement fertility level* which corresponds to a *net reproduction rate* (NRR) of 1.0) on a world average, the population will go on increasing. Because of the relatively young profile of the world population, even after the replacement fertility level has been attained and subsequently maintained, it will in fact still go on growing for between 50 and 100 years more. The crucial question is therefore how many decades will be needed before the total fertility rate comes down to the replacement fertility level of 2.13 live births per woman.

The present-day (period 1990-95) total fertility rate is 1.91 in the industrial countries, 3.64 in the developing countries, and 3.26 for the world as a whole (United Nations World Population Prospects, The 1992 Revision). If the two separate rates for the industrial and developing countries were each to continue unchanged, the effect on the world average total fertility rate would be for it to rise rather than fall as projections assume: for example, by the year 2050 it would have risen to 3.39 from the current 3.26. In view of the indisputable rise in the developing countries' share of total world population, it is fair to ask how probable it is that the world's total fertility rate really will have come down to replacement level by the year 2060 or even by the year 2055 as assumed, for example, by the *World Bank* in its latest estimates (World Population Projection, 1992-93 and 1994-95 Editions). That question will be addressed in this paper.

Over the past few decades, the average total fertility rate for the world population as a whole has fallen considerably, from 4.98 live births per woman in the 1960-65 period to 3.26 in 1990-95 (UN, 1993: 216; see *Figure 3*). This pronounced absolute drop has

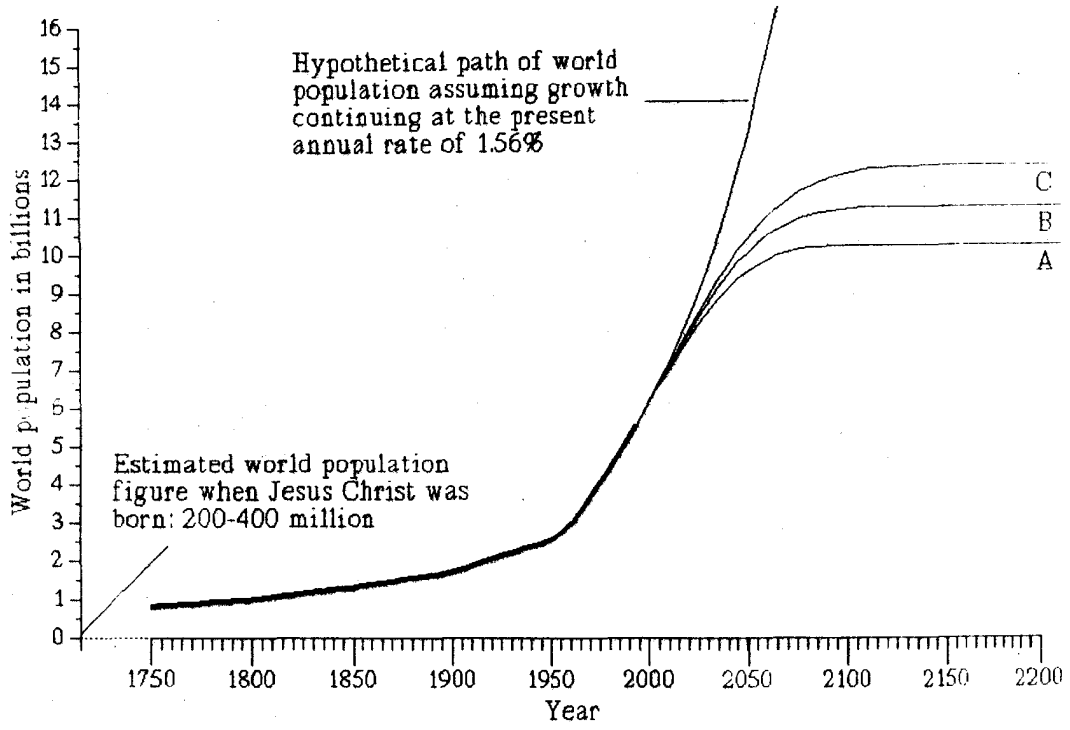
Table 1

World Population Growth since the Birth of Christ

	Year	Number of years needed to reach next billion
200 - 400 Millions	0	1800 years
⋮	⋮	
First Billion	1805	
Second Billion	1926	121 years
Third Billion	1960	34 years
Fourth Billion	1974	14 years
Fifth Billion	1987	13 years
Sixth Billion	1998	11 years
Seventh Billion	2010	12 years
Eighth Billion	2023	13 years
Ninth Billion	2040	17 years
Tenth Billion	2070	30 years
Eleventh Billion	c. 2100	30 years

Figure 1

World Population Growth since 1750 and Projections for the 21st Century



A = Hyperbolical decrease in fertility to reach 2.13 children per woman by 2040, remaining constant thereafter (medium mortlity level)
B = Hyperbolic decrease in fertility up to 2060
C = Hyperbolic decrease in fertility up to 2080

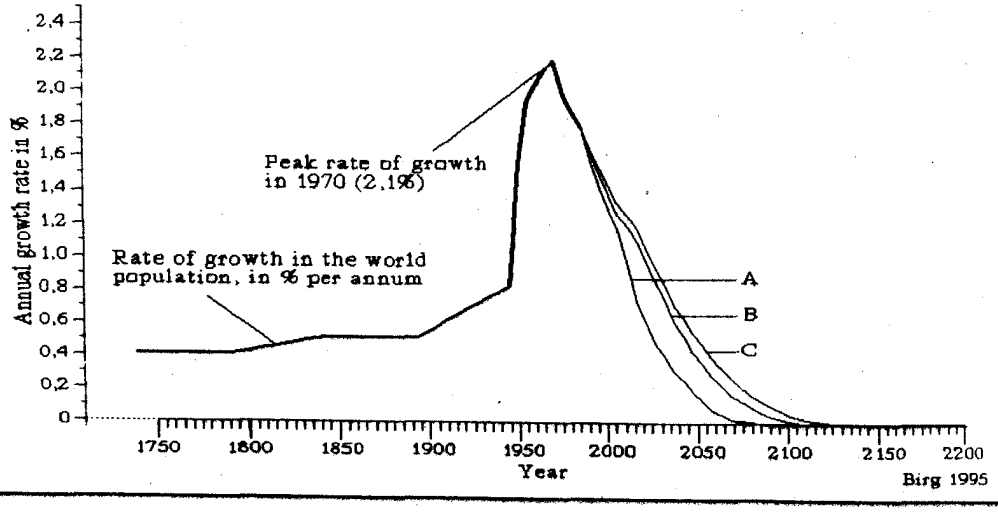
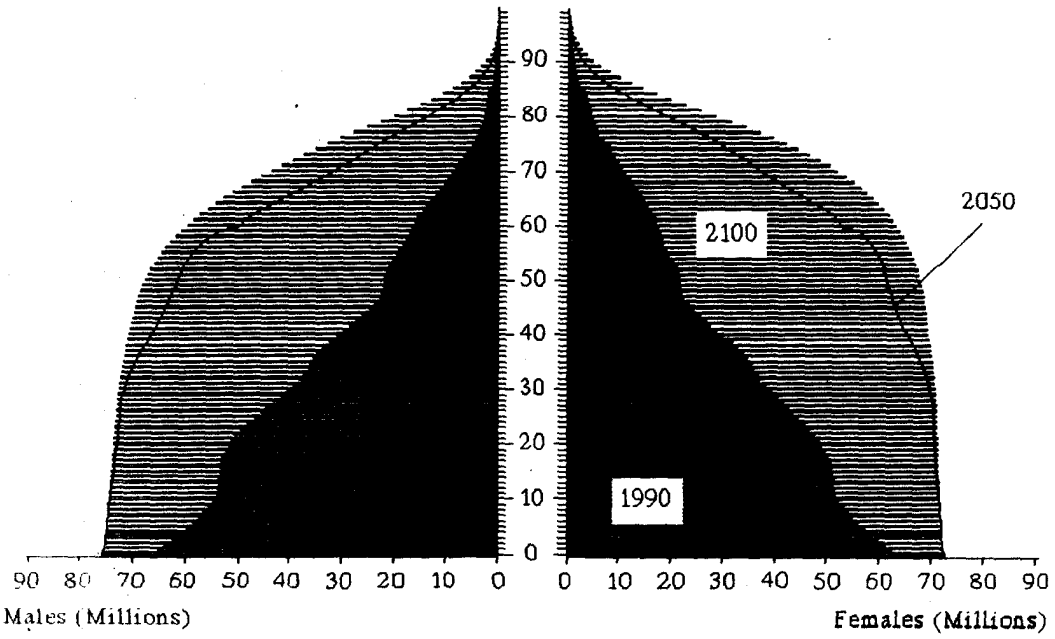


Figure 2

Age Structure of World Population 1990, 2050 and 2100

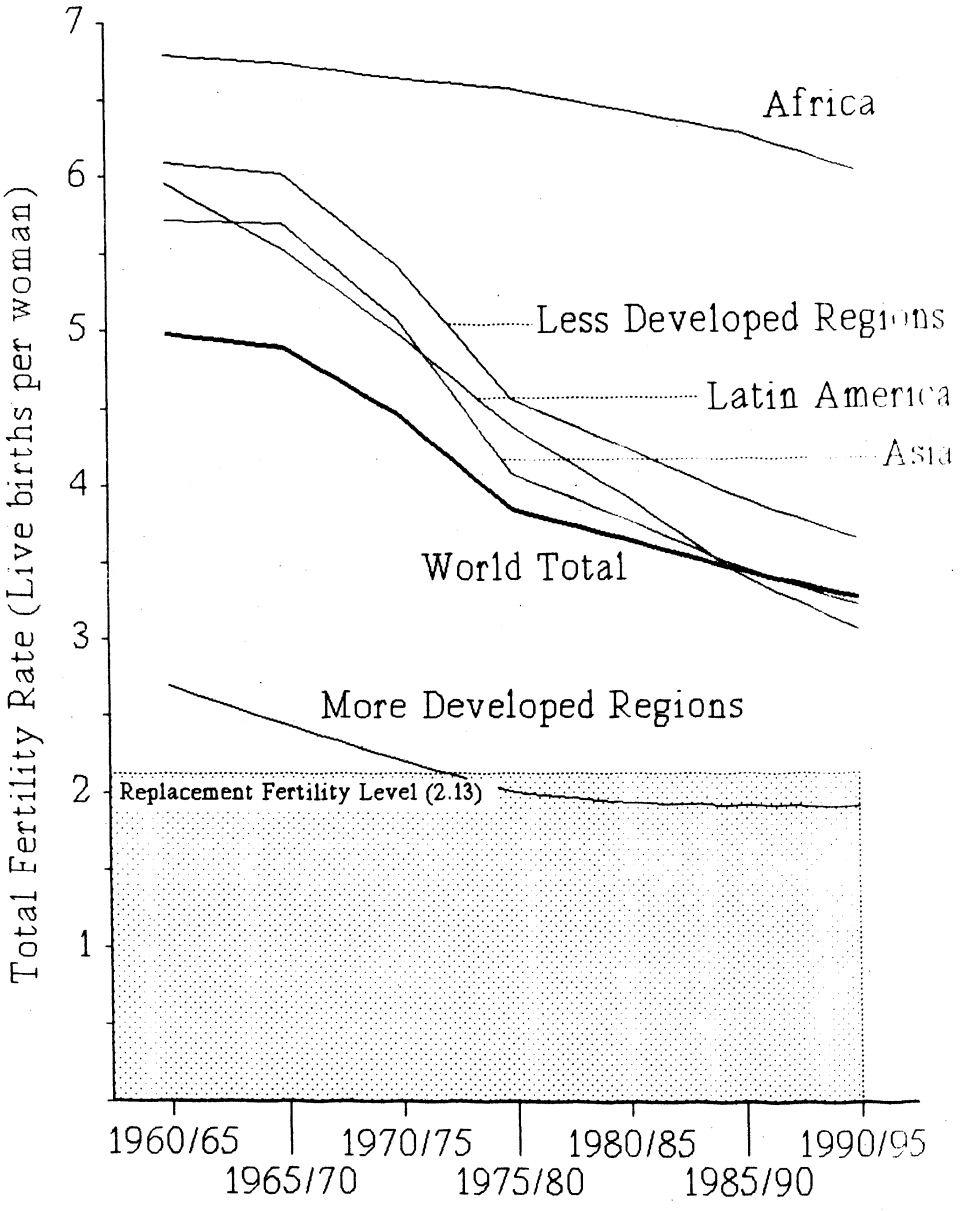


Population Projection No. 2060.R.M.

Target year for replacement fertility level (TFR = 2.13):	2060
Form of fertility decline:	Hyperbolic
Mortality level:	Medium
Total population:	1990 5 275 Million
	2050 9 824 Million
	2100 10 674 Million

Figure 3

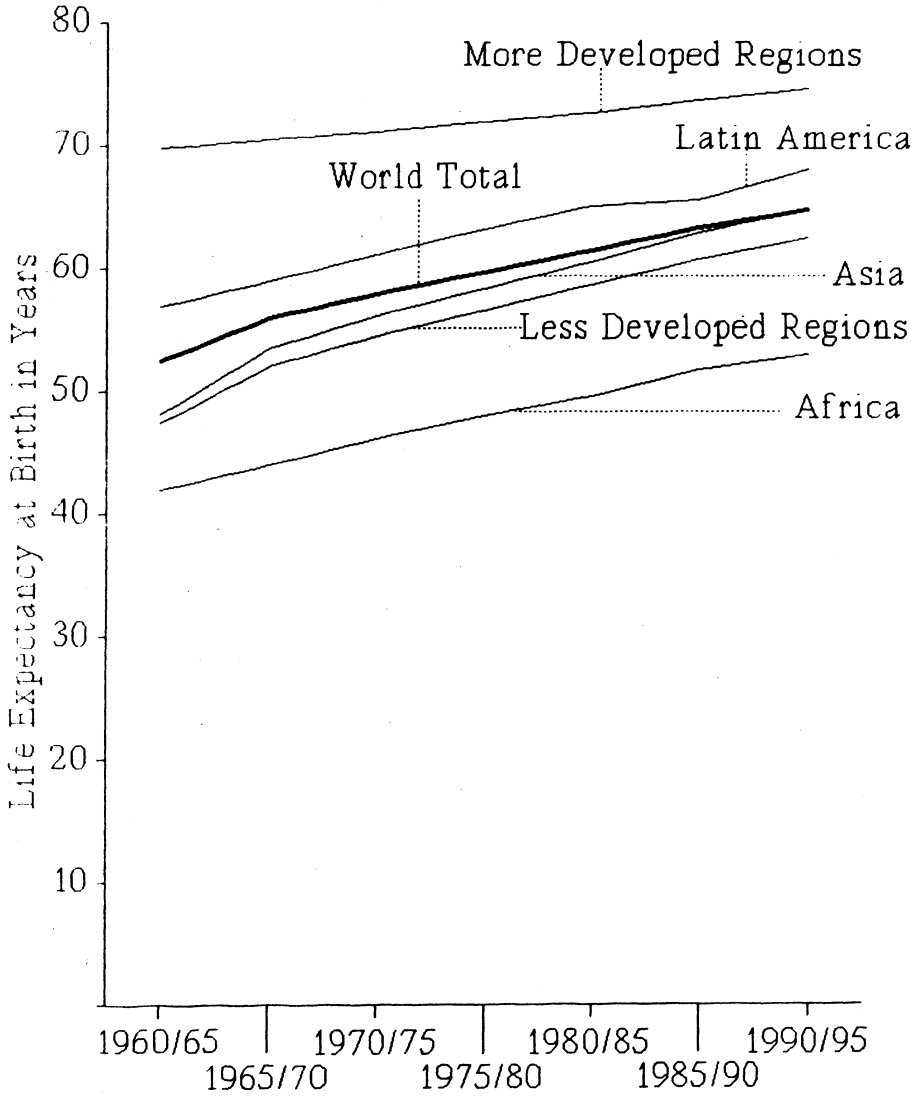
Decline in the Total Fertility Rate from 1960-65 to 1990-95 by Major Area



Source of Data: UN (Ed.), World Population Prospects - The 1992 Edition, New York 1993

Figure 4

Increase in Life Expectancy at Birth from 1960-65 to 1990-95 by Major Area



Source of Data: UN (Ed.), World Population Prospects - The 1992 Edition, New York 1993

diverted attention from the fact that the actual pace of the decline has slowed steadily during those three decades. Indeed, if the high rate of decline between 1965-70 and 1975-80 (-2.4 per cent p.a.) had been maintained, the total fertility rate ought to reach replacement level at the end of this decade: A number of statistics help to illustrate how much the pace of decline has slowed: between the second half of the 1960s and the second half of the 1970s, the TFR fell by 1.05 live births per woman; between the second half of the 1970s and the second of the 1980s, the corresponding fall was less than half of that, at only 0.41 live births per woman (1975-80: 3.84; 1985-90: 3.43). The *proposition* which will be put forward here is that the pace of decline in the total fertility rate is likely to continue slackening in the decades ahead. The proposition is not based simply on a projection of earlier trends, but on the following three substantive arguments:

1. People in the developing countries are likely to realize that, given the inadequacy of state unemployment and sickness benefits and old-age pensions, two children who attain adult age will not be sufficient to safeguard their parents' economic livelihood, to maintain family networks of mutual assistance or to comply with religious precepts and cultural norms.

2. Because of this, it will be all the more difficult to achieve further reductions in the level of fertility the lower that level has already sunk. In order to reduce the number of children per woman by the same amount each decade, ever greater efforts will be called for on the part of development, population and family-planning policies. That in turn will mean that so many funds will be required that donor countries will have to substantially increase the assistance they provide.

3. As their relative demographic weighting increases, the developing countries' contribution towards the world total fertility rate will also steadily increase, so that a growing proportion of development and population policy efforts will need to be devoted even just to counterbalancing the increase in world total fertility rate caused by that change in weighting alone.

These propositions do not contradict the findings of the Demographic and Health Surveys (DHS) or the Family Planning Surveys (FPS) conducted by *Johns Hopkins University* in 40 developing countries during the 1980s (Robey 1992 and 1994). When the results of these were published in December 1992, the figures were misunderstood all around the world as implying that the situation was now easing (Stevens, 1994). Yet demographic researchers see no reason at present to revise any earlier population

projections downwards - quite the reverse. The UN's *Population Division* did not make any adjustments at all to its 1990 assumptions when making its 1992 estimates of the future trend in the total fertility rate in developing countries, while the latest publications on the subject by the *World Bank* (1992-93 and 1994-95 revisions) actually revised the forecast TFR slightly upwards for the second half of the 21st century. According to the revision of 1992-93 the TFR in 2075 ist estimated at 2.08, and according to the revision of 1994-95 at 2.09.

2. Methodological Aspects, Basic Terms and the Initial Data used for Population Projections

(a) Initial Population, Fertility, Mortality and Projection Method

The population projections presented here have been prepared using the same method as those published by the World Bank and the UN Population Division, namely what is known as the *cohort survival method*. So as to be able to delineate as clearly as possible between the influence of the age profile and that of fertility and mortality rates on the final results obtained, the base population in 1990 was differentiated by 100 different years of age and by gender (the source of the initial data for *5-year* age groups is K.C. Zachariah and My T. Vu, 1988)). Taking 1990 as the *base year*, the next step is to calculate the number of males and females in each age cohort who are expected to survive into the following year, according to the statistical survival probability for the gender and age- group. When that operation is complete, one year is added to the age of each of the 200 cohorts, and the same procedure is then repeated for the surviving 1991 population thus obtained, and for each subsequent year until the end of the projection period is reached. Hence a projection running until the year 2100 which has 1990 as its base year will call for 110 computational steps, and the number of people surviving into, say, 2050 will be calculated on the basis of the projected population in 2049. The survival probabilities for the world population needed to apply this method were computed separately for each age cohort and each gender. The parameters used also took account of the fact that the survival probabilities of younger people are rising considerably faster than those of older age-groups in the population (for details see *technical appendix 1* in: Birg, 1995).

