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UNEP GEO4 DRIVER SCENARIOS USING IFS WITH PARDEE

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UNEP GEO4 Driver Scenarios Using IFs with Pardee

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Abstract

This paper provides a discussion of the demographic and economic drivers of the GEO-4 scenarios. More specifically, it describes the implementation of those scenarios in the International Futures (IFs) modeling system and provides population, GDP, and GDP per capita forecasts for each scenario. In response to requests from other modeling teams, this revision adds additional driver information on multifactor productivity/technology, value added, household consumption, and secondary education of women. In addition it conveys information about patterns of global distribution in each scenario. Finally, it identifies accompanying files that contain numerical values for the driver variables in each of the UNEP regions, subregions and constituent countries across the scenarios.

An analysis of the GEO-3 scenarios was undertaken as background for the implementation of those scenarios in IFs. That analysis is summarized as context for the framing of the scenarios in IFs.

This is a work in progress for internal working group discussion only. Feedback and suggestions are invited. Thanks to a variety of GEO team members for reactions on earlier versions of the paper. This version was prepared following the "Megameeting" in Bangkok, September 2005 and in preparation for use of the driver forecasts by other modeling teams.

Welcome to IFs with Pardee for UNEP

1. Introduction: Goals and Context

In support of preparing the Outlook Chapter in the fourth Global Environmental Outlook (GEO), it was decided at the Cambridge meeting (January 2005) that IFs should provide, in close collaboration with other team members, initial forecasts of key demographic and economic variables (with attention also to technological change). In a memo of February, the University of Denver/IFs team[1] indicated that it would provide selected forecasts for UNEP regions, sub-regions, and (if desired) the country members of sub-regions:

- Population
- Gross Domestic Product (Market Prices)
- Gross Domestic Product (Purchasing Power Parity)
- The above to be shown from 2000 through 2050 at five-year intervals.
- The above to have initial conditions in 2000 consistent with data in the UNEP Data Portal.
- The above to be shown for all four of the GEO-4 scenarios: Markets First, Policy First, Security First and Sustainability First.

The IFs team circulated the first draft in early April for comments; a second draft was circulated late in the month for more comments. A third draft was provided in June in advance of the Nairobi meeting of the larger GEO team. Additional feedback was obtained on that draft during meetings of GEO-4 team members in Rome (in association with IAASTD) and Kassel in July. The fourth version of working paper was prepared for both use and review by core and regional team members in Bangkok during September, 2005. This fifth version grew from feedback and requests in that meeting. The scenario representations, to be described below, can be further altered as GEO-4 proceeds, until the team preparing the Outlook Chapter feels fully comfortable with the forecasts.

In addition to this paper, the DU team is providing two additional products:

1. Excel files with representation of the key variables across the four scenarios for each year (some team members have requested annual output).

2. An on-line version of IFs at http://www.ifs.du.edu/ That version allows team members and others to further explore the four scenarios and even to create variations of them. The site will also allow download of the model. If anyone is not yet familiar with the IFs system, please go to http://www.du.edu/~bhughes/ifswelcome.html for the general IFs web site.

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[1] Thanks to Anwar Hossain, Mohammod Irfan, José Solórzano, and Marc Sydnor for critical support of this and other IFs activities. Hossain was responsible for the data base underlying this effort, Irfan for the education submodel and other aspects, Solórzano for the user interface that allows result generation and representation and for regional liaison, and Sydnor for assistance with scenario description and regional liaison.

2. GEO-4 Scenarios in IFs: Working Versions

International Futures (IFs) is an integrated, multi-issue global simulation tied to a large, country-specific database. The model itself is country-based. The significance of these structures is that (1) results are generated by interventions into the model intended to represent leverage points for human action or alternative assumptions about key uncertainties and (2) results shown at the regional and global levels are built upward from countries, rather than downward to them.

It therefore is useful to begin by discussing the conceptualization of the four GEO-4 scenarios within IFs, proceed to showing forecasts from them, and continue by comparing and contrasting those forecasts with those made by others, including those produced in GEO-3. Chapter 2 summarizes the state of the driver scenarios at this point. Chapter 3 provides driver results from the scenarios, with focus on global and UNEP-region aggregations and on graphical portrayals. It also provides selected numerical output for regions and summarizes the extended output prepared in supporting files. Chapter 4 provides background for those results, based on analysis of GEO-3 documents and other sources.

The basic conceptualizations of the GEO-4 scenarios were taken from the GEO-3 volume. The GEO-3 conceptualizations are reproduced here, followed by descriptions of the approach taken to implement them within IFs.

