

## ATTACHMENT B. SCENARIOS OF GLOBAL DEVELOPMENT

### B.1. REVIEW OF PAST QUANTITATIVE SCENARIOS

[Section B.1 is from Hayes (2004) and is to be revised and updated for the final working paper.]

**Box IA-1** shows projections of total world output associated with five noted models of world development. The scenarios are described in **IA-2**.

How do the authors of these models motivate these scenarios? Meadows, Nordhaus and Kahn all show economic growth coming to an end, but at different final levels and for different reasons. Meadows believes that biogeophysical limits to economic growth will compel us to live within them. Nordhaus believes that productivity-enhancing technological innovation will become increasingly subject to diminishing returns. Kahn believed that as wealth increases people will become satiated and jaded and lose their entrepreneurial and acquisitive desires. Romer's scenario does not show limits to growth. He believes that increasing returns to technology and knowledge should allow growth to continue indefinitely. Cline's growth projections are extensions of projections made by the Intergovernmental Panel on Climate Change and are not further motivated.

Different assumptions concerning population growth are not an important reason for the differences among the scenarios. Other than Meadows, all the authors use standard projections prepared by the United Nations. In these, population stabilizes at about 11 billion by the middle of the 21<sup>st</sup> century. Meadows uses a lower stabilization value of 7.7 billion.

These globally aggregated projections are a useful initial reference, but if we wish to consider questions regarding income inequality we need regionally disaggregated models. **IA-3** shows projections of economic growth for six scenarios ending in 2100, four of which—by Holdren, Nordhaus, Kahn, Greenpeace—are disaggregated on a regional basis.<sup>1</sup> These scenarios are described in IA-2.

Readers familiar with the global futures debate might suspect that I've mislabeled the projections in IA-3. Nordhaus and Kahn present "business-as-usual" scenarios in which world GDP reaches \$211 and \$274 trillion, respectively, by 2105. Greenpeace and Holdren present "preferred" scenarios in which world GDP reaches \$282 and \$460 trillion by that date. How can it be that the *preferred* scenarios recommended by two noted environmental advocates show *greater* economic growth than do the *business-as-usual* scenarios presented by two noted pro-growth neo-classical economists?

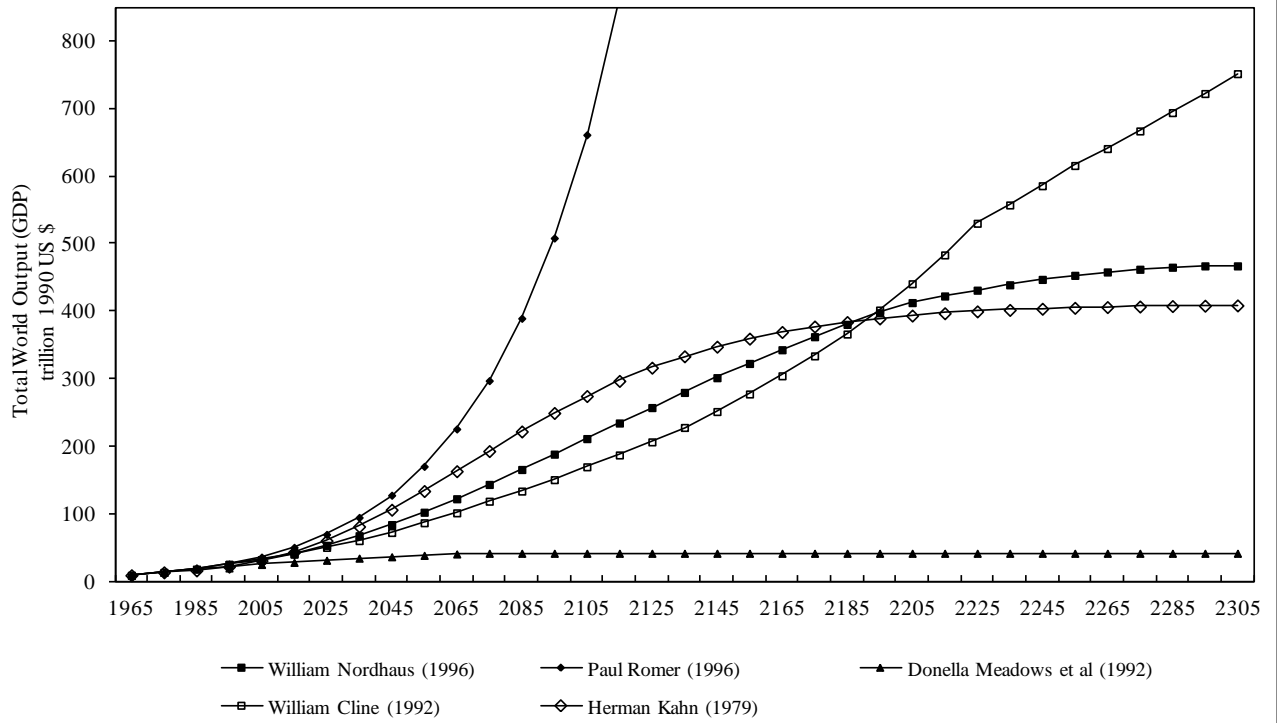
The answer is that the Greenpeace and Holdren scenarios incorporate a normative desire that the economic disparities between the rich and the poor countries of the world be significantly reduced, while the