The *number of live-born* children in any given year of the projection period less the figure deducted for infants dying before they reach one year of age gives the world population in the 0-1 age-group for the start of the following year. The method used to

calculate the number of live-born children each year is as follows: First the number of women in each of the 31 age cohorts (from 15 to 45 years old) who have survived until that year in the projection is identified from the calculations already made. Then the number of women in each of those cohorts is multiplied by the corresponding age-specific fertility rate (of which there are again 31 different rates), and the aggregate number of live births for the year is established by adding all of the age-specific results together. The *age- specific fertility rate* is nothing more than the probability that a woman in a particular age-group will give birth to a child during the following year. Starting out at a very low value at age 15, the age-specific fertility rates are distributed along a bell-shaped curve which returns to zero around the age of 45 years. The age-specific fertility rates all add together to give the *total fertility rate* (see technical appendix in: Birg, 1995).

(b) Basic Terms: Replacement Fertility Level, Momentum of Population Growth and "if-then"-Statements on the Future

The *replacement fertility level* is the particular total fertility rate which, at a predetermined mortality level (derived from the measure of survival probabilities), allows just enough children to be born to replace their parents' generation. On the basis of the present and future life expectancies which have been used and assumed for these projections, that replacement fertility rate is 2.13 live births per woman. In other words, every 100 women need to give birth to 213 children for the population to sustain itself in the long run.

However, even assuming that the world's total fertility rate, at some point in the future, were to reach the replacement fertility level, the population itself would continue to *grow* for a further 50 to 100 years because of the *demographic momentum* inherent in the relatively young age profile, before it attained a stationary state in which both the total population figure and the age profile remained stable. In such a stationary state, the *net reproduction rate* (NRR) equals 1. The net reproduction rate is the ratio of the size of a new generation to that of its parents' generation. As a general rule, if the NRR is greater than one (>1), the population will grow, if NRR<1 it will fall, and if it equals 1, it will remain constant in the long run. To illustrate, the net reproduction rate in the world is currently 1.314 implying an increase of 36% from one generation to another (in approx. 25 years).

The methods of demographic projection allow a precise answer to be given to the following ***hypothetical question***: Assuming the total fertility rate were to come down to

the replacement fertility level of 2.13 live births per woman in just one year, by how many people, or by what percentage, would the world population continue to grow? And that answer is that the world population would grow from 5.3 billion in 1990 to 7.3 billion in 2040, or in other words by approx. 40%! The significance of this hypothetical calculation is that it clearly demonstrates the importance of attaining replacement fertility as early as possible. If it were not attained in one year as in the hypothetical case just cited, but in an equally hypothetical period of 10 years, the world population would then go on growing until the year 2050, and would stabilize at the higher level of 7.9 billion. Such computations will be illustrated in more detail and on a systematic basis below.

The computations, projections and simulations shown here should *not* be regarded as *population forecasts or prophecies*; rather they consist of *"if ... then ... statements"* with regard to the future. That is to say, these statements as to future developments will prove true if the assumptions on which they are based are fulfilled. The consequences for fertility and mortality derived from these if-then conditions can be ascertained with a high degree of accuracy.

3. Impact of Alternative Fertility Scenarios on World Population Growth

(a) Alternative Patterns of Decline and Target Years for Fertility Reduction (= Fertility Paths)

The target year is the description given to the future year at which the world total fertility rate is expected to have fallen from the 3.4 live births per woman registered in the base year (1990) to the replacement fertility level of 2.13 live births per woman. The alternative target-year scenarios reflect varying degrees of optimism in the assumed rapidity with which fertility will decline in future. As has been pointed out, these are *not* forecast values, but alternative sets of if-then assumptions, and the current purpose is to investigate the consequences flowing from particular assumptions of this kind. As there is no special need here to examine particular target years, an interval of 10 years has been chosen, giving the sequence of 2000, 2010, 2020, ..., 2060 (i.e. the target year assumed in the World Bank's projections of 1992-93), 2070, ..., 2100. It would be equally possible to make the calculations for any other target year in between e.g. for the year 2055 (World Bank Projections 1994-95). Of course, each specific target year gives rise to its own variant projection of world population growth.

In addition to the target year for the reduction in fertility, it is also necessary to establish what *form* that reduction should take, i.e. what the pattern of decline might be. The proposition made in section 1 above, that as fertility goes on falling it will become increasingly difficult to achieve any further decline, is best reflected in the assumption that the fertility curve will take the shape of a concave *hyperbola*. As alternatives to the hyperbolic curve, calculations have also been carried out on the assumption that the fall in fertility describes an *S-curve* (with the fastest rate of decline in the middle of the period and slower initial and final rates of decline) and finally also assuming a *linear reduction* (*see Figures 5-9*). Hence the following variants of population projections have been computed for each of the target years selected, as follows:

Pattern of decline in fertility	*Target year for attaining replacement fertility level or intersection*
- Hyperbolic - S-curve - Linear	2000, 2010, ..., 2060, ..., 2100, ...

Each combination of a particular target year and a particular pattern of decline gives rise to its own *path of fertility decline over time* (or *"fertility path"* for short) and to a corresponding population projection. In the case of the S-curve and linear fertility paths, fertility was assumed to remain constant at replacement level once the target year had been reached. The same approach was also adopted for the hyperbolic path, but an additional variant was also computed in which fertility continued to decline beyond the target year.

(b) Population Projections for Alternative Fertility Paths and the Differences between Global and Country-Specific Population Projections (Aggregation Effects)

For the "*medium variant*" of the World Bank's population projections, 2060 or 2055 were chosen as the target years with constant fertility thereafter. When one of those target years, e.g. 2060, is chosen here, along with other alternative target years, the fertility paths arising from the different types of decline produce the projections set out in *Table 2*. The population figure for the year 2150 emerging from the World Bank's projection is 11.4 billion(*Table 3*), whereas the figure produced by the projections discussed here, on the lower variant, is just 10.7 billion. How does this discrepancy arise? To examine one possibility, the hyperbolic time path chosen here is compared

Figure 5

Decline in the Total Fertility Rate of the World Population from 1962-1990 and Scenarios for the Decline to Replacement Fertility Level (TFR = 2.13) in the Future (Form of Decline: Hyperbolic)

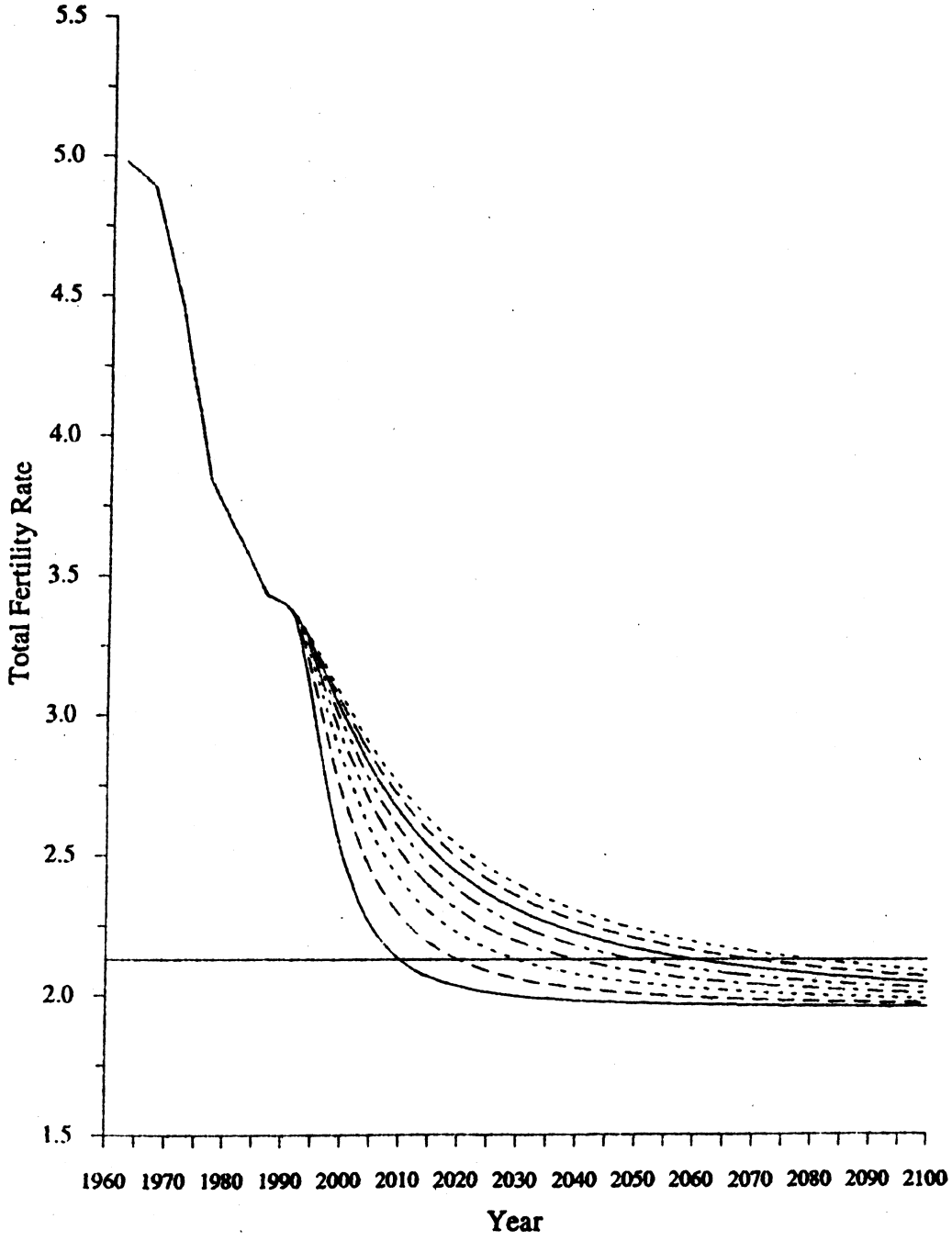


Figure 6

Decline in the Total Fertility Rate of the World Population to Replacement Fertility Level (TFR = 2.13) (Form of Decline: Hyperbolic)

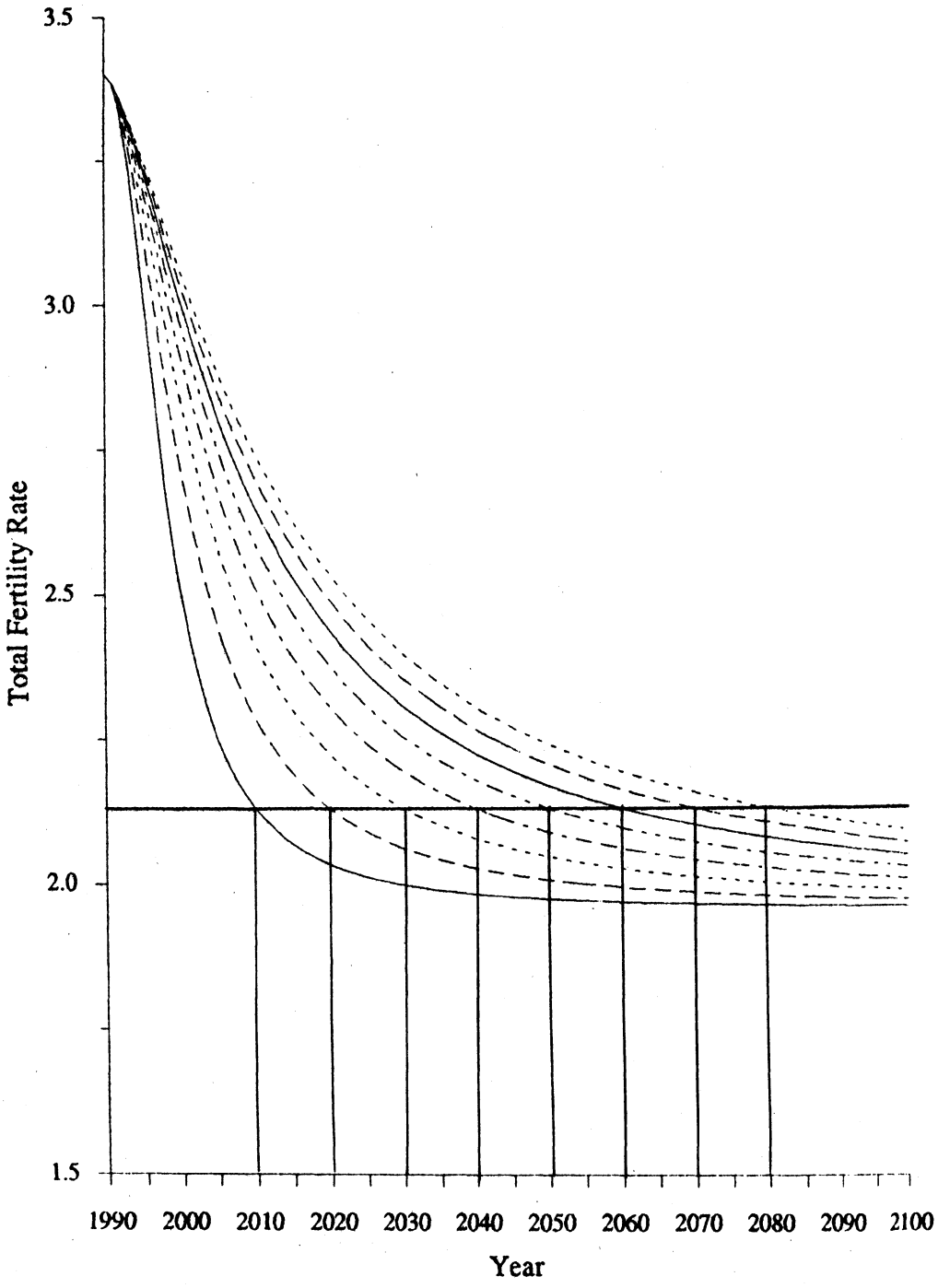


Figure 7
Decline in the Total Fertility Rate of the World Population to Replacement Fertility Level (TFR = 2.13) (Form of Decline: S-Shaped)

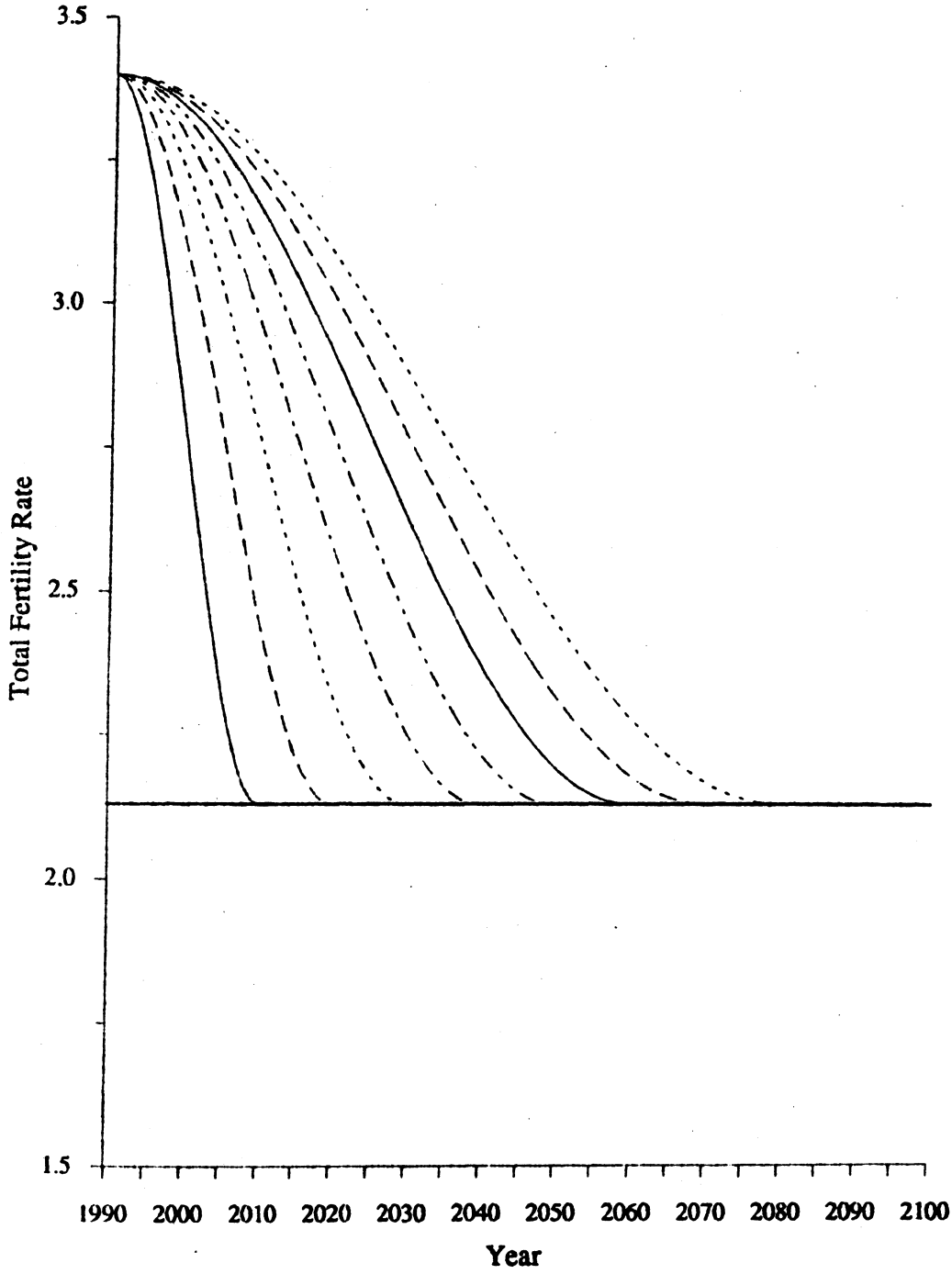


Figure 8

Decline in the Total Fertility Rate of the World Population to Replacement Fertility Level (TFR = 2.13) (Form of Decline: Linear)