One of the reasons for providing extensive information on the interventions taken to implement the scenarios is that those interventions may not only help elaborate the conceptualization of the scenarios, but may also help tie the GEO-4 outlook chapter to the policy chapter.

It is important to stress that the results presented in this paper, with a focus on demographic and economic scenario drivers, are preliminary and subject to discussion with the GEO-4 team. Feedback is not only welcome but encouraged. All of the assumptions shown here can be easily changed or removed; others can quite likely be added.[2]

[2] Thanks to a number of members of the GEO-4 modeling process for feedback on earlier versions of this document and suggestions concerning improvement of the scenarios (even when not all suggestions were fully implemented). Dale Rothman, Detlef van Vuuren, Bas Eichout, Ton Manders, and Hassan Yousif made valuable suggestions.

Markets First. From the GEO-3 Description (p. 329): "Most of the world adopts the values and expectations prevailing in today's industrialized countries. The wealth of nations and the optimal play of market forces dominate social and political agendas. Trust is placed in further globalization and liberalization to enhance corporate wealth, create new enterprises and livelihoods, and so help people and communities to afford to ensure against -- or pay to fix -- social and environmental problems."

The implementation of Markets First in International Futures (IFs) involves (in all cases relative to the base case):

- Continued liberalization of trade, leading to falls of 10% in the traded costs of goods and services
- Increasing (or accelerating) liberalization of domestic economies, rising to 20% gains in "economic freedom" relative to the base case
- Accelerating democratization globally, rising to a 10% gain in political freedom
- Increases in global migration, rising to 30% above the rates of the base case
- Increases in foreign direct investment flows rising to 50% above the base case
- Increases in the production rate of natural gas, rising by a factor of 1.5 over the period to 2020
- Accelerations in discovery rates of oil and natural gas by 50% relative to the base case
- Increases in global annual productivity gains by 0.2%, with further annual productivity gains rising to 0.25% globally, except for the United States and Sub-Saharan Africa (the rationale for this is that globalization enhances technological diffusion *from* the technological leader, the US, and that Sub-Saharan Africa is less likely than other regions to gain from this diffusion in a market-oriented scenario)

Implementations of all GEO scenarios in IFs generally reflect the core assumptions of the scenario summaries and their elaborations in other documents. They may, however, differ somewhat from the GEO descriptions, because of the structural and empirical specifications of IFs. Specific issues in implementing the Markets First scenario were:

- In the case of Markets First, the results of IFs forecasts generally do not suggest increasing global inequality, at least when inequality is measured in terms of the ratio of GDP per capita in richer and poorer areas. In fact, the rapid growth of China and India in Markets First tends to bring overall measures of global inequality down. At the same time, however, the absolute income gaps between

the rich and the poor (especially the very richest and the very poorest) do grow because of the rapidly expanding global economy.

- One complication in implementing the Markets First scenario was that rapid global growth strained energy systems; the response in this implementation was to posit the technological and discovery advances necessary to protect the system against rapid price increases. This implementation issue does, however, suggest one of the vulnerabiltiies of the scenario.

Policy First. From the GEO-3 Description (p. 334): "Decisive initiatives are taken by governments in an attempt to reach specific social and environmental goals. A coordinated pro-environment and anti-poverty drive balances the momentum for economic development at any cost. Environmental and social costs and gains are factored into policy measures, regulatory frameworks and planning processes. All these are reinforced by fiscal levers or incentives such as carbon taxes and tax breaks. International 'soft law' treaties and binding instruments affecting environment and development are integrated into unified blueprints and their status in law is upgraded, though fresh provisions to allow for regional and local variants."

The implementation of Policy First in International Futures (IFs) involves (in all cases relative to the base case) two relatively discrete sets of intervention assumptions, one with respect to the environment and one with respect to global development and equity.

1. Significant attention directly to the issues of environmental sustainability:

- Attention to renewable energy technology that doubles the rate of cost reduction over 10 years and sustains that rate.

- Attention to energy demand that reduces it by 20% relative to the base case over 50 years.

- The introduction of a tax on carbon of $200 per ton over 10 years in OECD countries and of $50 per ton in non-OECD countries over 15 years.

- Attention to agricultural and food needs that raises yields over 10 years by 20% relative to the base case.

- Attention to fertility, with a 20% reduction in total fertility rates in non-OECD countries over 20 years relative to the base case.