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<sup>1</sup> Box IA-3 includes the scenarios shown in IA-1 except for Cline's, and adds new ones by Holdren and Greenpeace. Cline's scenario was not included to avoid crowding. Termination of the time horizon at 2105 allows the main points of this section to be illustrated more conveniently.

# BOX IA-1. WORLD OUTPUT TRAJECTORIES

1965 - 2305



## BOX IA-2. WORLD OUTPUT TRAJECTORIES – DESCRIPTIONS

### 1. World Output Trajectories, 1965-2305 (Box IA-1)

Box IA-1 shows projections of total world output made by noted economists and other analysts for the period 1965-2305. All figures are in 1990 U.S. dollars.

**Nordhaus:** This is the reference case output trajectory used by Nordhaus for his RICE model (Nordhaus and Yang, 1996). He uses United Nations mid-range population forecasts, which show stabilization at 10.6 billion. World per capita output reaches \$20,500 by 2100 and stabilizes near \$42,000 shortly after 2200.

**Romer:** At the July 1996 Western Economic Association annual convention in San Francisco Paul Romer estimated that the global economy should be able to sustain a per capita output growth rate of about 2 to 3 percent for the indefinite future. The trajectory shown in the chart uses a value of 2.5%, along with the United Nations population projections used by Nordhaus. Per capita output in 2100 is about \$60,000.

**Meadows:** This is the path of global output that Meadows et al., in *Beyond the Limits to Growth* (1992), suggest should be followed in order to avoid the catastrophic reduction in output that would otherwise result as biogeophysical limits are exceeded. Population is limited to 7.7 billion and per capita output is estimated to stabilize at about \$5,400.

**Cline:** This is the reference case output trajectory used by Cline in *The Economics of Global Warming* (1992). It is based on extrapolations of mid-range projections used by the World Bank and the United Nations for the coming century, tempered by Cline's judgment that these rates will slow in later decades. In 2100 population is stable at 10.5 billion and per capita output is about \$15,200.

**Kahn:** This is the output trajectory offered by Kahn in *World Economic Development* (1979) as an alternative to that offered by the authors of *The Limits to Growth*. Population stabilizes at 10 billion. In 2100 per capita output is about \$26,000 and it stabilizes a century later at about \$40,000.