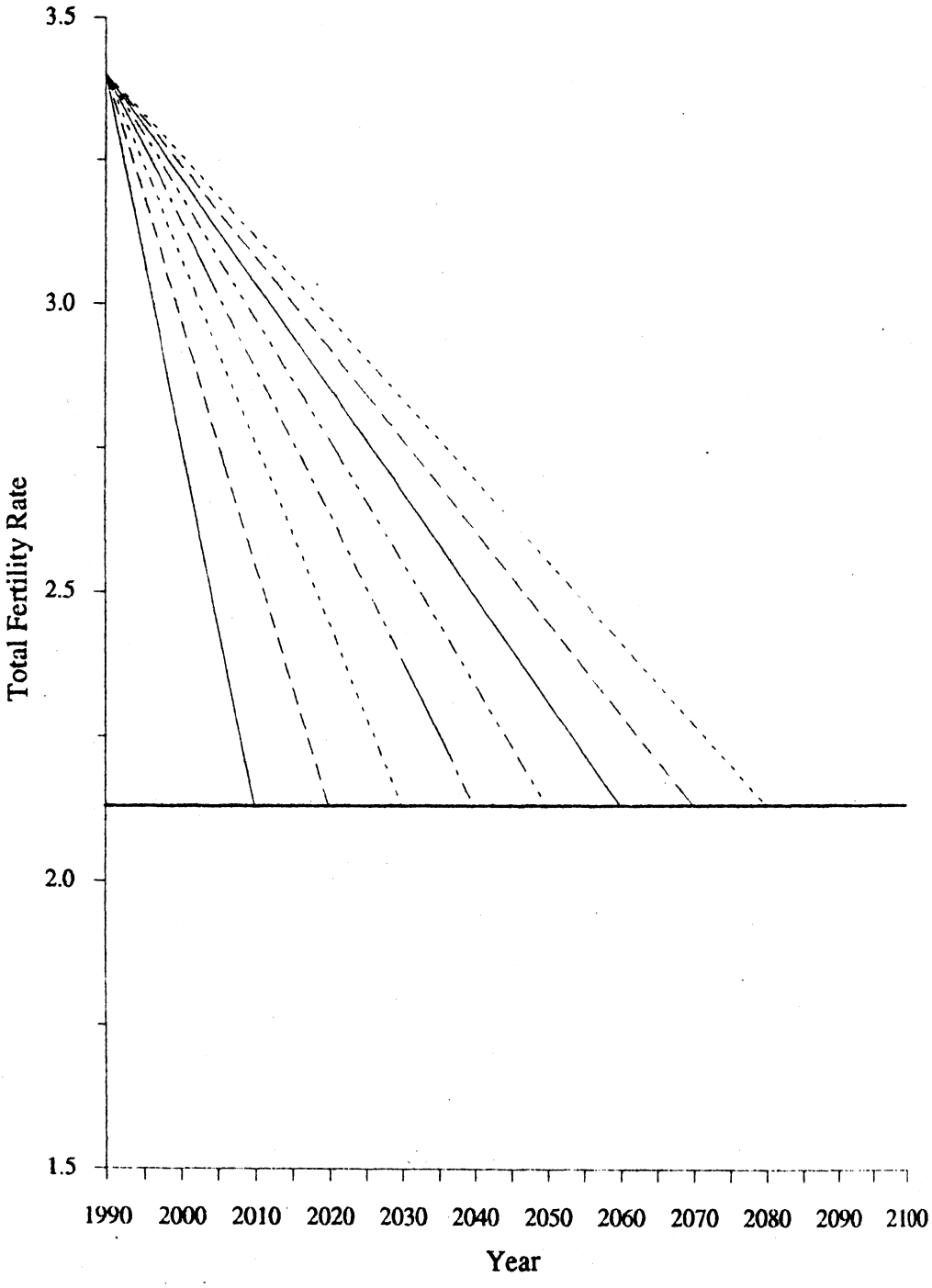


Figure 9
Decline in the Total Fertility Rate of the World Population to Replacement Fertility Level (TFR = 2.13) (Form of Decline: Hyperbolic and S-Shaped)

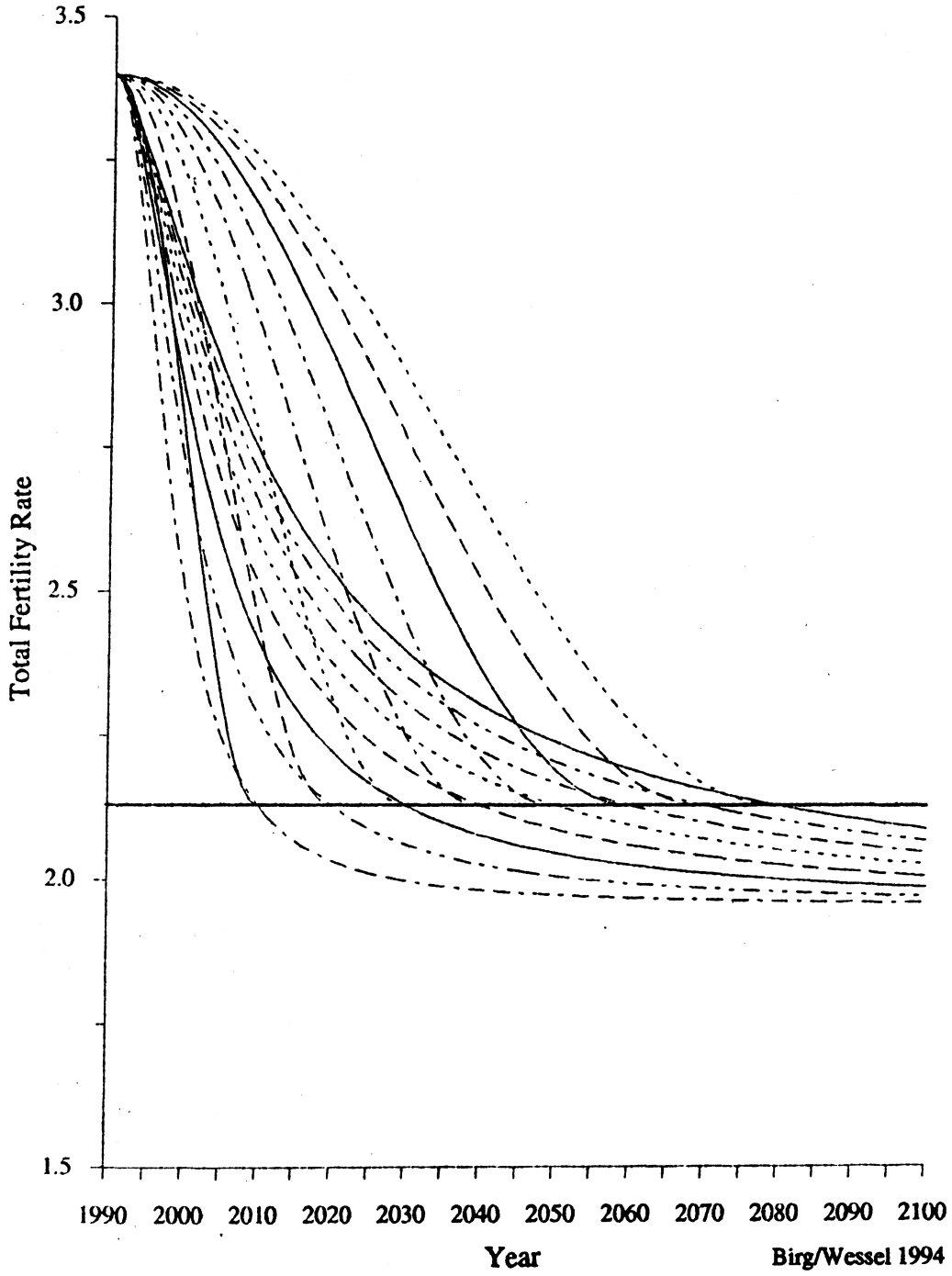


Table 2

The World Population Level in 2150, Based on Different Assumptions as to the Rapidity of the Decline in Fertility (TFR) to the Replacement Level of 2.13 Live Births per Woman

The number of years needed, starting in 1990, for fertility to reach replacement level, by the target year of...	Target year	World population in 2150, in billions, assuming different forms of decline in fertility (TFR) to the same final value of 2.13 live births per woman by the target year stated		
		Form 1	Form 2	Form 3
20 years	2010	8.3	8.6	8.7
30 years	2020	8.8	9.5	9.5
40 years	2030	9.3	10.4	10.5
50 years	2040	9.7	11.4	11.5
60 years	2050	10.2	12.5	12.7
70 years	2060	10.7	13.7	13.9
80 years	2070	11.2	15.1	15.3
90 years	2080	11.7	16.5	16.8
100 years	2090	12.2	18.2	18.5
110 years	2100	12.7	19.9	20.3

Form 1: Very rapid decline in fertility in the early years, slackening off over time (hyperbolic function intercepting x-axes in the target year, after intersection constant)

Form 2: S-shaped decline in three fertility phases:
phase 1 - weak initial decline, but increasingly accelerating;
phase 2 - very pronounced decline;
phase 3 - decline easing off again (sine-function)

Form 3: Equal decline in fertility each year until the target date (linear function)

with the World Bank's assumption on the decline of fertility in *Figure 10.* Readers will notice that the hyperbolic curve runs above the World Bank's assumed fertility curve from 2035 onwards. If anything, then, one would expect a *higher* projection than the World Bank's to result, and not a lower one.

The reason for this discrepancy is what is known as the *aggregation effect*, the essence of which will be illustrated below. The population projections made by the World Bank and by the UN Population Division are based on separate computations for more than 150 countries around the world, which are subsequently added together to obtain the world total. This approach is known as a *disaggregated projection.* By way of contrast, the projections under discussion have been prepared on an *aggregated* world basis from the outset. One might at first think that the aggregated and disaggregated projections would be identical in their outcomes provided that they used the same base data and that all the underlying fertility and mortality assumptions were the same. However, that is not the case, as will be demonstrated by the following example.

Suppose we prepare one population projection for the world as a whole on an aggregate basis, and that we then make a second projection in which the world population is subdivided into two large parts, one for the industrial and one for the developing countries (a disaggregated projection). In the latter case, the projection for the world as a whole is obtained by adding together the two sub-populations for the industrial countries and the developing countries. Suppose also that we apply the same assumptions on future fertility trends to both the aggregated and disaggregated projections. For the sake of simplicity, we may take a constant total fertility rate both in the industrial and in the developing countries, but with the latter higher than the former. Now, if we similarly assume a constant total fertility rate for the aggregated projection, this is where the discrepancy arises, for in the case of the disaggregated computation method the assumption of constant fertility in each sub-group would actually imply an increase in the world total fertility rate over time, since it is calculated as the weighted average of the specific fertility rates in the industrial countries on the one hand and the developing countries on the other. Provided that the TFR in each of the two sub-groups remains constant, that weighted average will inevitably increase because the developing countries with their higher specific fertility rate will take up an increasing relative share of the world population while the relative share of the industrial countries, with their lower fertility rate, declines. Thus precisely *because* we have supposed that the TFRs are constant in both the developing countries and the industrial countries, it is *impossible* for the world TFR to remain constant in the disaggregated projection method - it *must inevitably* increase. Conversely, one can conclude that if the world

fertility path of a disaggregated population projection derived from specific country figures is the same as the fertility path underlying an aggregated world population projection, then the fertility assumptions made must have been *different*. As will be seen from *Figure 10*, the fertility paths for the target year of 2060 in the projection presented here and for the World Bank's projection are broadly the same, which means that the underlying fertility assumptions must be *different*, with a lower assumed fertility in this study than in the World Bank projection with the same target year. Consequently, the projected eventual population figure is also lower, since both projections work with the same base population and with largely identical mortality assumptions (for further examples of aggregation effects see Lutz and Prinz 1991 and Birg 1980, with computations of regionally differentiated population projections for the more than 300 counties in former West Germany). From these considerations, we can conclude that it will be necessary to select a higher fertility path if we wish to compare the population projections presented here with those of the World Bank and the UN Population Division. The comparison can readily be made if a higher fertility path is chosen instead of the path with 2060 as the target year. The figures in *Table 2* show that the hyperbolic fertility path with a target year in the 2080-85 range would fit such a comparison: by shifting the target 20-25 years further forward in time to 2080- 85, we obtain a fertility path equivalent to that of the World Bank's projection, and the resulting projected population figures are in the same order of magnitude.

Another possible way of attaining comparability between aggregated and disaggregated population projections is to choose an S-curve or linear decline in fertility instead of the hyperbolic curve, as the resulting fertility level is in- variably higher in either of these alternative cases for any given target year. However, the fertility with a target year of 2060 then turns out higher than in the World Bank's projection: the linear fertility path produces a projected population in 2150 of 13.9 billion, and the S-curve path a projection of 13.7 billion (*Table 2*). The population level projected by the World Bank is now arrived at by bringing the target closer in time, to the years 2045-50 for the linear option or 2040-45 for the S-curve option.

Table 2 and *Figures 11-14* show the resulting aggregated population projections for various alternative target years and patterns of fertility decline. Further computations are presented in Part II of Birg 1995, containing detailed quantitative simulations for a number of alternative szenarios. The following findings should be particularly pointed out:

The outcome of population projections is curcially dependent on the pattern of decline in fertility:

1. Given a medium mortality trend and a replacement fertility level of 2.13, *choosing which pattern* of fertility reduction to assume results in a discrepancy, taking the target year of 2060 as an example, of approximately 3 billion in the final population figure projected (difference between 10.7 billion for a hyperbolic and 13.7 billion for a linear reduction in fertility). If the target year chosen is 2070, that discrepancy widens to 4 billion, and if it is 2080, to 5 billion. Even if the relatively close target year of 2030 is chosen, there is still a discrepancy in the final total of 1.2 billion.

2. The results obtained using S-curve and linear fertility paths are quite similar, and the final population projections they give when the target year for replacement fertility is 2060 lie approximately 30% above the final level obtained when a hyperbolic fertility path is assumed.

To sum up, not only the target year for replacement fertility and the replacement level itself are significant, but the actual pattern of fertility decline is an important factor in population growth in its own right, and the latter has received too little attention to date.

(c) Path Effects

In *Figure 15*, a linear fertility path with 2060 as the target year (curve "C") is superimposed on a hyperbolic curve with 2080 as the target year (curve "B"). Although one would normally expect a higher final population to result from selecting the more distant target year, in fact the population curve for the linear/2060 case tracks substantially above that based on the hyperbolic fertility path to 2080. The reason for this is that the aggregate of the TFR values for each successive calendar year is considerably greater for the linear path than for the hyperbolic, even though the target year for the latter comes so much later.

One could now go on to examine what happens if both the target year and the sum of the TFR values are the same for two fertility curves. This case is illustrated in *Figure 16*. The linear and S-curved paths shown here share the same target year of 2060, and the sums of their TFR values are also virtually identical. Nevertheless, the population curve derived from the S-curved path exceeds the curve derived from the linear fertility

path not just until the intersection of the paths in the year 2024, but right on until 2076 before it begins to grow more slowly than the other. This phenomenon will be termed the "*path effect*". Its explanation lies in the momentum of population growth due to the cumulative impact of the age profile on the total population figure. The existence of such path effects further underlines the importance of the pattern of fertility decline for future trends in total population. This conclusion has important connotations for policy-makers, namely that any time lost in reducing fertility levels will lead to an increased overall population figure for many decades, even if that lost time is subsequently made up by a more urgent policy approach.

(d) The Impact upon World Population Growth of Delays in Reducing Fertility

There are a number of ways in which the decline in fertility rates may be delayed:

Case 1: For a given pattern of fertility decline, replacement fertility may not be attained until a much later date than the original target.

Case 2: Even if replacement fertility is indeed attained by the target year, a delay may occur along the way if the path of decline follows the slower S-curve or is linear instead of following the rapid, hyperbolic curve. As shown in the previous section, the result may be an eventual total population which is higher by 3—5 billion.

Case 3: The lowest level of fertility eventually attained may still exceed the replacement level, meaning that the world population will not reach an upper limit, but will go on growing indefinitely.

These three cases may occur together in a variety of different combinations. Due to space constraints, it will have to suffice here to conclude with a short examination of the case in which replacement fertility is not actually reached. To demonstrate this, a computation has been made (see *Table 4*) based on a final fertility level of 2.17 live births per woman instead of 2.13, with the following result:

Final fertility rate in the year 2060 (hyperbolic decline)	*Population level in the year 2100, in billions*
2.13	10.7
2.17	11.4

The difference between the fertility rates is 1.9%, whereas the difference between the corresponding population levels in 2100 is 6.5%. The absolute difference is one of 700 million people. Nevertheless, more important than the absolute difference is the high degree of sensitivity with which population growth responds to small increases in fertility (*Table 5*).

If the final fertility rate attained is *below* the replacement fertility level, the world population will still continue growing for a number of decades because of the in-built momentum, then reaching a maximum in the 21st or 22nd century before declining thereafter (see *Figure 12*). *Tables 5 and 6* show the results emerging from three different final fertility rates (2.0, 2.1 and 2.13), assuming a hyperbolic or a linear decline in fertility. *Table 7* and *Figure 26* show the dependence of the growth in the number of women in reproductive age upon the fertility path.

(e) Note on the Precision of World Population Projections to Date

The Population Division of the United Nations' Department of Economic and Social Affairs has been regularly drawing up world population projections since the 1950s. Those projections have in fact proved very reliable. If the projections for the year 2000 which were made in 1958, 1962, 1982 and 1992 are compared, the degree of accuracy achieved is astonishingly good. It is possible to say this today as the world population figure for 2000 is already almost settled at this stage.

Because the projection period is now only 10 years long, the authors' projections for the year 2000 presented here all lie within a relatively narrow range, between 6.1 billion (with 2010 as the target year) and 6.2 billion (with 2080 as the target year). The UN's projections since 1958, with the exception of the deviating projection made in 1962, equally fit into a range which is hardly any broader. The following table shows the medium variants in each case:

	Projected population in the year 2000
1958 UN projection	6.3 billion
1962 UN projection	6.6 billion
1982 UN projection	6.1 billion
1992 UN projection	6.2 billion
The author's projection	6.1-6.2 billion

Figure 10
Comparison of Various Assumptions on Fertility Decline for the World Population

