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It is generally known that for the last two or three decades population growth in developing countries, especially in Latin America and Africa, has been much higher than in the past. Excluding China, the average rate of growth for developing countries is about 2.6 percent per annum, and about 3 percent for the two continents mentioned. In China the rate of growth is reported to be 1.4 percent, and in India between 1960 and 1970 it was 2.3 percent.

This phenomenon is one of the elements of the concern expressed by the Club of Rome and the Meadows Report.[1] Other elements are increasing pollution and the exhaustion of natural resources, mostly attributable to the rapid growth of some industries in the developed nations. The main question arising from the world's demographic development is whether the increasing population can be provided with a decent standard of living around the year 2000. In addition to the elements already mentioned the answer to this question depends on the improvement that can be attained in the standard of living of the poor masses of the world—a subject that is a central concern of the United Nations Development Strategy for the Second Development Decade (1971–1980). This strategy was adopted on paper by all member governments of the United Nations, on the occasion of the 25th anniversary of that organization, 24 October 1970. So far the actual performance of most nations, especially the richest and largest, has remained much below what had been expected.[2]

The main problem of the population explosion and the increasing scarcity of natural resources should therefore be seen to be: how can we

decelerate the use of natural resources by the world at large, without forgetting the need for improving the lot of the masses? If we do not add the last condition, we miss the point. It is clear that a considerable part of the required action consists of a redistribution of welfare—between rich and poor countries and between rich and poor social groups within most countries.

Lack of Data and Ensuing Uncertainty

Opinions on the problems just set out—that is, both the Meadows, or Club of Rome, aspect and the development aspect of the total problem—differ enormously among scholars of differing disciplines and among individual scholars within one discipline. Opinions range from those of social scientists who practically deny the existence of the problem—for instance, many economists in the Anglo-Saxon tradition, or technicians such as Herman Kahn—to those of biologists who hold the opinion that the world is heading for disaster, among them my brother Niko Tinbergen. The optimists rely on human inventiveness, hence technological development; the pessimists point to the tremendous pollution of the Great Lakes and the oceans, where already many species of fish have disappeared.

In a more quantitative way, the differences of opinion may be illustrated by the estimates about energy sources and about the food producing capacity of the earth. Some energy experts, among them those of the United Nations,[3] deny the dangers of nuclear energy and believe in the possibility of fusion; others are much more reserved, for instance the Dutch academician J. J. Broeze.[4] Another example of large differences of opinion is on the question of the maximal food production potential of the earth, where optimists think that 50 billion persons can be fed adequately,[5] while others doubt the continuation even of today's level of food production.

For most scholars working in the field, opinions shift from one possible bottleneck to another, depending on which available evidence they find convincing. In addition, of course, the results depend on the assumptions on policies that can realistically be applied for the solution of a number of subproblems.

For these reasons I do not think any standpoint today can claim to be a scientific view. Together with large parts of biology and related sciences on the one hand, and of political science and related subjects on the other, those who try to dovetail the various parts of the problem complex must admit they still are in a pre-scientific stage of understanding the problem and its solution. I mean the stage of reconnaissance, preceding the stage at which theories can be considered to have been established and tested to the extent that a sizable majority of scholars agree.

A Pre-Scientific Frame for Population and Income Targets

I prefer to formulate my point of view as a target, that is as a proposed policy aim rather than as a forecast. It constitutes an attempt to reconcile intuitively some of the most important forces and tensions existing in today's world in the fields of social, economic, technological, geological, and agronomic sciences, as expressed in debates and exchanges of ideas in the United Nations system and in political programs of a number of the groups involved. Since at present biologists feel unable to give a quantitative worldwide form to the limitations they see or expect, it is mainly meant as a challenge to them. But to a lesser degree it is addressed also to other groups—in particular to politicians and political scientists, since the execution of the policies implied is their responsibility. A warning should be given here: nobody will find the targets easy to attain. There simply are no easy ways out of our present situation; there are only either difficult ways or no ways at all. To reach the targets will require the utmost effort from all involved and their understanding of other people's points of view. For those who are not prepared to cooperate there only remains the catastrophe, earlier or later.