2. Considerable attention to elements of the Millennium Development Goals, including partial implementation of the Global Compact through increased foreign assistance:

- Increase in educational spending in OECD countries of 10% relative to the base case over 20 years and 20% in non-OECD countries over 20 years.

- Increase in health spending in OECD countries of 10% relative to the base case over 20 years and 20% in non-OECD countries over 20 years.

- Increase in foreign aid donations as a percent of GDP from OECD countries from just over 0.2% of GDP to 0.4% of GDP (with specific increases of EU25 countries from just under 0.3% to 0.45% and of the US. from slightly under 0.1% to 0.25%.

- Increase in R&D spending in OECD countries of 10% relative to the base case over 20 years and of 20% in non-OECD countries over 20 years.

- Attention to electronic connectivity that increases it by 25% over 20 years for OECD countries relative to the base case and by 50% for non-OECD countries.

Security First. From the GEO-3 Description (p. 339): "This scenario assumes a world of striking disparities where inequality and conflict prevail. Socio-economic and environmental stresses give way to waves of protest and counteraction. As such troubles become increasingly prevalent, the more powerful and wealthy groups focus on self-protection, creating enclaves akin to the present day 'gated communities.' Such islands of advantage provide a degree of enhanced security and economic benefits for dependent communities in their immediate surroundings but they exclude the disadvantaged mass of outsiders. Welfare and regulatory services fall into disuse, but market forces continue to operate outside the walls."

The Security First scenario builds on assumptions of the spread of pervasive economic and personal insecurity and reactions that attempt, often counter-productively to achieve security of self or nation. Exclusion, armament, and lack of cooperation prevail. Counteractions inevitably disrupt many processes of globalization.

The implementation of Security First in International Futures (IFs) involves (in all instances relative to the base case):

- Increasing protectionism globally, rising to 20% increases in the cost of traded goods and services.

- Decreasing (or reversing) liberalization of domestic economies globally, leading to a 10% loss of "economic freedom."

- Slowing democratization globally (or a loss of past gains), leading to a 10% loss of "political freedom."

- Substantial drops in foreign direct investment, falling to a 40% loss.

- Substantial drops in migration levels, falling to a 25% loss (as always, relative to the base case). The scenario still includes significant immigration from Sub-

Saharan African countries, because regional-based analysis concluded that Security First could actually increase many intra-continental refugee flows.

- Significant rises in military spending globally (reaching levels 20% above the base case).

- Rises in fertility in non-OECD countries, in substantial part as a reaction to population losses through disease, conflict, and malnutrition/starvation and a desire to gain security through one's children; specifically, fertility rates rise by 20% relative to the base case over 20 years.

- A slow-down in the trend of global fertility reduction that has led since the early 1970s to major declines in fertility globally, often more rapid than those forecast by the UN and other sources. Historic reductions were substantially related to the spread of family-planning technologies and of family-planning support systems, which substantially slows in this scenario.

- A slow-down in the rate of cost-reduction progress in renewable energy technologies of 0.25% annually relative to the base case.

- Increases in disease burdens such as SARS or Avian Flu that are especially disruptive in China and South-Central Asia, leading to 10% increases in mortality rates.

- Losses in potential annual productivity gains, the losses increasing to 0.5% globally because of the full syndrome of effects in the scenario.

- Heavier losses in potential annual economic productivity gains in China and South-Central Asia rising to 2% and 1%, respectively, as a result of globalization setbacks and health problems.

An early implementation of this scenario in IFs included fairly strong neo-Malthusian loops around nutrition and disease that, because of very poor economic, social, and environmental performance in this scenario, actually reduced population relative to other scenarios. For the purposes of this implementation, those loops were put into the scenario at low levels of impact, affecting global economic growth performance and calling into question the sustainability of demographic growth.

Sustainability First. From the GEO-3 Description (p. 344): "A new environment and development paradigm emerges in response to the challenge of sustainability, supported by new, more equitable values and institutions. A more visionary state of affairs prevails, where radical shifts in the way people interact with one another and with the world around them stimulate and support sustainable policy measures and accountable corporate behavior. There is much fuller collaboration between governments, citizens and other stakeholder groups in decision-making on issues of close common concern. A consensus is reached on what needs to be done to satisfy basic needs and realize personal goals without beggaring others or spoiling the outlook for posterity."

The implementation of Sustainability First in International Futures (IFs) involves (in all cases relative to the base case) assumptions that cluster into three categories: policy on environmental sustainability (much as in Policy First), policy on global development and equity (as in Policy First), and value/life style changes (an increment to Policy First).