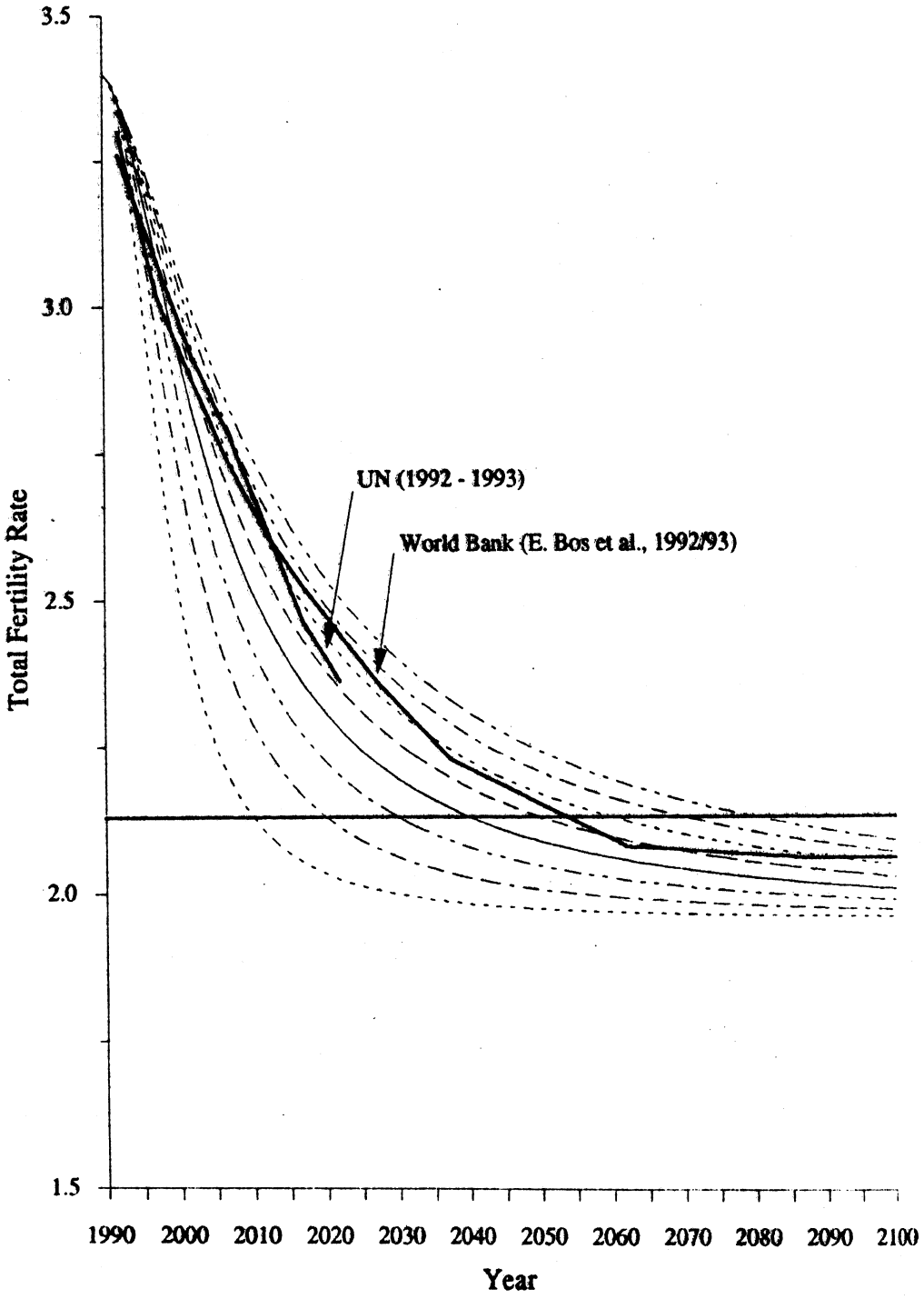
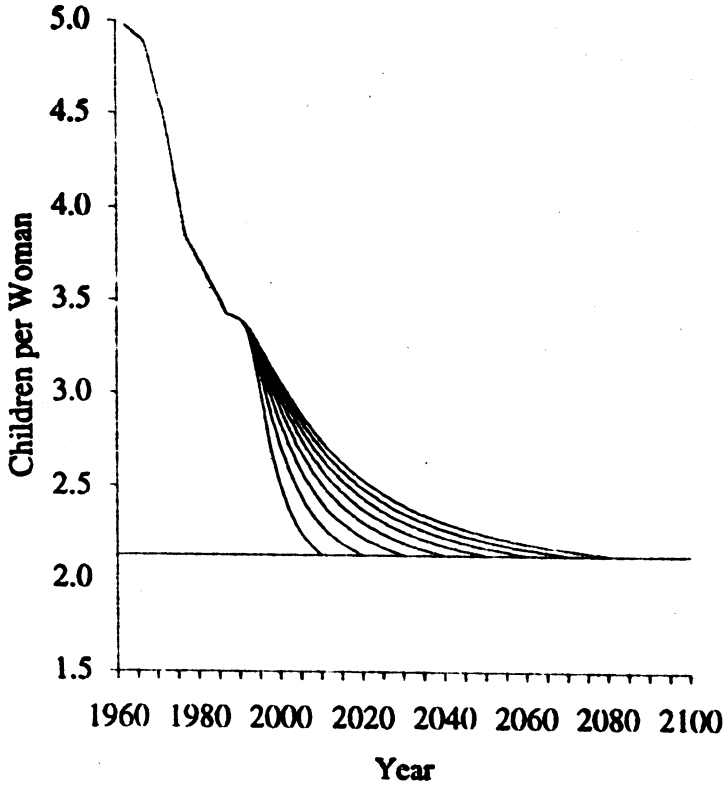


Figure 11

8 Variants of World Population Growth
- Hyperbolic Decline in Fertility, Medium Mortality Level -



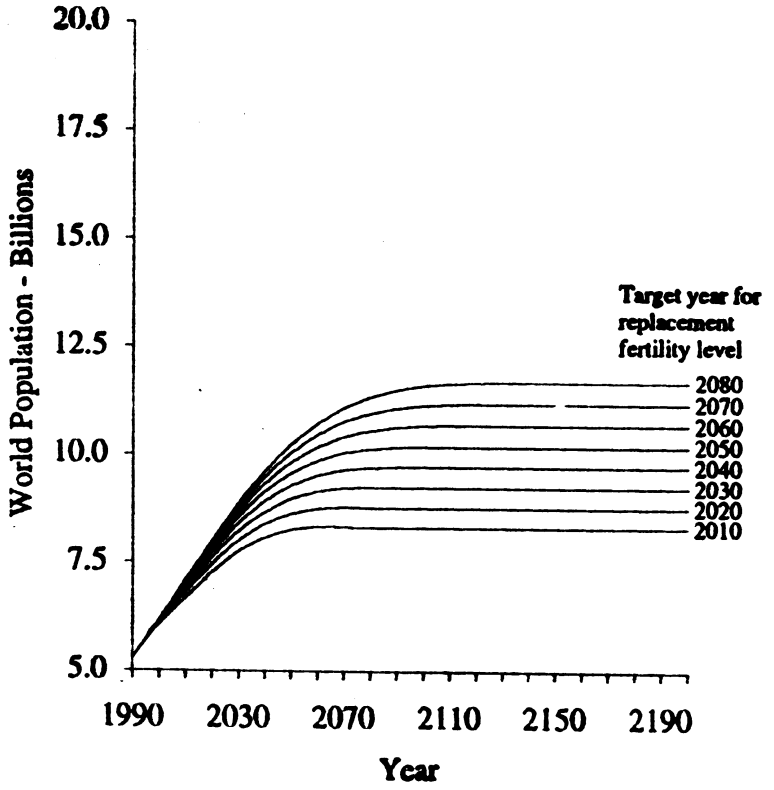
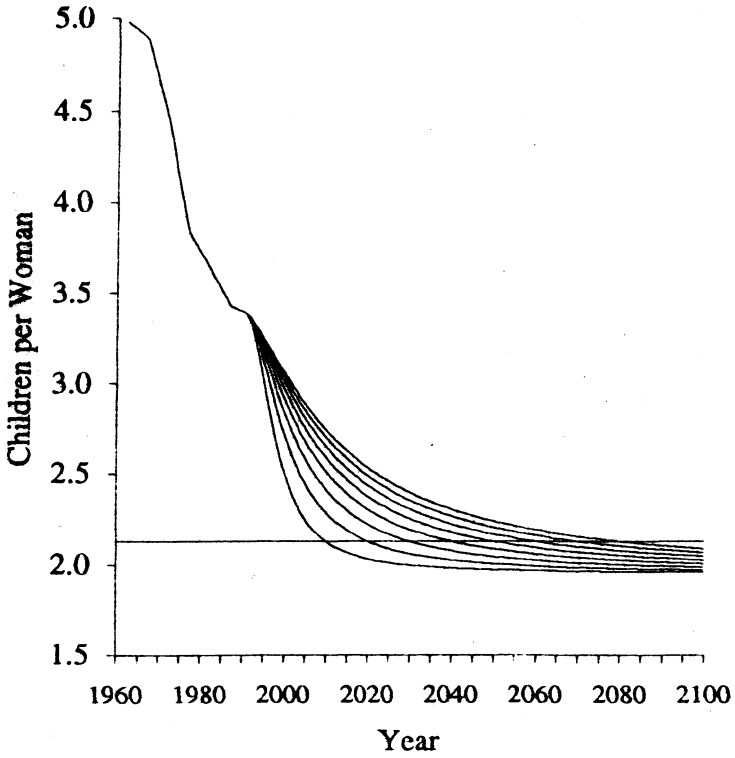


Figure 12

8 Variants of World Population Growth

- Hyperbolic Decline in Fertility Below Replacement Level, Medium Mortality Level -



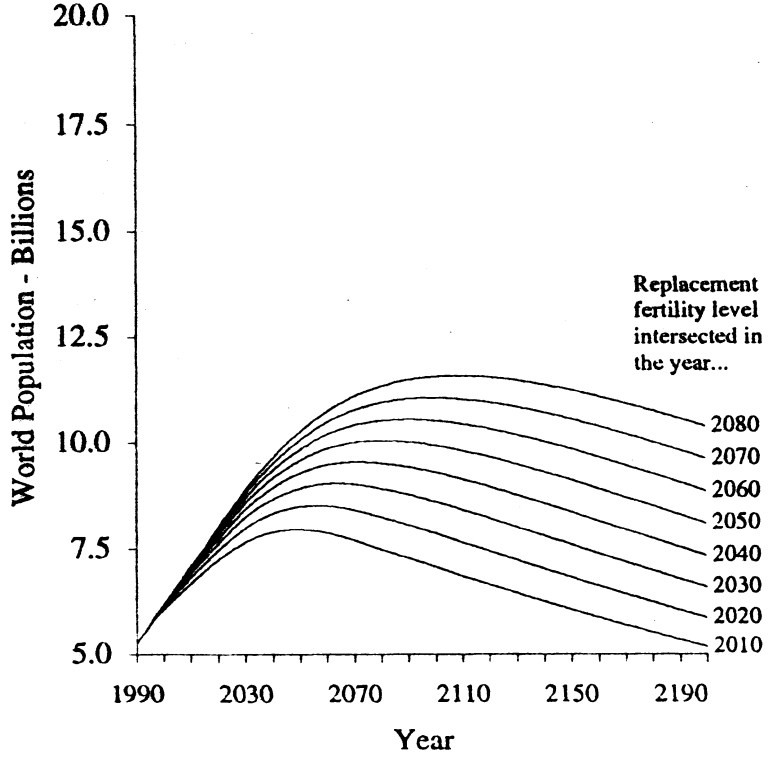
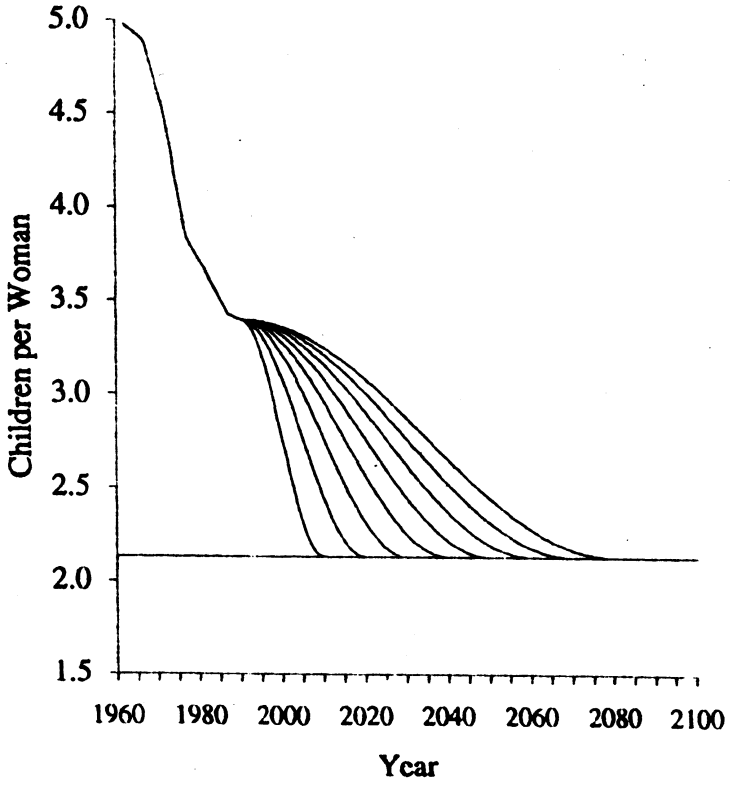


Figure 13

8 Variants of World Population Growth

- S-Shaped Decline in Fertility, Medium Mortality Level -



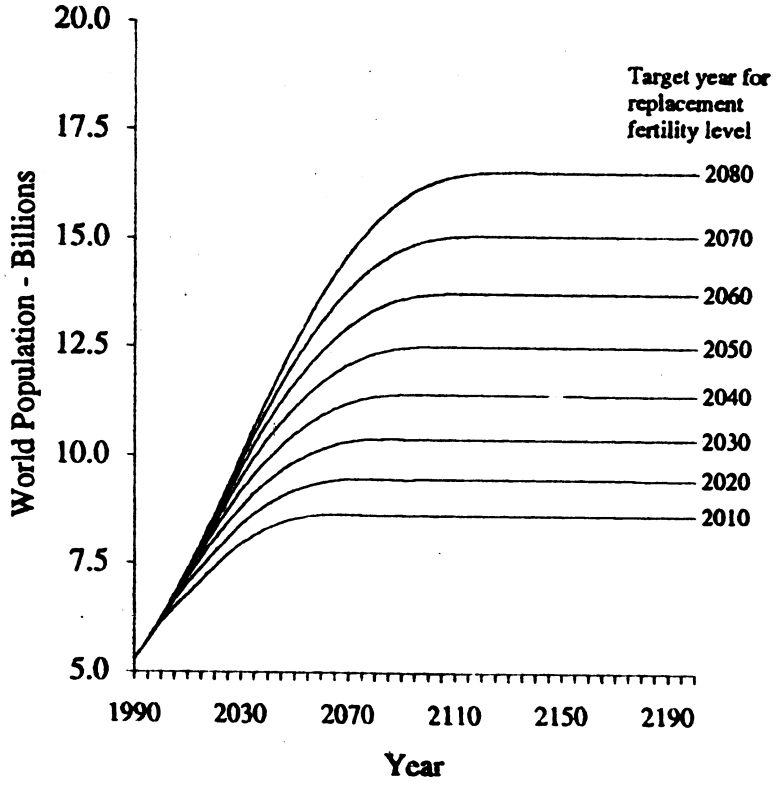


Figure 14

8 Variants of World Population Growth

- Linear Decline in Fertility, Medium Mortality Level -

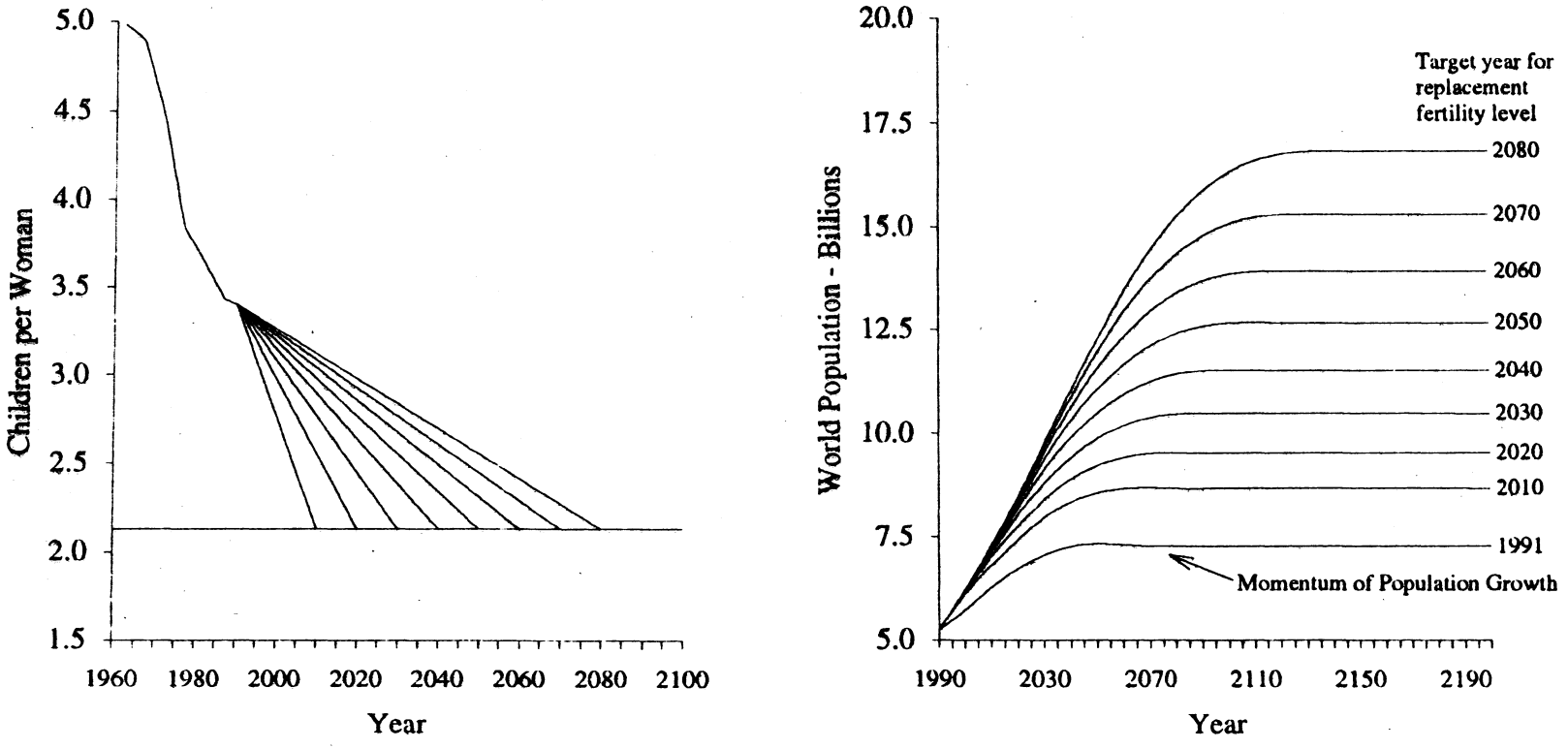


Table 3

Comparison between the World Bank Population Projections of 1989/90, 1992/93 and 1994/95

(figures in millions)

	1989/90 Projection			1992/93 Projection			1994/95 Projection		
	1990	2050	2150	1990	2050	2150	1990	2050	2150
World	5285	10035	11499	5268	10055	12078	5266	9578	11401
Developing Countries	4074	8716	10186	4053	8623	10610	4051	8219	10013
Industrial Countries	1211	1319	1314	1214	1433	1469	1215	1367	1399
Africa	651	2275	3042	627	2079	2954	627	1999	2827
Americas	721	1146	1200	721	1201	1308	715	1178	1294
of which									
Latin America	441	814	871	441	839	935	435	804	906
North America	280	332	329	280	362	373	281	374	388
Asia	3100	5728	6367	3103	5811	6817	3174	5638	6509
Europe and former USSR	787	843	846	790	922	954	723	721	726
Oceania	27	42	45	27	43	46	27	42	46

Compiled from: (a) R. A. Bulatao et al.: World Population Projections 1989-90 Edition, Baltimore and London, 1990; (b) E. Bos et al.: World Population Projections 1992-93 Edition, Baltimore and London, 1992; (c) E. Bos et al.: World Population Projections 1994-95 Edition, Baltimore and London, 1994.