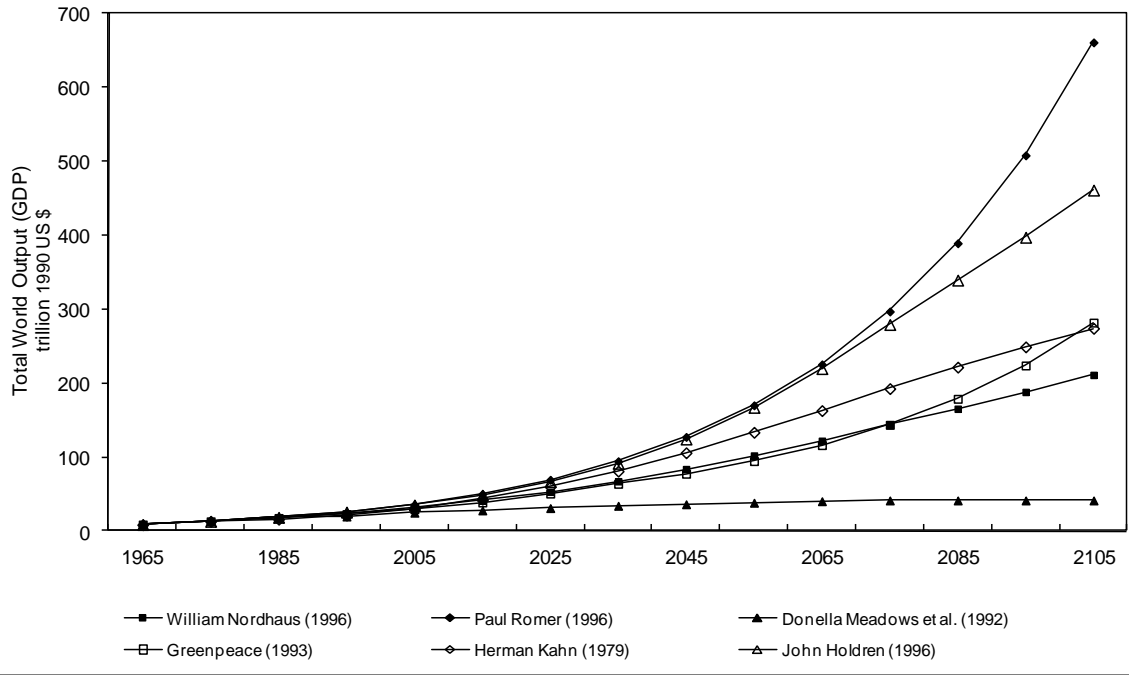
### 2. World Output Trajectories, 1965-2105 (Box IA-3)

Box IA-3 shows output trajectories for the period 1965-2105. Four of the trajectories (Nordhaus, Romer, Meadows and Kahn) are the same as those shown in Box IA-1 but here cover only the period through 2105. Cline's trajectory has been deleted and new ones by Holdren and Greenpeace have been added.

**Holdren:** John Holdren (1996) presented his "best plausible" scenario for reducing reliance on fossil fuels and achieving distributional equity among nations at an April U.C. Berkeley symposium. The trajectory shown in IA-3 is the output trajectory used in this best plausible scenario. In 2100 population has stabilized at 9 billion and per capita output is about \$47,700.

**Greenpeace:** This is the growth path used in the study *Towards a Fossil Free Energy Future* (1993) prepared for Greenpeace by Lazarus et al. of the Stockholm Environmental Institute. It uses the same population and total world output assumptions adopted by the Intergovernmental Panel on Climate Change (IPCC), but modifies per capita output growth rates among regions to reduce inequities. In 2100 population has stabilized at 11.3 billion and per capita output is about \$22,400.

BOX IA-3. WORLD OUTPUT TRAJECTORIES  
1965 - 2105



scenarios of Nordhaus and Kahn do not. Because income inequality between the rich and the poor countries is in fact so large, Greenpeace and Holdren must show strong, continuous economic growth by poor countries if they are to offer any hope that economic disparities can be reduced by more than a trivial amount within any time less than several centuries.<sup>2</sup>

The Greenpeace and Holdren scenarios also incorporate a desire that total world output does not grow so large that important environmental values are threatened. Holdren sets a limit of 30 terawatts (TW) on the growth of world energy use, which he estimates is the maximum desirable level that can be provided with renewable sources alone. For Greenpeace the limit is set by the desire to eliminate the use of fossil fuels by 2100. In order to live within these limits, while simultaneously reducing income inequality among countries, economic growth in the highest income nations must slow over the coming decades. This can be seen clearly in **IA-4** and **IA-5**.

In the Nordhaus and Kahn scenarios the growth rates of low income countries exceed those of the richer countries by little more than 1-1.5%. The result is that only minimal progress is made in reducing economic inequality among countries by 2100. The Nordhaus regional projections are shown in **IA-6**. Further inspection of the Nordhaus and Kahn scenarios shows that economic growth in all regions slows to zero while substantial economic inequalities still exist. This condition is problematic, to say the least.