The central part of my view, which I call the Frame, makes a distinction between developing and developed countries and between population and production (or income) targets. Later in this section the Frame will be further specified. As the starting point I take the year 1970, for which World Bank data are available[6] and as the end point, for arithmetical convenience, the year 2012. The period is therefore 42 years.

The assumptions made in order to fix the target figures for 2012 are:

1. the population of the developed countries in 2012 will be the same as in 1970;
2. the average rate of increase of population of all developing countries taken together as well as the poorest decile of world population (taken as countries) over the period will be 1.5 percent per annum, coming down to zero in 2012;
3. income per capita of the developed countries will rise at an average annual rate of 1.7 percent over the period, which is equivalent to doubling in the period as a whole;
4. income per capita of the developing countries will rise by 5 percent per annum, again as an average over the period.

Using these assumptions we obtain the figures given in Tables 1 and 2. As a technical explanation it should be added that the figures of the World Bank atlas have been corrected for the higher purchasing power of the dollar in countries with per capita incomes lower than that of the United

Table 1
World Population, Total Income, and per Capita Income for Developed and Developing Countries, 1970 and 2012

	Population (millions)			Total Income ($ billions)[a]			Income per Capita ($)[a]	
Year	Developed	Developing	Total	Developed	Developing	Total	Developed	Developing
1970	1089	2588	3677	4030	830	4860	3700	320
2012	1089	4835	5924	8060	12400	20460	7400	2560

[a]1970 purchasing power.

States. Technical details have been described elsewhere,[7] and should not occupy us here.

According to Nordhaus and Tobin[8] a better yardstick of US per-capita welfare is about one-quarter lower than gross national product (GNP) per capita. This would imply that the ratio of welfare of rich countries to poor may be reduced by at most one-quarter. The last column of Table 2 would then be 24 and 6.

Table 2
Total and per Capita Income of the Richest and Poorest Deciles within Countries (measured in terms of population) and Ratio of per Capita Income of Richest to Poorest, 1970 and 2012

	Richest Decile		Poorest Decile		
Year	Total Income ($ billion)[a]	Per Capita Income ($)[a]	Total Income ($ billion)[a]	Per Capita Income ($)[a]	Ratio of per Capita Incomes
1970	1620	4400	50	136	32
2012	4870	8200	630	1060	8

[a]1970 purchasing power.

From Tables 1 and 2 one important conclusion can be drawn immediately. Even the utmost effort (assumed in our figures) will not eliminate the welfare gap between the upper and the lower 10 percent of countries (measured in terms of their population). It will still amount to a ratio of almost 6 to 1. Although this constitutes a considerable reduction in comparison to the ratio prevailing in 1970, estimated to be at least 24 to 1, it still represents a large gap. To illustrate its significance we mention the ratio existing within well integrated nations, such as the United States, France, and West Germany; there the ratio of average income of the most to the least prosperous regions, again with 10 percent of the population in each of them, amounts to less than 2 to 1. In a less well-integrated country, Italy, it is 3 to 1, and Italy visibly suffers from these regional differences. Thus, even

if around the year 2010 the world as a whole were to be considerably better integrated in terms of regional income disparities than it is now, we may well ask whether a ratio of 6 to 1 would be sufficiently low.

In the preceding paragraphs we have stressed that our assumptions (1)–(4) refer to averages over time and for groups of countries. We explained that over time the rate of population growth assumed for the poor countries represented a gradual decline from the present figure of some 2.5 percent to zero. The same applies to the rate of growth of income per capita of the rich countries. But the figures would not necessarily be uniform among countries. It seems unavoidable to assume some further growth in income in the developed countries, since part of their population is still poor and this poverty cannot be eliminated by redistribution of income alone in such marginal countries as those of southern and eastern Europe (Italy, Spain, Portugal, Greece, Turkey, Albania, Yugoslavia, and Romania). On the other hand, the rich strata in rich countries such as the United States, Sweden, Canada, and Switzerland will have to face the necessity of incomes lower than today. From their point of view, if they do not already understand the situation, to give up some of their privileges may be seen as a form of insurance premium.