Table 4

World Population Growth Assuming a Hyperbolic Decline in Fertility up to 2060 (in Billions)

	final fertility value in the year 2060 [1]	
	TFR = 2.13	TFR = 2.17
1990	5.3	5.3
2050	9.8	10.1
2100	10.7	11.4
2150	10.7	11.8
2200	10.7	12.2

1) assuming constant fertility thereafter, and the medium mortality variant

Table 5

The Impact of Delays in the Decline in Fertility of the Replacement Level (TFR = 2.13), or to Just Under Replacement Level (TFR = 2.0 or 2.1)

Length of time needed for fertility decline	World population in 2150, in billions assuming final fertility values of...		
	TFR = 2.0	TFR = 2.1	TFR = 2.13
20 years (= 2010)	5.9	7.7	8.3
30 years (= 2020)	6.2	8.2	8.8
40 years (= 2030)	6.4	8.6	9.3
50 years (= 2040)	6.7	9.0	9.7
60 years (= 2050)	6.9	9.4	10.2
70 years (= 2060)	7.2	9.9	10.7
80 years (= 2070)	7.4	10.3	11.2
90 years (= 2080)	7.6	10.8	11.7
100 years (= 2090)	7.9	11.2	12.2
110 years (= 2100)	8.1	11.7	12.8
120 years (= 2110)	8.4	12.2	13.3
130 years (= 2120)	8.6	12.7	13.8
140 years (= 2130)	8.8	13.2	14.4
150 years (= 2140)	9.1	13.7	14.9
Assumption: Hyperbolic fertility decline, medium mortality level			

Table 6

The Impact of Delays in the Decline in Fertility to the Replacement Level (TFR = 2.13) or Just Under Replacement Level (TFR = 2.0 or 2.1)

Length of time needed for fertility decline	World population in 2150, in billions assuming final fertility values of...		
	TFR = 2.0	TFR = 2.1	TFR = 2.13
50 years (= 2040)	8.9	10.9	11.5
60 years (= 2050)	10.0	12.0	12.7
70 years (= 2060)	11.1	13.2	13.9
80 years (= 2070)	12.4	14.6	15.3
90 years (= 2080)	13.8	16.1	16.8
100 years (= 2090)	15.4	17.7	18.5
110 years (= 2100)	17.1	19.6	20.3
120 years (= 2110)	19.0	21.5	22.3
130 years (= 2120)	21.0	23.5	24.3
140 years (= 2130)	23.1	25.7	26.5
150 years (= 2140)	25.2	27.8	28.6
Assumption: Linear fertility decline, medium mortality level			

Table 7

Dependence of the Number of Women in Reproductive Age (15 - 49) upon the Fertility Path (Number of women in millions)

Year	Fertility path: Target year for replacement fertility							
	2010	2020	2030	2040	2050	2060	2070	2080
1990	1314	1314	1314	1314	1314	1314	1314	1314
2000	1560	1560	1560	1560	1560	1560	1560	1560
2010	1797	1802	1804	1805	1806	1806	1807	1807
2020	1891	1938	1965	1983	1996	2005	2012	2018
2030	1932	2014	2074	2117	2150	2175	2195	2212
2040	1937	2042	2135	2209	2267	2314	2353	2385
2050	1897	2013	2122	2223	2307	2378	2438	2489
2060	1922	2025	2135	2241	2344	2434	2512	2580
2070	1916	2024	2131	2241	2350	2456	2552	2637
2080	1912	2021	2128	2236	2348	2459	2568	2669
2090	1917	2023	2130	2239	2348	2462	2575	2688
2100	1915	2023	2129	2239	2348	2460	2575	2692
2110	1915	2022	2130	2238	2348	2460	2574	2692
2120	1915	2022	2130	2238	2348	2460	2574	2691
2130	1915	2022	2130	2238	2348	2460	2574	2691
2140	1915	2022	2130	2238	2348	2460	2574	2691
2150	1915	2022	2130	2238	2348	2460	2574	2691
2160	1915	2022	2130	2238	2348	2460	2574	2691
2170	1915	2022	2129	2238	2348	2460	2574	2691
2180	1915	2022	2129	2238	2348	2459	2574	2691
2190	1914	2022	2129	2238	2347	2459	2574	2691
2200	1914	2022	2129	2238	2347	2459	2574	2691

Medium mortality level. See projection variants 2010 R.M.,..., 2080 R.M. in H. Birg: World Population Projections, 1995

The precision of projections made in the past does not necessarily mean that they will achieve a correspondingly high degree of precision in the future. Thus it is all the more important to demonstrate the potential scope for variation by portraying alternative scenarios, in the form of "if ..., then ..." projections.

4. The Impact of Alternative Mortality Scenarios upon World Population Growth

(a) Assumptions on Changes in Life Expectancy

The trend in life expectancy has been computed separately for each individual age cohort within the world population. It is assumed that improvements in health conditions and the overall standard of living will lead to an increase in the average life expectancy of men and women together from 68.5 years for those who are now almost 20 years of age (the 1975 age cohort) to 73.8 years for those born in 2030. No further improvement in life expectancy has been assumed for those born later than the year 2030. Nevertheless, because at least some of the people born in 2030 can be expected to live on beyond the end of the 21st century, the calendar-year life expectancy (according to the period concept conventionally used, rather than the cohort concept used here) will in fact continue to rise, though only slightly, until the end of that century (for detials see technical appendix in: Birg, 1995).

The life expectancies assumed by the World Bank and the UN Population Division are more optimistic than those underlying the projections presented here. The World Bank supposes that the average period-concept life expectancy of the two sexes will have increased to 82.3 years by the end of the 21st century (1992-93 estimates). This entails an optimistic assumption that the differential in life expectancies between the industrial and developing countries will by that time have narrowed to just three years (85 years for the industrial countries, 82 years for the developing countries). In 1990, that differential was still 12.4 years (74.3 years in the industrial, 61.9 years in the developing countries).

The author does not share the above optimism. In reality, a more likely presumption is that rapid population growth will create nutrition problems and trigger a number of demographically and politically determined development crises, all of which will prevent health conditions and overall living standards from reaching the levels which would be necessary to attain the long life expectancy of 82 years. For the sake of

comparison, it is worth noting that the average current male life expectancy in an industrialized country like Germany is 72.2 years, and the female life expectancy 78.7 years.

(b) The Impact upon World Population Growth of Alternative Assumptions on General Mortality Trends and the Influence of AIDS

Overall life expectancy is a complex measure computed from 200 separately ascertained cohort life expectancies i.e. 100 each for males and females. The probability of mortality (x) is the complementary quantity to the probability of survival (y), i.e. $x = 1-y$. If a change is made to the assumed life expectancy in a population projection, this entails altering 100 male and 100 female age-specific mortality rates, similar to the 31 age-specific fertility rates encountered earlier.

How pronounced, then, are the changes in population projections which result from changed assumptions on mortality? *Table 8* and *Figure 19* show the results of population projections based on a hyperbolic fertility decline with a target year of 2060, with alternative scenarios for a reduction in mortality rates of 1%, 2%, ..., and 10%. A similar variant is presented in *Table 9* and *Figure 20* for the target year of 2070 and a linear decline in fertlity. Readers will notice that the impact of changes in mortality is comparatively slight relative to changes in fertility: for example, a 5% reduction in mortality in the case illustrated in *Table 8* would give rise to a total population of 10.9 billion in the year 2100, as against 10.7 billion with mortality unchanged. A 10% reduction in mortality would lead to a total population of 11.1 billion in the same year.

These findings also illustrate why the influence of AIDS upon world population growth has been estimated to be relatively limited in all demographic surveys to date. For example, the main distinction between the first two World Bank projections for Africa contained in *Table 3* is that AIDS was considered as a factor in the later projection (1992/93) whilst it did not play any major part in the earlier projection of 1989/90. The overall difference in Africa's projected population in 2050 is 196 million people. The second projection assumes slightly higher fertility rates than the first, so that under normal circumstances with unchanged mortality a higher rather than a lower population figure would have been expected to result. Consequently, the overall impact of AIDS as projected can be assumed to amount to less than 10% of the population of the continent in the year 2050.

(c) *The Impact upon World Population Growth of an Increase in Child and Infant Mortality*

The computations presented in this section were carried out under the dark shadow cast by an issue which was the focus of discussion at the *Deutsches Institut für Ärztliche Mission* (Medical Mission Institute) in Tübingen in November 1993. *Maurice King*, in a controversial article in *The Lancet*, had put forward the idea that the movement towards "demographic entrapment" faced by the developing countries as their populations grew too large could only be retarded -- and therefore had to be retarded - by deliberately settling for an increase in child and infant mortality, for the consequence of not doing so would be the destruction of the Earth's ecosystem by overpopulation (King 1990 and 1993; Kind and Elliot 1993). The proposition harks back to Thomas Malthus' classic population theory proposed in 1798. This mode of thinking also provides the basis for *lifeboat ethics* and, taken to its logical conclusion, creates the maxim that to provide aid is immoral. *Maurice King* propounded his ideas in person at the Tübingen conference, and it was the author's task to respond in a separate paper. That response included a whole series of counter-arguments, some of them ethical but others demographic in their essence. I presented the ethical objections in chapter 6 of Birg 1995, and at this point I shall concentrate on the demographic core argument. Let us therefore scrutinize the proposition that an increase in mortality by consciously allowing children in developing countries to die offers the only means of solving the problem of overpopulation on the planet Earth.

Six population projections have been prepared based on the assumption of a hyperbolic decline in fertility with the target year for the replacement fertility level set at 2060, in which child and infant mortality is increased by 50%, 100%, ..., 300% (*Table 10* and *Figure 20)*. Another six variants are based on the assumptions of a linear reduction in fertility for the same target year (*Table 11* and *Figure 22*). This extreme form of hypothetical experiment produced the following results:

1. An increase in child and infant mortality even of up to 300% would, assuming a hyperbolic decline in fertility with 2060 as the target year for 2.13 live births per woman, still be unable to prevent the continuation of population growth at least until the year 2030 (hyperbolic case or 2050 (linear case), albeit in a less pronounced form. The initial population figure in the base year of 1990 (5.3 billion) would not be reached again until 2080 (hyperbolic case) or 2135 (linear case) even if child and infant mortality rose by 300%.

2. In the scenario in which child and infant mortality increases by 50%, population growth continues until the year 2080 (hyperbolic case) or 2100 (linear case), when it reaches a peak of 9.5 or 12.2 billion. Without any increase in child and infant mortality, the world population in 2100 is projected at 10.7 billion (hyperbolic case) or 13.8 bilion (linear case), or 1.2 (1.6) billion more. Thus, in percentage terms, a 50% increase in child and infant mortality leads in both the hyperbolic and the linear cases to a 12% reduction in the population in 2100.

The *conclusion* from these calculations is as follows: The grim recommendations made by Maurice King and his Malthusian school are not suited to the objective decisively reducing in population growth, nor to resolving other, population- related problems. Thus the pursuit of such an aim as a matter of deliberate policy would not yield success. While demographically ineffective on the one hand, it would also be quite ghastly in its dehumanizing impact. By resorting to such means, we would cast aside all the objectives we live for. Its inner contradictions push Malthusian policy to the point of absurdity. The fact that such thinking nevertheless has so many supporters is largely a manifestation of a lack of seriousness in analysing demographic problems rather than of ethical incapacity. Consequently, it is a worthwhile exercise to contribute to a clearer insight into the nature of the problems involved by means of rational argument.

5. Population Changes by Country and Region

The method of population projection used here for the world as a whole can equally be applied separately to individual countries, but additional account then needs to be taken of inward and outward migratory flows. There are many countries in which annual net immigration has almost equalled - or in Germany's case, even exceeded - the number of live-born children from the domestic population. As far as these countries are concerned, the quality of any population projection depends extraordinarily heavily on how well migratory flows can be projected. A migration projection in turn requires painstaking research into economic trends - this is beyond the scope of demographic computations alone, and can only be dealt with by expanding the demographic projection procedures to become a demo-economic model.

The World Bank subdivides its world population projections by country, so it would be desirable for it to base them on a demo-economic rather than a purely demographic projection model. The fact that it has not so far done so restricts the realism of the

projections. Taking Germany as an example, one has to criticize the fact that the World Bank assumes zero net immigration for the country during the next century, even though it has had a net intake of immigrants for several decades, and has considerably more immigrants per 1,000 population even than a classic immigration country such as the United States or Canada.

In spite of these deficiencies in the country results, there are certain central findings made by the World Bank projections which come out approximately the same in all projection models and do not depend so heavily on migration assumptions. These central findings are naturally particularly reliable if the country results are aggregated to give projections for groups of countries or world regions. The following key features can be identified.

(1) Absolute population growth is by far the greatest in the Asian countries, while relative growth is highest in Africa (*Figures 23* and *24* and *Table 3*). In the first quarter of the 21st century, Asia's population is set to grow by approx. 45 million per annum, and Africa's by 25-30 million per annum.

(2) Africa and Latin America have the greatest population momentum of all the continental groupings:

Africa	1.5
Latin America	1.5
North America	1.1
Asia	1.4
Europe	1.0
Oceania	1.2
World	*1.4*

In some countries within Africa, the population momentum has values well in excess of 1.5, examples being Nigeria (1.6), Kenya (1.7), Algeria (1.7), Libya (1.7) and Botswana (1.8). High country values are also found in Latin America, such as Venezuela (1.6), Costa Rica (1.6), Guatemala (1.7), Honduras (1.7) and Nicaragua (1.8). On a comparative basis, the population momentum in large Asian countries is relatively low: China (1.3), India (1.4) and Indonesia (1.4). It is chiefly the Moslem countries in Asia which have high values: Pakistan (1.6), Iran (1.7), Uzbekistan (1.7), Tajikistan (1.8) and Syria (1.8).

The most significant changes likely to occur in the rankings of the world's most populous countries by the end of the 21st century are that India will then have the largest number of inhabitants (1,813 million), ahead of China with 1,630 million. Pakistan and Nigeria will by that time have pushed the USA down from third to fifth place:

		Population (million)	
		1995	2100
1.	India	934	1,813
2.	China	1,199	1,630
3.	Pakistan	129	379
4.	Nigeria	111	355
5.	United States	263	344
6.	Indonesia	193	338

Other changes in the ranking of the top 20 countries are shown in *Table 12*. Germany, which currently occupies 12th position with its 81 million inhabitants, will no longer be among the 20 largest countries due to its shrinking population, and Japan will similarly fall back from 8th to 20th position (its population decreasing from 125 to 107 million).

As regards these purely quantitative computations, it should be stressed that population-induced problems do not primarily depend on the actual number of inhabitants, but on changes in the age profile or the ethnic or social composition of the population, and on its culturally determined capacity to solve political and social problems. Whether or not policy-makers can successfully deal with population-induced problems in any particular country chiefly depends upon whether its economy and society can adapt quickly enough to changing demographic conditions. When it comes to coping with ecological problems, a population's consuming and producing habits are far more important than its sheer numbers. This point was looked at in more detail in *Chapter 5* of Birg, 1995.

6. Summary

International discussion of population issues is chiefly centred around the demographic world population projections published by two United Nations institutions, namely by the *World Bank* and by the Population Division of the *UN Department for Economic*

and Social Information and Policy Analysis (previously named the Department of International Economic and Social Affairs). These population projections are not a reflection of current prospects, nor are they forecasts or prophecies, but computations which predict exactly what would happen to future population patterns if a particular set of assumptions were met (*"if ..., then ..." statements*). The "if..." conditions consist of assumptions on the future trends in fertility (as expressed by the total fertility rate, or number of live births per woman) and in mortality (the decrease in mortality or increase in life expectancy). If those assumptions on fertility and mortality should be borne out in reality, then the statements derived from them regarding the future population size will also be correct.

The fertility assumptions underlying the UN population projections are made in the following way. Target years are cited by which time the number of live births per woman (TFR) is assumed to have fallen from 3.3 in the early 1990s to the replacement fertility level. Replacement fertility level refers to the number of live-born children per woman at which the world population will cease to grow in the long term (i.e., some time after the end of the 21st century). At the mortality levels currently assumed and used in this book, that replacement level of fertility is 2.13 live births per woman. In its medium variant, the World Bank takes 2060 (1992-93 estimates) or 2055 (1994-95 estimates) as its target year for replacement fertility. On this optimistic assumption, the world population is projected to grow from 5.3 billion in 1990 to 11.7 (or 11.0) billion in 2100. Population growth, on this projection, will come to a stop by 2150, when the world total will be 12.1 (11.4) billion.

The author's own population projections are computed for the world as a whole (=aggregate projections). They add a number of additional variants to those contained in the UN projections, by including further target years which are both more optimistic than 2060 (i.e., earlier targets such as 2030 or 2040) or more pessimistic (later years) and computing the consequential changes in the world population. Further variations have been included by calculating the impact of different patterns of decline in fertility. For any particular target year, the reduction in the number of live births per woman may, for example, be swift in the initial period but becoming slower over time (i.e., following a hyperbolic curve), or it may be equal each year (i.e., linear). The projections shown here also vary the mortality assumptions, both to take account of the impact of AIDS and to estimate the consequences for world population growth of deliberately allowing child and infant mortality to rise (i.e., by allowing children in developing countries to die), as advocated by a currently influential Malthusian school of thought.

The most important findings of the alternative population projections presented here are:

1. The final population figures computed for the planet Earth of 10.7 billion in the year 2150 (for the assumptions see *Table 2*, first column) will be exceeded if it does not prove possible by means of development and family policies to achieve a fall in the number of children born per woman in the developing countries from the current level of 3.6 to just *2.5 by 2020-25 and 2.3 by 2025-30.* The author is sceptical as to whether this objective can be achieved, for people in the developing countries will find that just two children are insufficient to insure against economic and social risks in countries which lack adequate state provision for unemployment, sickness and old age, especially now that traditional help networks in extended families and local communities are breaking down as economies and societies undergo modernization processes. This could result in a slackening pace of fertility decline in years to come, and the consequence of that in turn would be heavier population growth than has so far been allowed for in the UN's population projections.

2. The simulations show that the impact of mortality changes is substantially less than that of fertility changes. For example, AIDS is not expected to have any decisive effect in reducing population growth. The reduction in the eventual population of Africa in the year 2050 resulting from AIDS is estimated at less than 10%.

3. Special significance attaches to the future trend in child and infant mortality. Yet even here, variations in mortality still have a relatively low impact on population growth overall. Even if infant and child mortality were to increase by 50%, for example, the world population would still continue to grow up to the period 2080-2100. At that peak level, the total would be only 12% lower than with the initially assumed mortality rates. These alternative mortality scenarios were calculated in order to demonstrate that any policy following the inhumane recommendations of Malthusian population theorists who advocate deliberately allowing children born in developing countries to die would still not succeed in preventing population growth, quite apart from the ethical unacceptability of such policies.