The distribution of income between countries has rightly received great attention among global scenario modelers over the past thirty years, but the distribution of income *within* countries has received much less.<sup>3</sup> This is a remarkable omission. Income inequality is arguably the single greatest source of social conflict throughout history and at the present time. Scenarios of global development that are intended to help inform broad world-views of the human prospect cannot do this unless they include projections of income distribution within countries, and describe how these might be expected to change under different conditions and policies.

The topic of income inequality within countries is discussed at length in Section II.B [Hayes 2004]. As we'll see, empirical studies and analytic models suggest that the distribution of income tends to change only slowly over time, and is resistant to policy.

This brief review suggests that there are important ways in which economic growth, environmental protection and distributional equity between and within countries either conflict with or help support one another. In the next section we present a simple regionalized world model that can help us study these relations in more detail.

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<sup>2</sup> Appendix 1 in Hayes (2004) shows that under the conventional business-as-usual assumptions used by Cline, the gap between the developed and the developing countries would be eliminated sometime between 2600 and 2700, at which time mean GDP would be about \$2,000,000 per household (1990 US\$).

<sup>3</sup> Authors who have sought to model within-country income distributions over time include Chenery, Ahluwalia, et al (1974), Adelman and Robinson (1978), Taylor and Lysy (1979), Chichilnisky and Cole (1978), Moreland (1984), and Bessant and Cole (1985). In general their projections do not show results for periods much longer than several decades.

## BOX IA-4. HOLDREN'S SCENARIO

[Holdren 1996]

Figure 1. World Per Capita GDP under Business-As-Usual Scenario

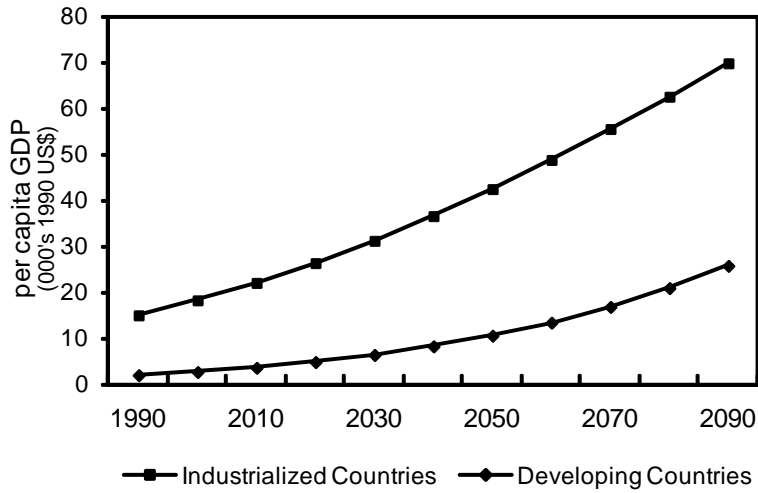
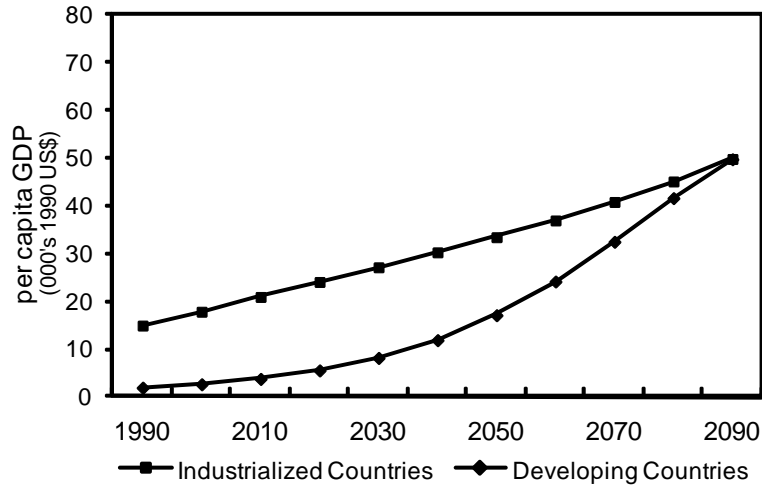