1. Some significant attention directly to the issues of environmental sustainability:

- Attention to renewable energy technology that doubles the rate of cost reduction over 10 years and sustains that rate.
- Attention to energy demand that reduces it by 50% relative to the base case over 50 years.
- The introduction of a tax on carbon of $200 per ton over 10 years in OECD countries and of $50 per ton in non-OECD countries over 15 years.
- Attention to agricultural and food needs that raises yields over 10 years by 20% relative to the base case.
- Attention to fertility, with a 20% reduction in total fertility rates in non-OECD countries over 20 years relative to the base case.

2. Considerable attention to elements of the Millennium Development Goals, including partial implementation of the Global Compact through increased foreign assistance:

- Increase in educational spending in OECD countries of 10% relative to the base case over 20 years and 20% in non-OECD countries over 20 years.
- Increase in health spending in OECD countries of 10% relative to the base case over 20 years and 20% in non-OECD countries over 20 years.
- Increase in foreign aid donations as a percent of GDP from OECD countries from just over 0.2% of GDP to 0.4% of GDP (with specific increases of EU25 countries from just under 0.3% to 0.45% and of the US. from slightly under 0.1% to 0.25%.

- Increase in R&D spending in OECD countries of 10% relative to the base case over 20 years and of 20% in non-OECD countries over 20 years.

- Attention to electronic connectivity that increases it by 50% for non-OECD countries.

3. The above elements are also components of the Policy First scenario, although in Sustainability First the social consensus around their importance allows greater reduction in world energy demand. In addition, however the Sustainability First scenario brings changes in values and social patterns that allow additional changes. Among the most striking is a backing away in rich countries from consumption in favor of more leisure and social interaction:

- Citizens in OECD countries effectively reduce their working lives by 45% over 50 years and 70% over 100 (the assumption is that citizens of non-OECD countries continue to work at base case rates because of lower standards of living). Note: the change in the rate of decline in working lives after 50 years creates a slight transient in economic growth rates for OECD countries in 2050.

- The reduced emphasis on material achievement slows down emphasis on productivity rather than life-style and productivity rates globally drop by 0.5% over 20 years.

- Non-OECD countries decrease their fertility rate by as much as 40% relative to the base case over 50 years (but not below reasonable minimums).

- The total fertility rates that countries move towards for the long term at higher levels of GDP per capita are reduced from 1.8 in the base case to 1.6.

UNEP GEO-4 Intervention Summary
IFs Model Inputs for GEO Scenarios

Intervention Category	Sub-Category	Security First	Markets First	Policy First	Sustainability First
Economic	Economic Freedom	10% Decrease	20% Increase		
	Trade Liberalization	Increase to 20% Traded Costs	Decrease to 10% Traded Costs		
	Productivity	0.5% Decrease Globally, 2% China, 1% South Asia	0.2% Increase Globally plus 0.25% Increase World (ex. US/Sub-Saharan)		
	Foreign Direct Investment	40% Decrease	50% Increase		
	Foreign Aid			Increase 0.2% to 0.4% from OECD	Increase 0.2% to 0.4% from OECD
	Research and Development			10% increase OECD 20% non-OECD in 20yrs	10% increase OECD 25% non-OECD in 20yrs
	Electronic Connectivity			20% in OECD 50% non-OECD in 20yrs	50% increase non-OECD
Political	Military Spending	20% Increase			
	Political Freedom	10% Decrease	10% Increase		
	Global Migration	25% Decrease	30% Increase		
Energy	Production of Natural Gas		Increase by factor of 1.5 to 2020		
	Discovery of Oil/Gas		50% Increase		
	Carbon Taxes			$200/ton in 10yrs OECD $50/ton in non-OECD in 15yrs	$200/ton in 10yrs OECD $50/ton in non-OECD in 15yrs
	Renewable Energy	Slowdown of Annual Reductions in Cost by 0.25%.		Doubling of Cost Reduction in 10 yrs.	Doubling of Cost Reduction in 10 yrs.
	Energy Demand			20% Reduction over 50 years	50% Reduction over 50 years
Health	Mortality Rates	10% Increase			
	Fertility Rates	20% Increase in 20 yrs		20% Reduction in non-OECD over 20 yrs	20% Reduction in non-OECD over 20 yrs
	Health Spending			10% increase OECD 20% non-OECD in 20yrs	10% increase OECD 25% non-OECD in 20yrs
Ed	Education Spending			10% in 20 yrs in OECD 20% in 20 yrs non-OECD	10% in 20 yrs in OECD 25% in 20 yrs non-OECD
Ag	Yield			Increase 20% over 10 years	Increase 20% over 10 years
Cultural					OECD Reduction of 40% of working life over 50yrs and 60% over 100
					Productivity Rates Decrease 0.5% in 20yrs
					Non-OECD fertility decrease of 40% over 50yrs
					Fertility Rate Reduction of 1.8 to 1.6