Figure 15

Forms of Decline in the Total Fertility Rate to Replacement Fertility Level and their Impact on World Population Growth

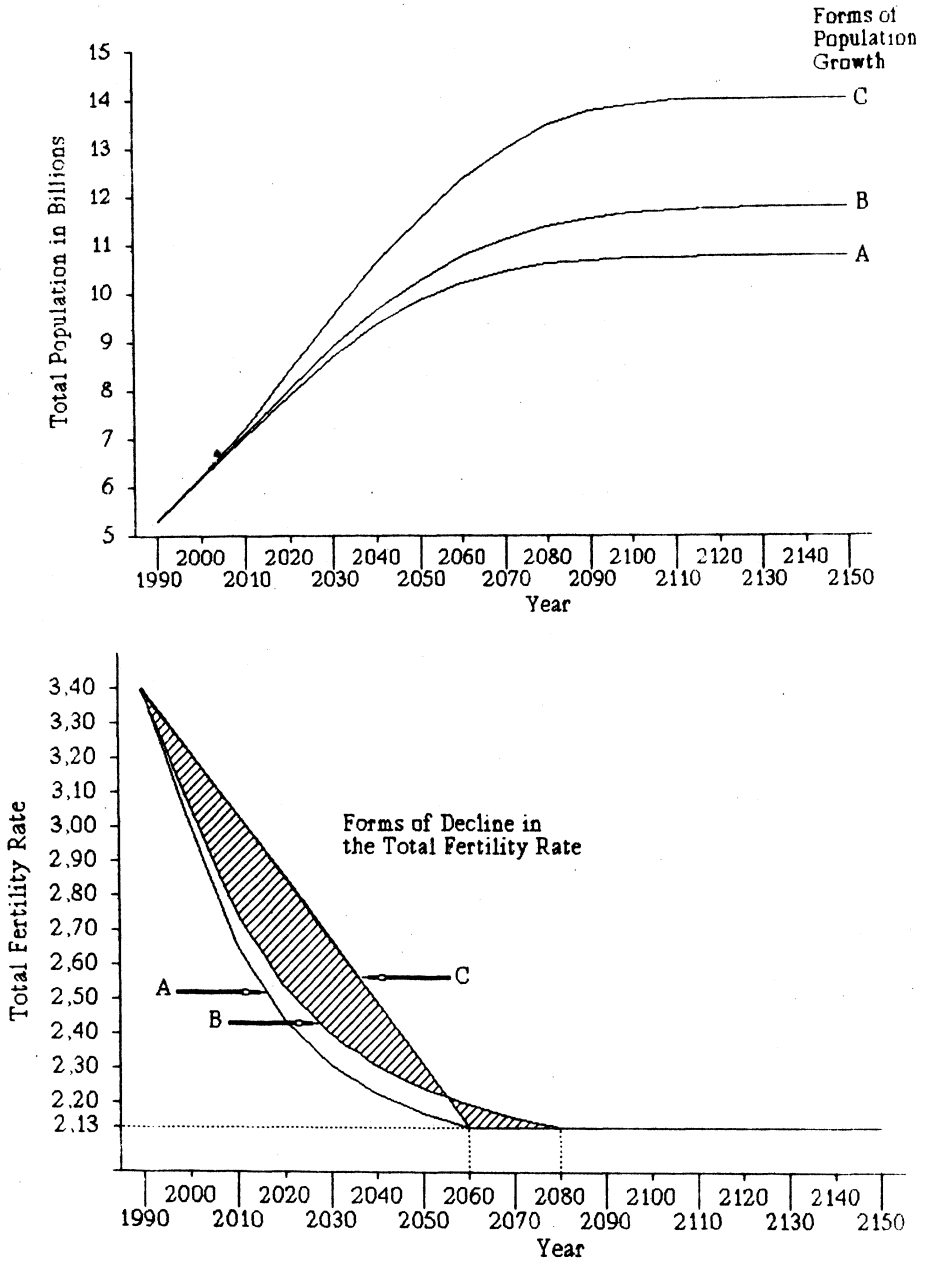
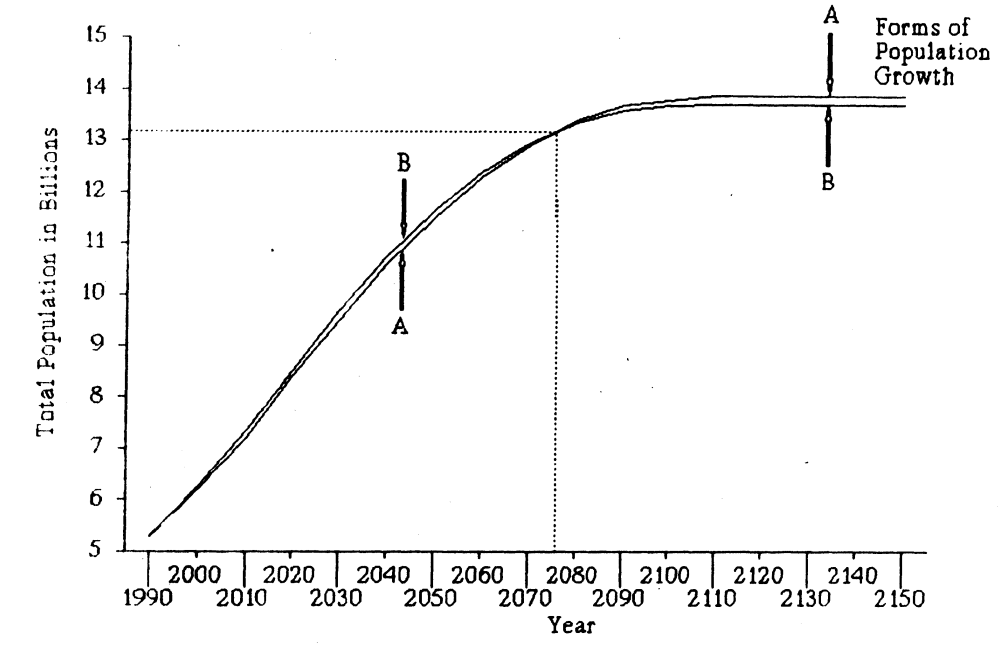


Figure 16

Forms of Decline in the Total Fertility Rate to Replacement Fertility Level and their Impact on World Population Growth



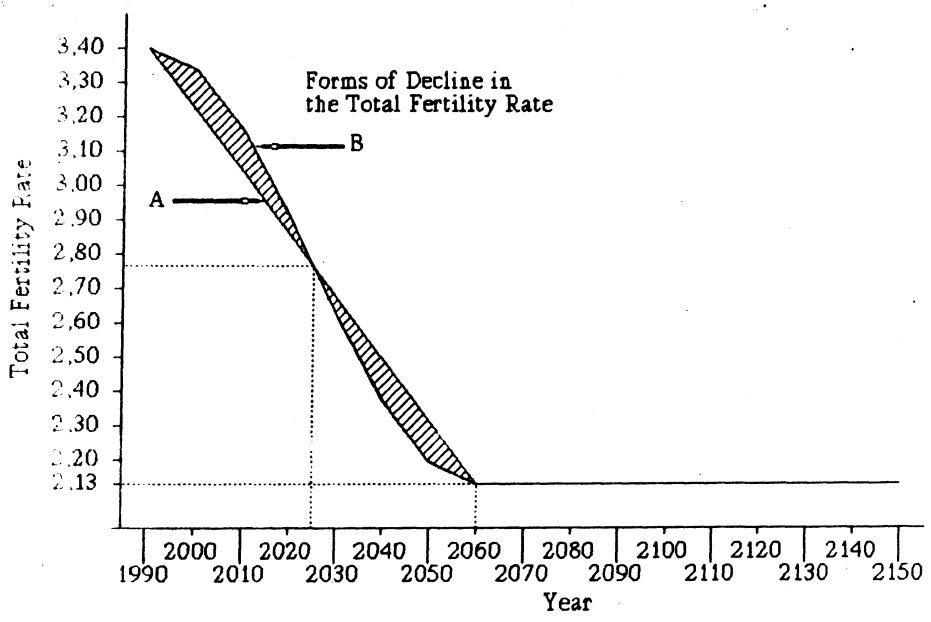


Figure 17
Components of Population Change
World Population Projection No. 2060.R.M.
Decline to Replacement Fertility Level (2.13)
Form of Fertility Decline: Hyperbolic
Mortality Level: Medium

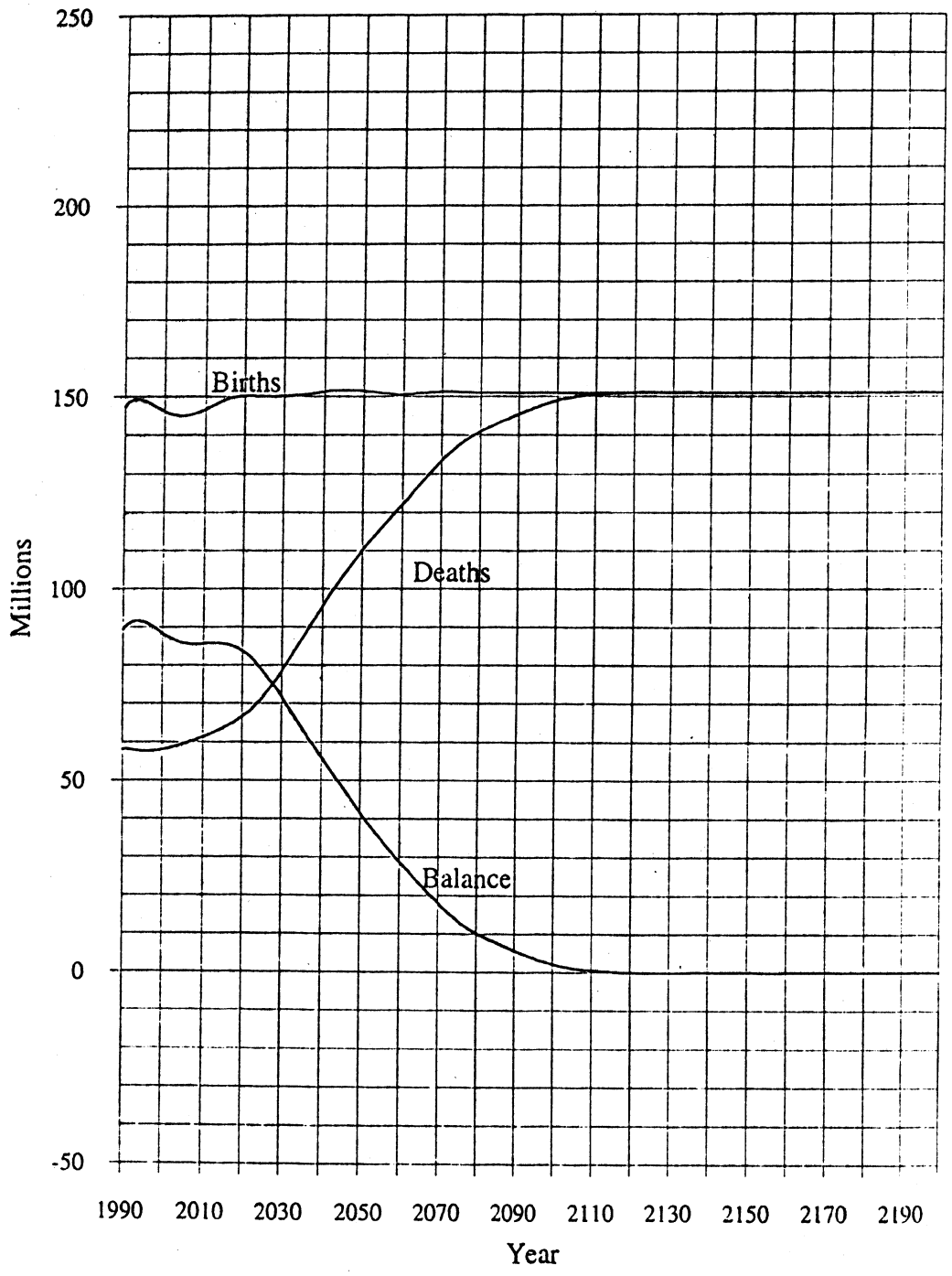


Figure 18
Components of Population Change
World Population Projection No. 2060.R.M.
Target Year for Replacement Fertility:2060
(Form of Fertility Decline: Linear,
Mortality Level: Medium)

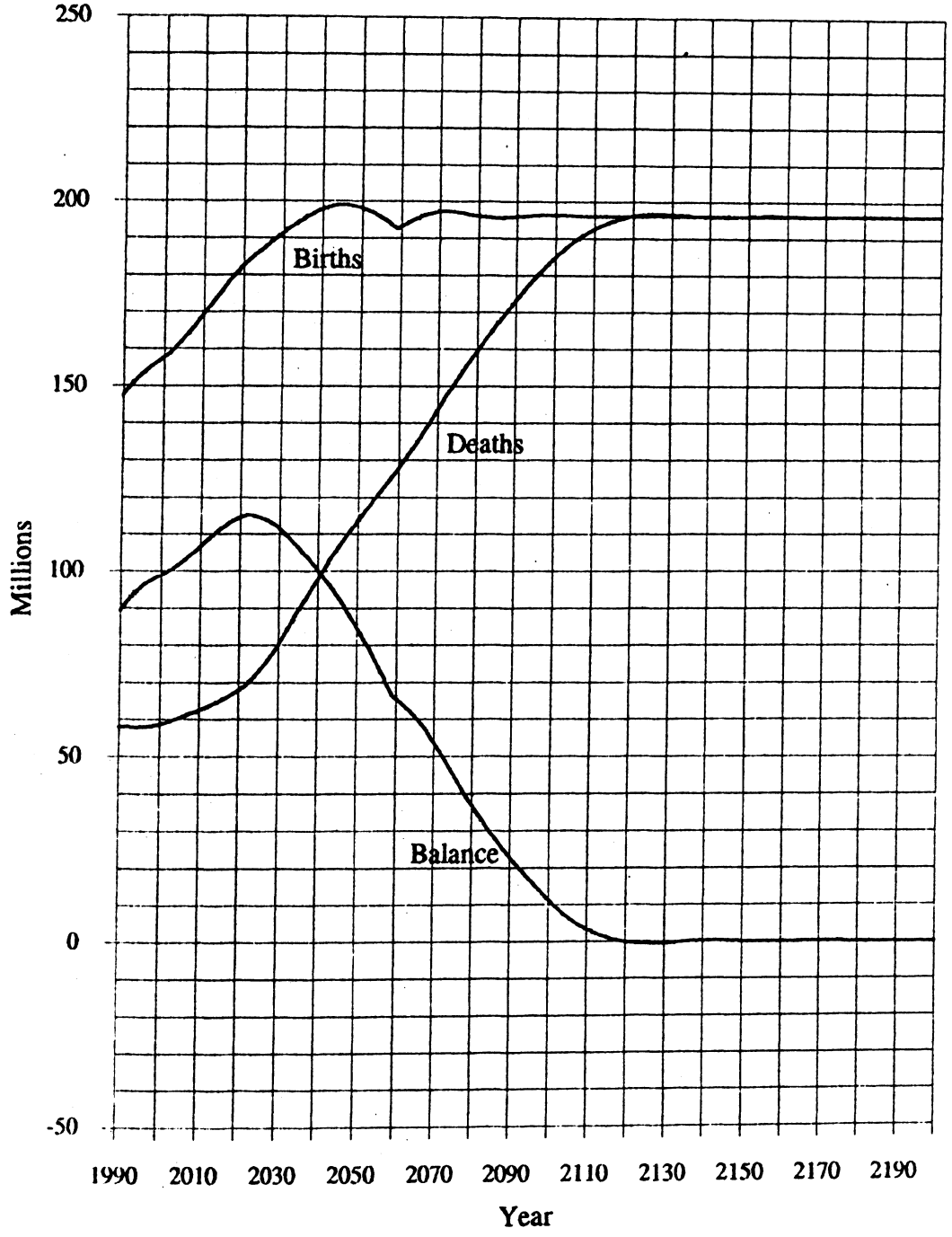


Figure 19
World Population Levels Resulting from
Different Reductions in Mortality
(Mortality Reductions Between 0 and 10 Percent,
Fertility Assumption: Hyperbolic Reduction to Replacement
Fertility Level by the Year 2060)

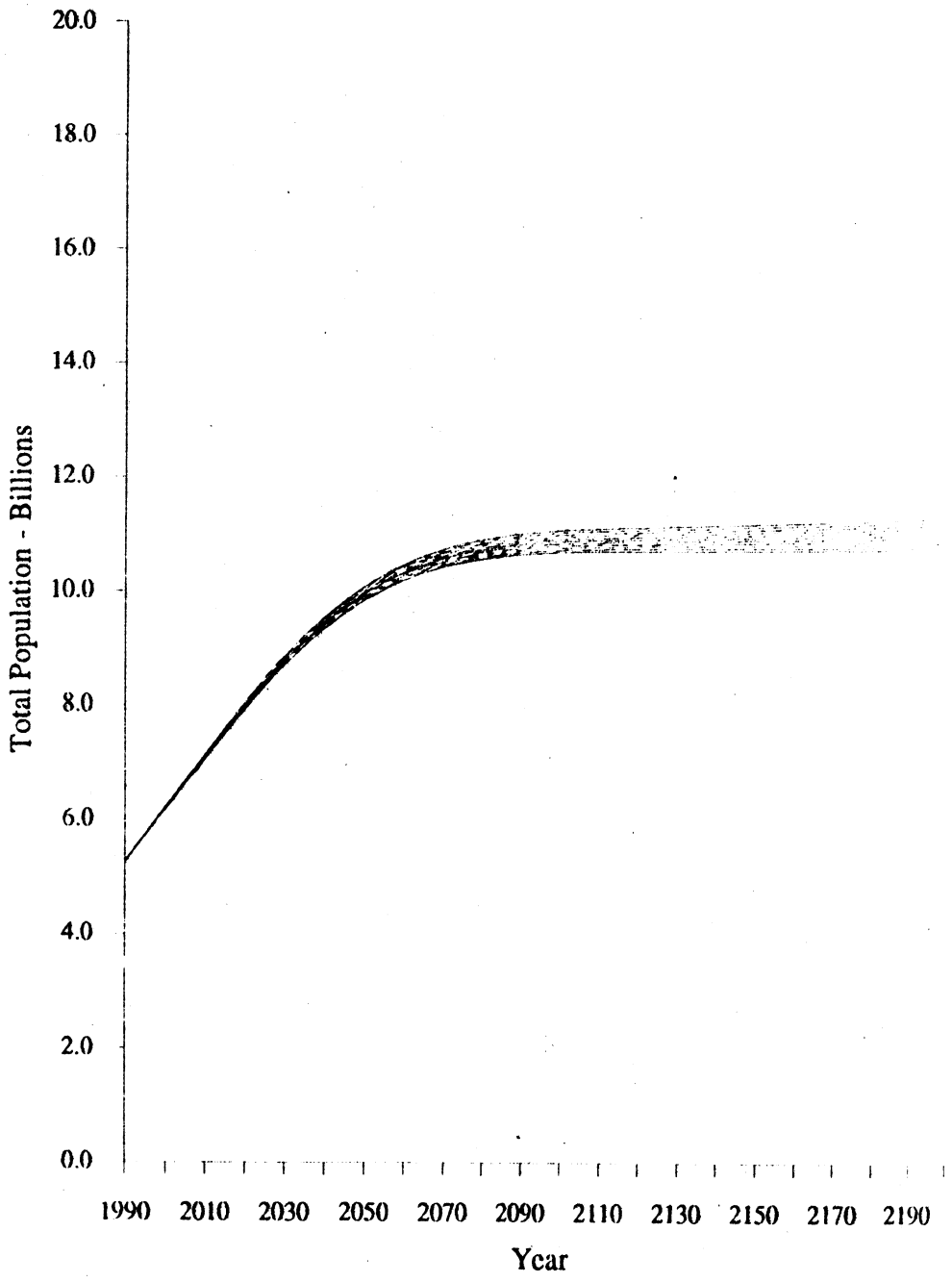


Figure 20
World Population Levels Resulting from
Different Reductions in Mortality
(Mortality Reductions Between 0 and 10 Percent,
Fertility Assumption: Linear Reduction to Replacement
Fertility Level by the Year 2070)