From Table 1 we can derive a crude estimate of the growth of agricultural and nonagricultural production implied in the assumptions. World agricultural production would have to rise threefold over the period 1970–2012, corresponding to an annual rate of growth of almost 3 percent. This threefold increase is considered possible by the well-known German expert on agriculture and development, F. Baade.[9] The rate of increase is not far from that of the last ten years and well below the 4 percent deemed possible by FAO in its 20-year World Indicative Plan 1965–1985. Our question to biologists is whether they believe that we are asking too much. If they do, then we must consider which components of our target estimates can be revised downward.

Nonagricultural production will have to rise by about 4 percent per annum as an average over the period for all countries taken together. In production as a whole, the use of scarce natural resources will have to increase as little as possible. If our experience of the last century (1870–1970) can be extrapolated, the annual rate of growth of the production of "exhaustibles" will be one percentage point less than that of total production. Over 1970–2012, the latter would average 3.5 percent per annum. The rate of growth of the use of exhaustibles would therefore amount to 2.5 percent as an average over the period, as compared with rates of growth of world food production of 1.7 percent (1936–1959) and of metal production projected from 1966 to 2000 of 5 percent.[10] The figure of 2.5 should be seen as an average, with a tendency to diminish over the period and eventually to become negative as I have suggested elsewhere.[11]

Comparison of Target Figures with Projections of Herman Kahn

In their well-known book *The Year 2000,* Kahn and Wiener[12] offer projections for population and income for roughly the same period that we have chosen. It is of interest to compare their figures with ours. Table 3 shows some results for the year 2012.

Table 3
Population and per Capita Income, 2012: Comparison of Kahn and Wiener Projections and Tinbergen Target Estimates

	Population (millions)		Per Capita Income (1970 dollars)	
Region	Kahn and Wiener	Tinbergen	Kahn and Wiener	Tinbergen
Developing countries	6220	4835	2100	2560
Developed countries	1750	1089	10800	7400

Kahn and Wiener's figures have been expressed in terms of 1970 dollars and corrected for the David-Balassa bias.[13] Whereas in my figures the ratio of income per capita of developed to underdeveloped continents becomes 2.9, Kahn and Wiener show a ratio of 3.5; total population ratios of poor to rich countries are 4.4 in my computations, but 3.6 in theirs. These differences illustrate my opinion that distribution of world production has to shift more in favor of developing continents than present trends make likely. My figures also concede much more to the warnings by Meadows and biologists that population growth must be curbed as much as possible, especially in the rich countries, and that the latter have to impose upon themselves a stronger brake on growth than the poor countries.

Income Redistribution within Countries

These brakes on development can only be imposed successfully if they are accompanied by a reduction in income inequality within countries. In a series of studies on the forces at work in income distribution,[14] I arrived at the following picture. Since incomes are prices of productive services, they are subject to the forces of demand and supply. Thus, an increase in demand for any type of labor or any other factor of production will tend to raise the corresponding income and an increase in supply will tend to lower that income. This can also be applied to relative incomes of labor with high and low qualifications. Over the last half century or century the scanty information we have seems to indicate that technological development tended to raise the demand for skilled over less skilled labor and hence to raise inequality of incomes; but the development of education tended to in-

crease the relative supply of skilled labor and hence to reduce inequality of incomes. The process can be described as a "race between technological development and education." Between 1900 and 1920, and again between 1930 and 1958 Ullman[15] found a fall in income inequality in the United States, comparing third-level educated groups with second-level. In an attempt to extrapolate demand and supply up to 1990, I have estimated that between 1960 and 1990 a slight further reduction in inequality may be expected.[16] In the time periods 1920–1930 and 1958–1963 inequality increased, but the overall trend for the United States has been a fairly distinct diminution of inequality. The same has been found to be true for Norway over about the last century by Soltow[17] and for the Netherlands by several studies covering the last half century and the coming two decades.[18]