Figure 2. World Per Capita GDP under "Best Plausible" Scenario



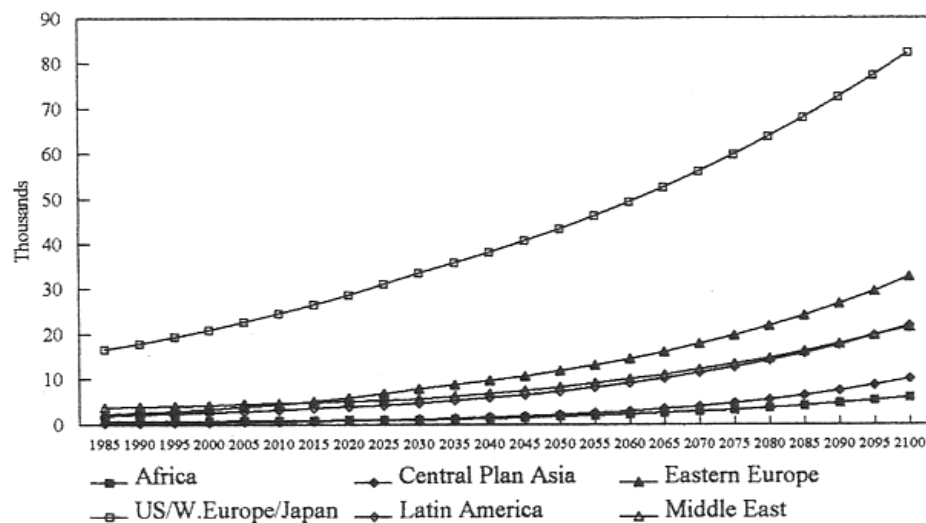
### BOX IA-5. GREENPEACE SCENARIOS OF PER CAPITA GDP GROWTH

[Lazarus et al., 1993]

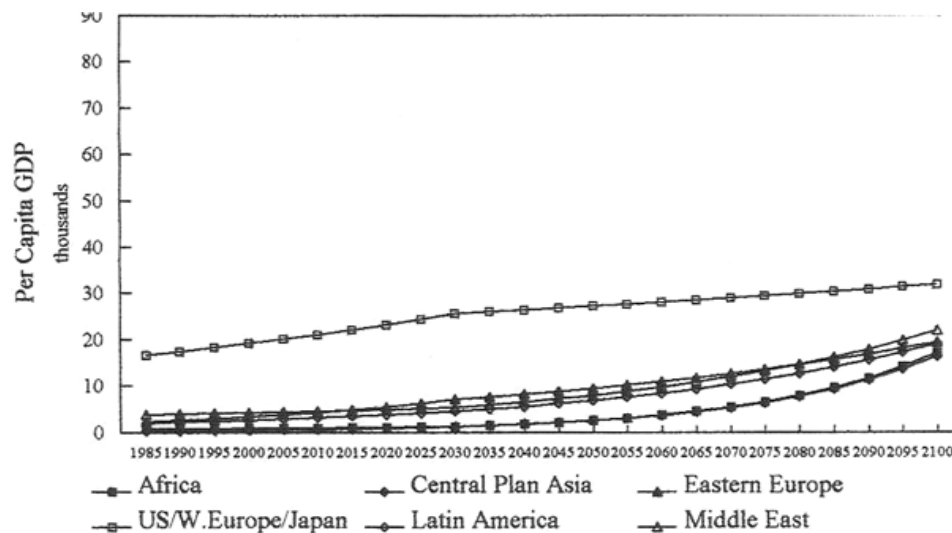
Figure 1 shows reference scenario per capita GDP growth for six world regions from 1990 to 2100 adopted by the IPCC (1990). Greenpeace modified this trajectory to give the “Equity Scenario” shown in Figure 2. Under the Equity Scenario:

“[W]e propose an assumption for regional income equity wherein the ratio of highest to lowest average income drops to 2:1 by 2100, compared with the current ratio of over 14:1. We maintain the IPCC90 projected regional growth rates over the next 20 years, and then gradually adjust them over the 2010-2100 period to achieve this increased equity objective.”  
(p 23)

**Figure 1. Per Capita GDP under the IPCC 1990 Reference Scenario (1985 US\$)**



**Figure 2. Per Capita GDP under the Greenpeace “Equity Scenario” (1985 US\$)**



**BOX IA-6. RICE REFERENCE SCENARIO PROJECTIONS  
OF PER CAPIITA INCOME**  
[Nordhaus 1996]