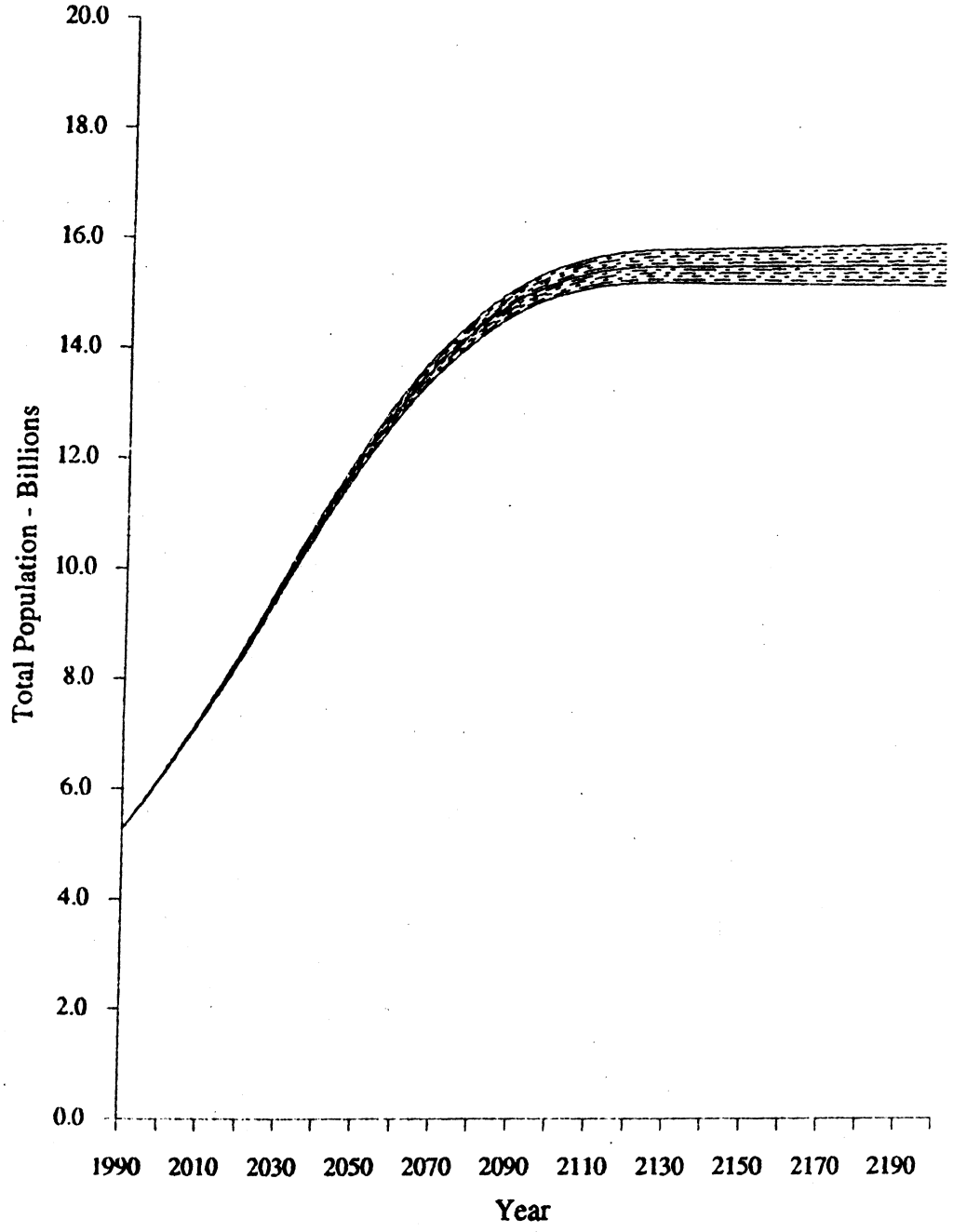


Figure 21
Scenarios of World Population Growth Based on Different Assumptions Concerning an Increase in Infant and Child Mortality (Malthus-Variants, Hyperbolic Fertility Decline)

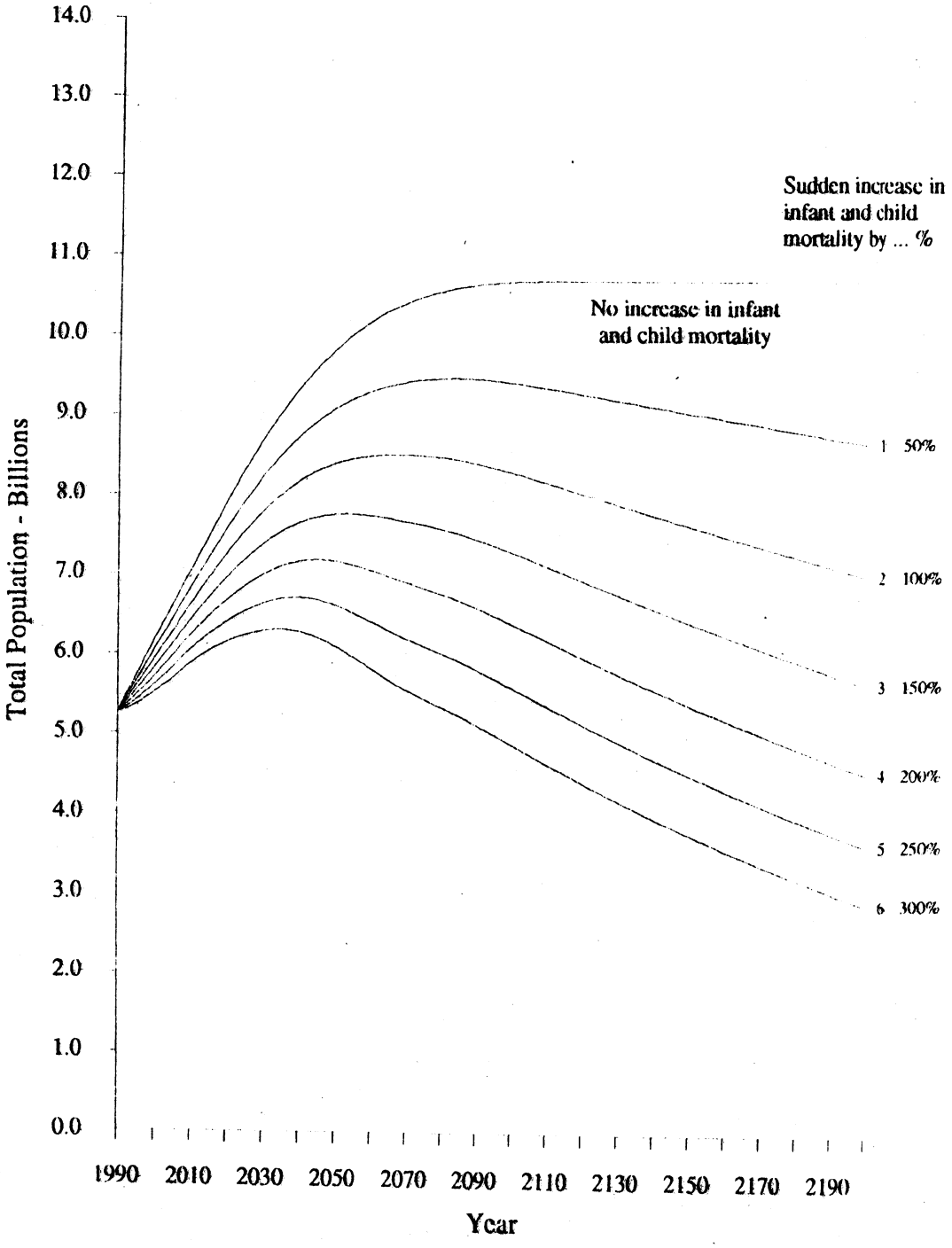


Figure 22
Scenarios of World Population Growth Based on Different Assumptions Concerning an Increase in Infant and Child Mortality (Malthus-Variants, Linear Fertility Decline)

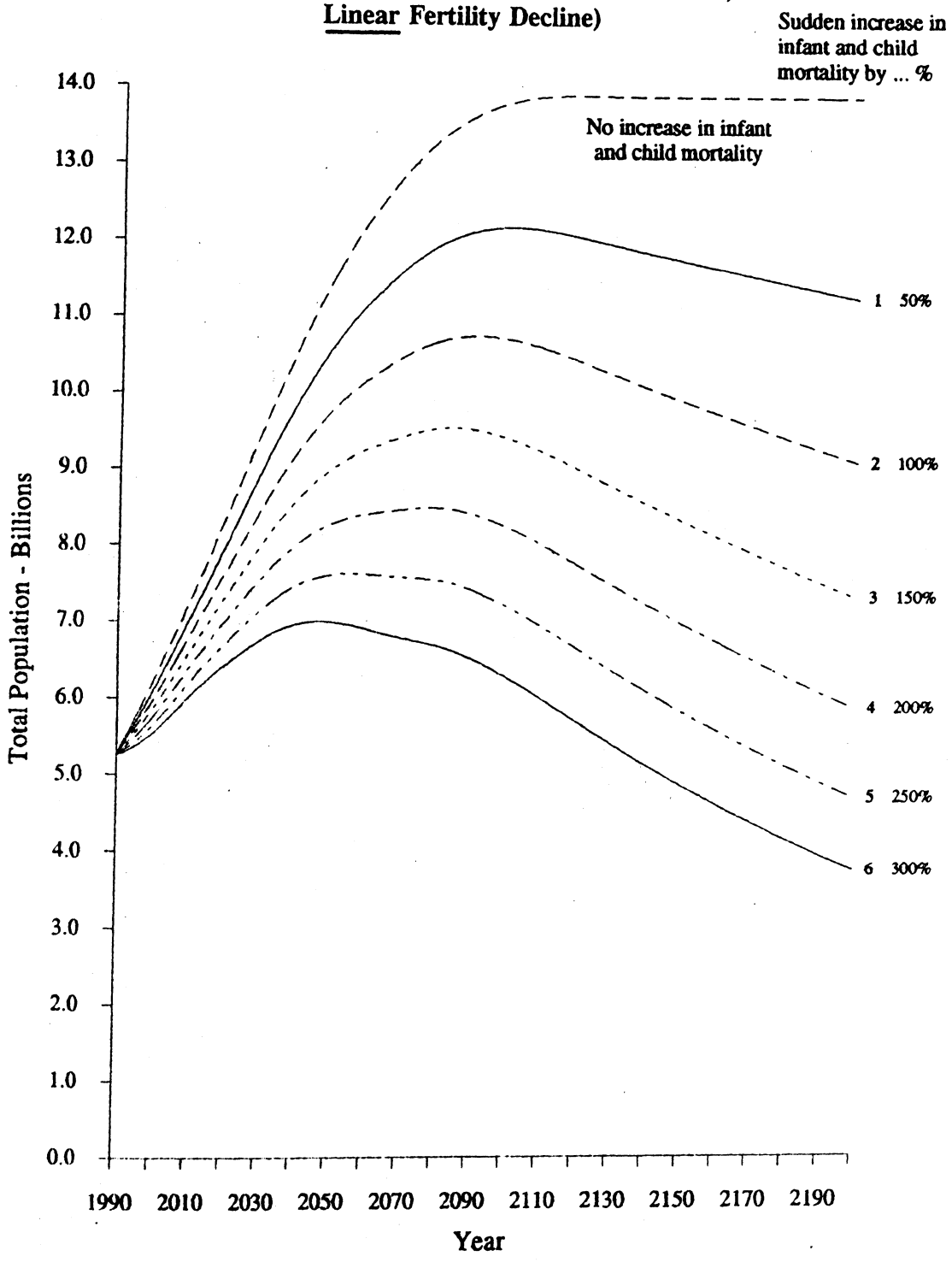
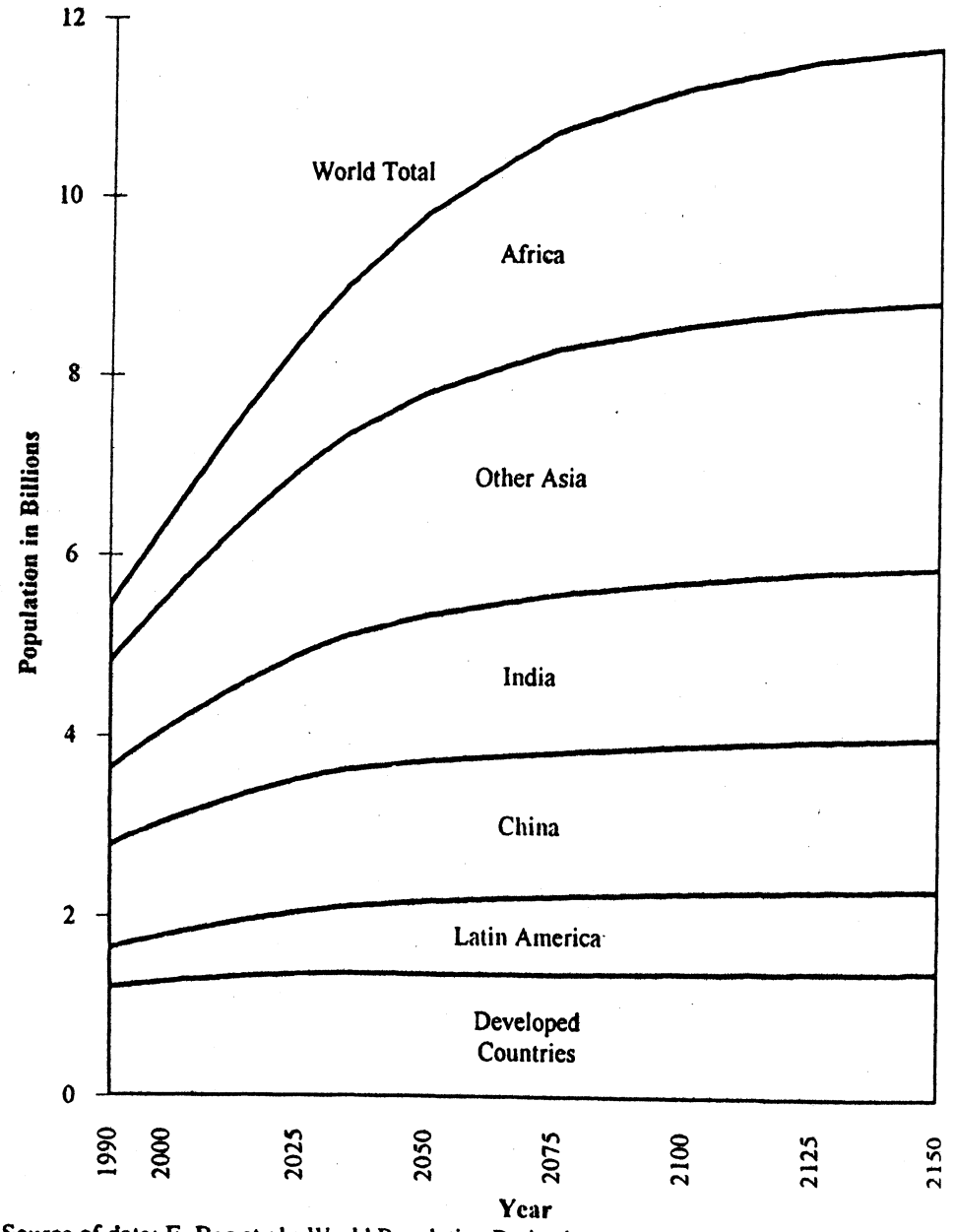


Figure 23

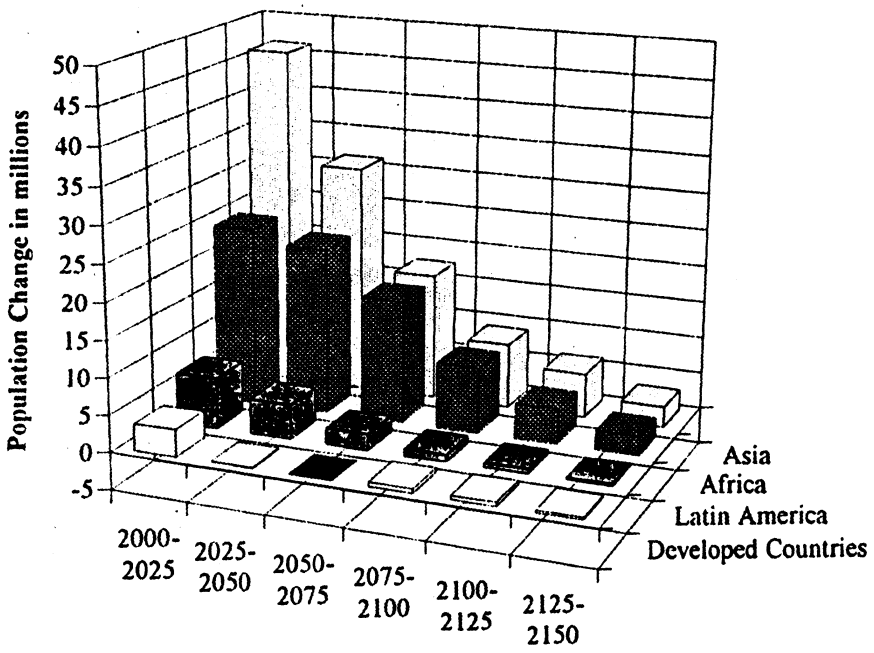
World Population Projections by Geographic Regions and Countries



Source of data: E. Bos et al.: World Population Projections 1994 - 95, Baltimore and London, 1994.

Figure 24

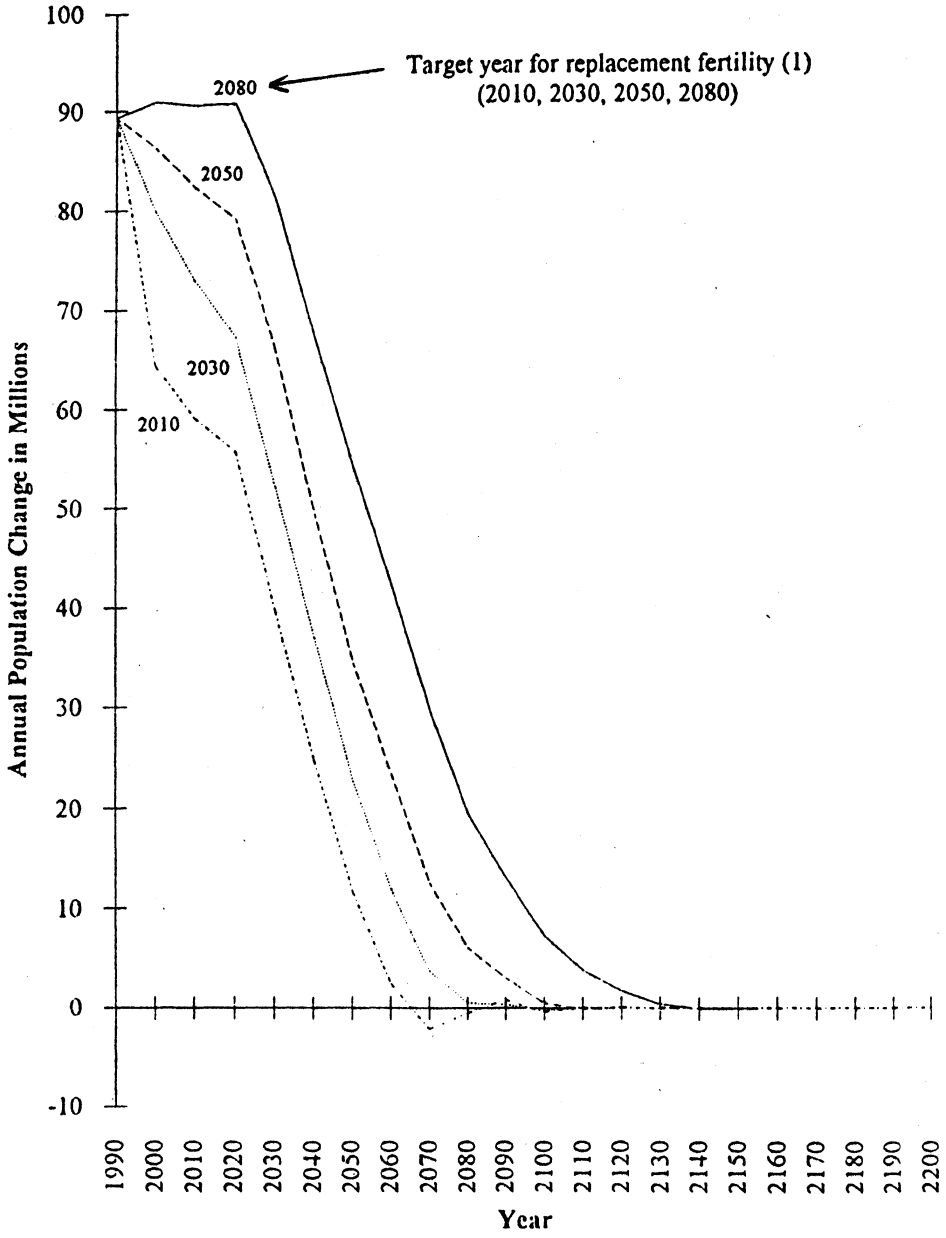
Average Annual Absolute Increments to Total Population of World Regions, 2000 - 2150



Source of data: E. Bos et al.: World Population Projections 1994 - 95, Baltimore and London, 1994.