The preceding statements apply to primary income, or income before redistribution. If we consider income after redistribution, that is deducting taxes and adding services received below cost, inequality has diminished considerably more. Thus, family income after redistribution in the Netherlands in 1962 was 4.7 times as high for the upper 20 percent as for the lower 20 percent, but before redistribution that ratio was 5.9. For Denmark in 1963 these ratios were 2.5 and 8.[19]

From results such as these we can conclude that a further reduction of inequality could be obtained—for example, if Danish redistributive policies were followed.

Population Policy and Its Impact

I propose to return to the theme of population policy. We earlier noted that increasing pollution and scarcity of natural resources require a reduction in the growth of population. At the same time, a lower rate of growth of population will imply that a larger part of any country's savings can be used for improving its level of well-being. A third contribution can be made if poor households are larger than wealthy ones, as is the case in many developing countries and as used to be so in my own country, the Netherlands, in the 1930s (See Table 4).

Table 4
Average Household Size in Lowest and Highest Income Groups, United States, Netherlands, and India

			India (1967-68)[a]	
Income Group	United States[a] (1959)	Netherlands[b] (1935-36)	Rural	Urban
Lowest	3.24	5.35	5.80	6.05
Highest	3.89	4.20	4.48	2.70

[a]Data refer to families instead of households.

[b]Data are for 10 percent groups.

The situation shown in Table 4 suggests the possibility for poor households to improve their incomes by the application of birth control. In the Netherlands the prevalence of birth control practice had changed markedly by 1962 and, as a consequence, the ratio of per capita incomes between the highest and the lowest 10 percent income groups was about 3, compared to a ratio of income per household of more than 10.

Birth control operates in two ways here. It reduces the number of persons who have to live from a given income; this could be called the individual impact. And, if applied by many people, a second favorable change will be added. The lowest-paid labor will become more scarce and as a consequence be better paid. The latter process may be illustrated by the following calculations. Let us consider the area now consisting of India, Pakistan, and Bangladesh. If these countries had been able to maintain, from 1941 onwards, a rate of population growth of 1 percent per annum, as they did before World War II, their population in 1971 would have been 524 million, or 79 percent of the actual figure of 667 million. Since there has been a surplus of labor all the time, we can assume that national product would have been the same as it actually was during the period. If we assume further that population growth would have been less especially in the large families, it would have reduced the poorer half of the population because, whereas the median number of persons per household is 5.25, the poorer half shows an average size of 5.7.[20] Assuming that all the theoretical 21 percent reduction in population would have been in the poorer half only, the reduction would have been 42 percent in that half and would have reduced the average household size to 3.3, a figure close to that of the richest one-quarter of the urban population. Assuming that a Cobb-Douglas production function applies, in which unskilled workers, skilled workers, qualified personnel, and capital would enter as factors of production, it would follow that income shares of each of these categories would not change with a change in their numbers. Hence the per capita income of unskilled workers (largely "landless peasants" in the usual terminology) would have been $1/0.58 = 1.7$ times what it is now.

Estimates such as these are only crude approximations to what might have happened. The assumption about the production function can be—and probably has to be—replaced by a more sophisticated one. (I did find some evidence in support of the assumption made, however.[21] But the order of magnitude found suggests that the application of birth control may be the only weapon left to the poorest groups to improve their situation—and one that yields sizable results.

Summarizing, I want to stress that population policy constitutes a powerful instrument to synthesize development policy and environmental policy. I made an attempt to formulate an intuitive view on a frame of population and production targets for the next 40 years, with a view to submitting this to biologists and ecologists for their comments. Although I

tried to remain on the safe side with regard to the total production of the earth, I insisted on a twofold need for redistribution of income—that is, both among and within nations. And I indicated some means to be used, namely extended education and birth control.

Notes

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