Figure 25

The Surplus of Births over Deaths - Annual Population Change in Millions

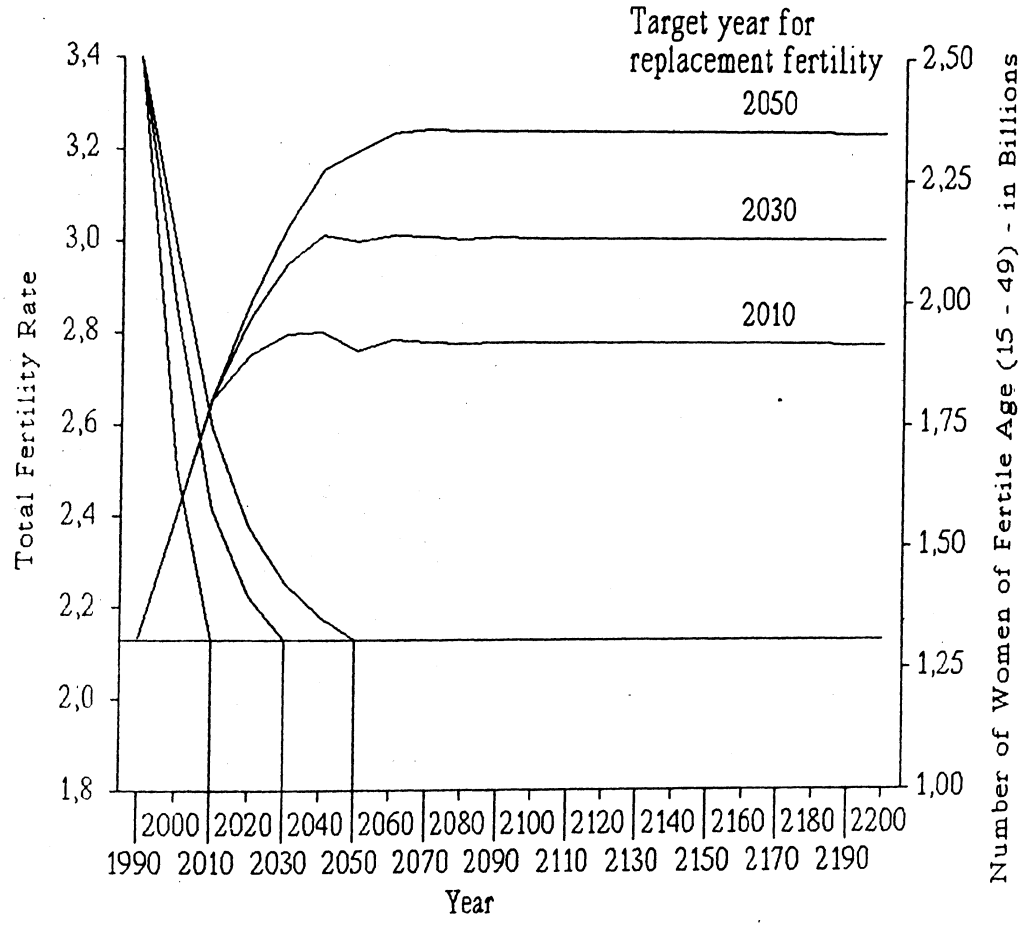


(1) Medium mortality level

Source: H. Birg, World Population Projections, 1995, p. 136.

Figure 26

Number of Women of Fertile Age (15 - 49) for Different Fertility Paths



Source: H. Birg, World Population Projections, 1995, p. 137

Table 8

The Influence of Alternative Assumptions on the Outcome of World Population Projections

	Reduction in Mortality Rates										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Year	population figures in 1000										
1990	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612
2000	6179936	6184726	6189531	6194350	6199183	6204032	6208894	6213772	6218665	6223573	6228496
2010	7042654	7051118	7059617	7068150	7076718	7085322	7093962	7102638	7111351	7120102	7128891
2020	7896185	7908271	7920409	7932602	7944848	7957150	7969508	7981923	7994396	8006928	8019520
2030	8686097	8701914	8717802	8733764	8749798	8765908	8782094	8798357	8814699	8831121	8847623
2040	9330948	9350623	9370394	9390262	9410230	9430298	9450469	9470744	9491125	9511613	9532210
2050	9823846	9847269	9870816	9894488	9918287	9942216	9966277	9990472	10014802	10039271	10063881
2060	10177586	10204435	10231434	10258586	10285892	10313356	10340979	10368765	10396716	10424836	10453126
2070	10415512	10445494	10475654	10505995	10536520	10567232	10598133	10629227	10660517	10692006	10723697
2080	10555673	10588180	10620894	10653818	10686954	10720308	10753881	10787679	10821705	10855962	10890455
2090	10634933	10669501	10704292	10739310	10774558	10810042	10845765	10881730	10917943	10954407	10991128
2100	10673851	10710348	10747084	10784064	10821292	10858771	10896507	10934503	10972764	11011295	11050100
2110	10685944	10724124	10762560	10801254	10840212	10879437	10918935	10958710	10998766	11039109	11079744
2120	10688213	10727949	10767951	10808225	10848775	10889605	10930719	10972124	11013823	11055822	11098126
2130	10687175	10728420	10769945	10811752	10853848	10896236	10938922	10981910	11025206	11068814	11112741
2140	10686548	10729274	10772290	10815602	10859213	10903128	10947353	10991893	11036752	11081937	11127453
2150	10686579	10730803	10775330	10820164	10865309	10910771	10956556	11002667	11049110	11095892	11143017
2160	10686039	10731761	10777798	10824156	10870838	10917850	10965197	11012884	11060918	11109303	11158046
2170	10685684	10732898	10780441	10828316	10876529	10925086	10973990	11023249	11072868	11122852	11173208
2180	10685379	10734091	10783143	10832542	10882293	10932400	10982870	11033708	11084920	11136512	11188490
2190	10684982	10735188	10785750	10836673	10887961	10939620	10991656	11044074	11096882	11150084	11203687
2200	10684634	10736336	10788408	10840854	10893680	10946892	11000495	11054497	11108902	11163717	11218949

Fertility assumptions: Target year of 2060 for replacement fertility, hyperbolic decline

Table 9

The Influence of Alternative Assumptions on the Outcome of World Population Projections

	Reduction in Mortality Rates										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Year	population figures in 1000										
1990	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612	5274612
2000	6226719	6231554	6236404	6241268	6246147	6251040	6255948	6260871	6265809	6270763	6275731
2010	7263292	7271982	7280707	7289465	7298259	7307089	7315955	7324858	7333798	7342775	7351791
2020	8406721	8419432	8432197	8445016	8457890	8470820	8483807	8496852	8509955	8523118	8536341
2030	9614606	9631684	9648135	9666060	9683361	9700738	9718193	9735726	9753340	9771035	9788813
2040	10785893	10807722	10829651	10851679	10873810	10896045	10918385	10940832	10963388	10986053	11008831
2050	11876315	11903078	11929969	11956991	11984145	12011434	12038859	12066424	12094129	12121978	12149973
2060	12845864	12877524	12909342	12941320	12973462	13005769	13038245	13070891	13103711	13136707	13169883
2070	13634925	13671478	13708224	13745164	13782302	13819640	13857182	13894930	13932889	13971060	14009448
2080	14250967	14292201	14333666	14375366	14417304	14459484	14501911	14544586	14587515	14630702	14674151
2090	14714132	14759771	14805676	14851853	14898304	14945035	14992049	15039352	15086948	15134842	15183038
2100	15011333	15061070	15111111	15161460	15212123	15263103	15314407	15366039	15418005	15470310	15522959
2110	15179841	15233165	15286829	15340837	15395196	15449910	15504985	15560428	15616243	15672439	15729020
2120	15253364	15309742	15366489	15423613	15481118	15539011	15597299	15655986	15115081	15774590	15834519
2130	15267843	15326782	15386116	15445853	15505999	15566560	15627543	15688955	15750803	15813094	15875837
2140	15262824	15323942	15385477	15447435	15509822	15572646	15635914	15699633	15763810	15828453	15893570
2150	15261433	15324618	15388235	15452292	15516794	15581750	15647167	15713051	15779411	15846255	15913591
2160	15262833	15328173	15393962	15460208	15526918	15594098	15661757	15729901	15798539	15867680	15937330
2170	15261332	15328820	15396776	15465209	15534126	15603533	15673439	15743851	15814777	15886227	15958208
2180	15260903	15330511	15400606	15471197	15542289	15613893	15686014	15758661	15831843	15905567	15979844
2190	15260656	15332407	15404666	15477440	15550736	15624563	15698928	15773840	15849308	15925340	16001945
2200	15259941	15333827	15408242	15483192	15558686	15634731	15711336	15788510	15866261	15944598	16023531

Fertility assumptions: Target year of 2070 for replacement fertility, linear decline

Table 10
World Population Level (in 1000) Assuming a Sudden Increase in Infant and Child Mortality (Malthusian Variant)

Variant	I (+50 %)			II (+ 100 %)			III (+ 150 %)		
Age	Males	Females	Total	Males	Females	Total	Males	Females	Total
1990	2657196	2617416	5274612	2657196	2617416	5274612	2657196	2617416	5274612
2000	3055615	3003112	6058727	2994345	2947906	5942250	2935588	2894846	5830433
2010	3435064	3394083	6829147	3325713	3298554	6624267	3221039	3206796	6427835
2020	3790143	3775391	7565534	3622379	3629530	7251909	3463752	3490902	6954654
2030	4102685	4122941	8225626	3870978	3920454	7791432	3653352	3729008	7382360
2040	4338736	4396280	8735016	4041597	4134899	8176496	3764297	3889160	7653458
2050	4497695	4587708	9085404	4133733	4264114	8397847	3796402	3961778	7758181
2060	4592795	4708429	9301225	4166877	4323665	8490542	3774855	3966371	7741226
2070	4642632	4776864	9419497	4166010	4339043	8505053	3730847	3935365	7666212
2080	4659716	4805786	9465501	4145304	4328155	8473458	3680016	3891568	7571584
2090	4652728	4805670	9458397	4104734	4292720	8397454	3613722	3828109	7441830
2100	4628493	4784511	9413004	4048754	4237137	8285892	3533932	3745656	7279588
2110	4594056	4750710	9344766	3984699	4171637	8156336	3448410	3656276	7104686
2120	4555767	4711796	9267563	3917658	4102100	8019758	3361077	3564308	6925385
2130	4516690	4671389	9188079	3850780	4032045	7882824	3275087	3473058	6748145
2140	4478255	4631510	9109764	3785366	3963450	7748816	3191649	3384493	6576142
2150	4440291	4592315	9032606	3721151	3896277	7617428	3110373	3298367	6408740
2160	4402451	4553177	8955628	3657863	3830003	7487866	3031033	3214219	6245252
2170	4365025	4514449	8879474	3595735	3764936	7360671	2953795	3132302	6086097
2180	4327915	4476084	8803999	3534655	3700995	7235650	2878513	3052482	5930994
2190	4291094	4437998	8729092	3474592	3638101	7112693	2805134	2974664	5779798
2200	4254605	4400259	8654864	3415566	3576296	6991862	2733640	2898849	5632489

Variant	IV (+ 200 %)			V (+ 250 %)			VI (+ 300 %)		
Age	Males	Females	Total	Males	Females	Total	Males	Females	Total
1990	2657196	2617416	5274612	2657196	2617416	5274612	2657196	2617416	5274612
2000	2879304	2843900	5723204	2825454	2795035	5620489	2773999	2748219	5522218
2010	3120943	3118734	6239677	3025328	3034295	6059623	2934098	2953405	5887503
2020	3313892	3359244	6673136	3172443	3234300	6406743	3039062	3115824	6154886
2030	3449151	3548150	6997301	3257743	3377441	6635184	3078521	3216460	6294982
2040	3505757	3658305	7164063	3264947	3441609	6706556	3040888	3238379	6279266
2050	3484046	3679519	7163565	3195102	3416212	6611314	2928094	3170792	6098886
2060	3414382	3634840	7049222	3083257	3327461	6410719	2779418	3042715	5822132
2070	3333947	3563454	6897401	2972334	3221088	6193423	2643246	2906186	5549431
2080	3259662	3492844	6752506	2880374	3129027	6009401	2538583	2797372	5335955
2090	3174374	3407713	6582087	2781825	3027733	5809558	2431622	2684668	5116290
2100	3077451	3304868	6382319	2673341	2910021	5583362	2316194	2556772	4872966
2110	2977197	3198193	6175390	2563869	2791560	5355429	2201967	2431094	4633061
2120	2876457	3090599	5967056	2455269	2673941	5129209	2089916	2308018	4397935
2130	2778318	2985062	5763380	2350489	2559711	4910200	1982790	2189572	4172362
2140	2683914	2883564	5567478	2250607	2450877	4701485	1881621	2077797	3959418
2150	2592711	2785637	5378348	2154927	2346746	4501673	1785544	1971769	3757313
2160	2504493	2690839	5195332	2063214	2246849	4310063	1694280	1870963	3565243
2170	2419354	2599357	5018711	1975482	2151302	4126784	1607760	1775416	3383177
2180	2337092	2510985	4848077	1891459	2059811	3951270	1525634	1684736	3210371
2190	2257616	2425591	4683206	1811001	1972188	3783189	1447697	1598666	3046362
2200	2180855	2343118	4523973	1733978	1888309	3622286	1373752	1517010	2890762

Target year = 2060, hyperbolic decline in fertility

Table 11
World Population Level (in 1000) Assuming a Sudden Increase in Infant and Child Mortality (Malthusian Variant)

Variant	I (+50 %)			II (+ 100 %)			III (+ 150 %)		
Age	Males	Females	Total	Males	Females	Total	Males	Females	Total
1990	2657196	2617416	5274612	2657196	2617416	5274612	2657196	2617416	5274612
2000	3075113	3021870	6096983	3012240	2965240	5977480	2951934	2910802	5862736
2010	3528683	3484844	7013528	3412245	3383319	6795563	3300774	3285786	6586560
2020	4001097	3980626	7981722	3815305	3819341	7634646	3639780	3666163	7305943
2030	4475424	4486102	8961526	4209673	4254091	8463764	3960356	4034935	7995291
2040	4903341	4947370	9850711	4552074	4638625	9190700	4224776	4348752	8573528
2050	5260817	5334729	10595546	4819840	4943123	9762963	4411881	4577851	8989732
2060	5533801	5634634	11168435	5008761	5161504	10170266	4526382	4722899	9249281
2070	5741467	5868389	11609856	5144101	5321640	10465741	4599561	4818326	9417887
2080	5888649	6040883	11929532	5232826	5433899	10666724	4640317	4879754	9520071
2090	5964393	6138663	12103056	5257833	5478568	10736401	4625211	4881153	9506365
2100	5983890	6174261	12158151	5231579	5464640	10696219	4563859	4827836	9391695
2110	5961549	6161573	12123122	5168615	5408145	10576760	4471056	4737903	9208959
2120	5915623	6118563	12034186	5085006	5324706	10409712	4360798	4624743	8985542
2130	5863355	6064490	11927845	4996854	5232349	10229203	4248050	4505087	8753137
2140	5813340	6012042	11825382	4911857	5142722	10054579	4139716	4389653	8529369
2150	5764614	5962027	11726641	4829022	5056325	9885347	4034726	4278620	8313346
2160	5715150	5910869	11626018	4746601	4970022	9716623	3931557	4169210	8100767
2170	5666624	5860553	11527177	4666027	4885547	9551574	3831409	4062914	7894322
2180	5618511	5810886	11429398	4586823	4802695	9389518	3733809	3959484	7693294
2190	5570648	5761358	11332007	4508828	4721008	9229836	3638583	3858484	7497067
2200	5523303	5712383	11235686	4432252	4640819	9073071	3545862	3760152	7306015

Variant	IV (+ 200 %)			V (+ 250 %)			VI (+ 300 %)		
Age	Males	Females	Total	Males	Females	Total	Males	Females	Total
1990	2657196	2617416	5274612	2657196	2617416	5274612	2657196	2617416	5274612
2000	2894155	2858522	5752677	2838862	2808367	5647229	2786016	2760304	5546320
2010	3194164	3192165	6386329	3092310	3102378	6194688	2995109	3016346	6011456
2020	3474095	3520787	6994882	3317837	3382921	6700757	3170610	3252279	6422889
2030	3726688	3828093	7554781	3507914	3633043	7140958	3303311	3449282	6752593
2040	3920102	4076808	7996910	3636776	3821893	7458669	3373584	3583149	6956733
2050	4034835	4237408	8272244	3686717	3920366	7607083	3365652	3625370	6991022
2060	4083645	4316624	8400269	3677727	3940608	7618335	3305981	3592902	6898884
2070	4103713	4355373	8459085	3652710	3929903	7582613	3242983	3539228	6782211
2080	4105668	4374305	8479973	3623847	3913707	7537554	3190216	3494389	6684605
2090	4059584	4341035	8400620	3554600	3853253	7407853	3104453	3413239	6517691
2100	3972123	4257041	8229164	3448562	3746033	7194594	2986101	3289131	6275232
2110	3858405	4142417	8000822	3321248	3614050	6935297	2851131	3145884	5997015
2120	3730475	4008429	7738905	3182877	3466557	6649434	2708066	2990860	5698926
2130	3602166	3870441	7472608	3046147	3317491	6363638	2568475	2836514	5404990
2140	3479667	3738345	7218013	2916610	3176001	6092610	2437338	2691327	5128665
2150	3361798	3611978	6973776	2792940	3041573	5834513	2313165	2554435	4867600
2160	3247199	3488842	6736041	2673894	2911915	5585809	2194781	2423687	4618468
2170	3136840	3370191	6507031	2560215	2788049	5348265	2082719	2299878	4382597
2180	3030226	3255704	6285931	2451361	2669558	5120919	1976365	2182480	4158845
2190	2927142	3144933	6072074	2347055	2555954	4903009	1875375	2070945	3946320
2200	2827628	3038009	5865637	2247242	2447252	4694494	1779593	1965170	3744763

Target year = 2060, linear decline in fertility

Table 12

Population by Country, 1995 and 2100

Population in millions			
Country	1995	Country (rang order 1995)	2100
(1) China	1199	India (2)	1813
(2) India	934	China (1)	1630
(3) United States of America	263	Pakistan (7)	379
(4) Indonesia	193	Nigeria (10)	355
(5) Brazil	161	United States of America (3)	344
(6) Russian Federation	149	Indonesia (4)	338
(7) Pakistan	129	Ethopia (22)	334
(8) Japan	125	Brazil (5)	275
(9) Bangladesh	121	Bangladesh (9)	247
(10) Nigeria	111	Iran (15)	198
(11) Mexico	90	Zaire (27)	191
(12) Germany	81	Mexico (11)	177
(13) Viet Nam	74	Philippines (14)	166
(14) Philippines	69	Viet Nam (13)	160
(15) Iran	65	Russian Federation (6)	155
(16) Turkey	61	Egypt (21)	116
(17) Thailand	60	Afghanistan (37)	113
(18) United Kingdom	58	Turkey (16)	109
(19) France	58	Tanzania (35)	108
(20) Italy	58	Japan (8)	107

Source: E. Bos et al.: World Population Projections 1992-93 Edition, Baltimore and London, 1994.

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