3. Driver Forecasts by Scenario

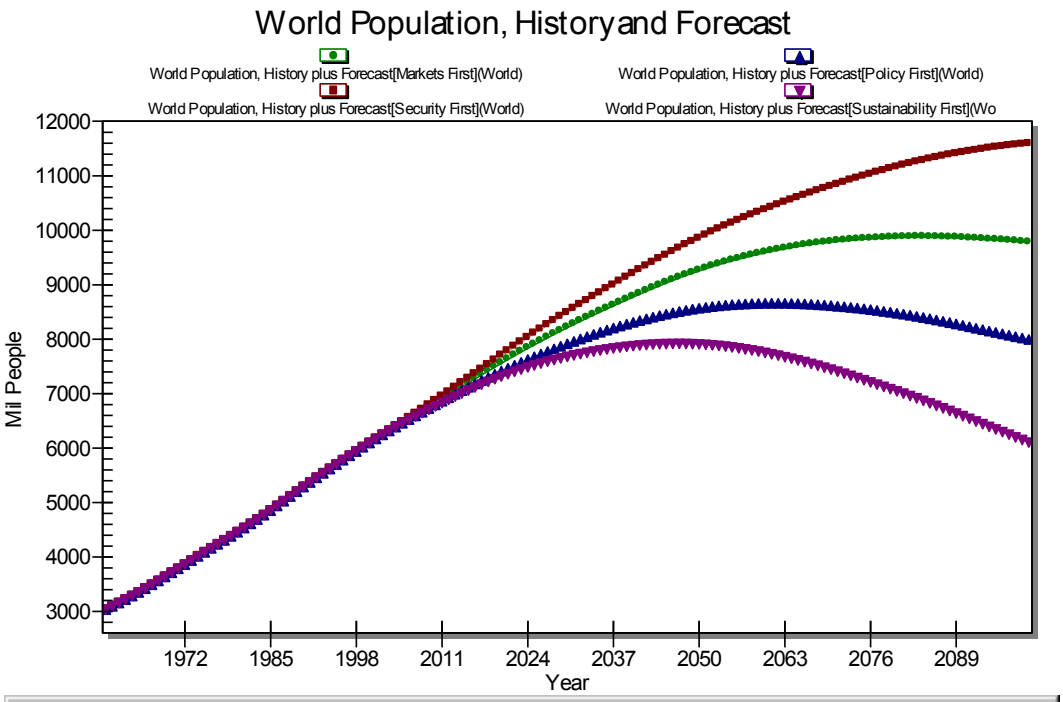
The conceptualizations of the GEO scenarios sketched above gave rise to the forecasts provided in this chapter. At the risk of too much repetition, the assumptions above and the results below are subject to revisions as deemed appropriate by team members.

In preparation for the scenario analysis, the initial conditions in 2000 of population and GDP (at market prices and at purchasing power parity) were adjusted for all IFs countries so that they were identical with those in the Data Portal of the UNEP (as of early April, 2005). The scenario results here reflect those reconciliations.[3] The numbers in the Data Portal have, however, been updated since that early adjustment, including most importantly a movement from 1995 dollars as the economic base unit of account to 2000 dollars. The adjustment of forecasts to Data Portal values will need to be redone.

3.1 Global Overview: Population

The graph below shows world population forecasts in the four GEO-3 and GEO-4 scenarios. These and other graphs of the chapter will be easiest to read in color. A few of the graphs shown here are produced with runs of the model through 2100 because the UNEP GEO project may want those for some purposes and so as to show very long-term behavior of the scenarios (just as the Millennium Ecological Assessment produced scenarios through 2100). Most figures and tables will be shown only through the UNEP GEO-4 horizon of 2050, but the accompanying data files will provide values through 2100 for those who want them. The numbers in the graph are built up from the country-specific forecasts produced by IFs, so they can also be shown by UNEP region, UNEP sub-region, and by country (subsequent text and sections will provide elaboration).

[3] Also, the Global Trade and Analysis Project (GTAP) 6 data have been released and have already been incorporated into IFs. Over the next two years the numbers in the UNEP Data Portal will continue to change. For instance, the World Bank updates its World Development Indicators annually (the 2005 WDI are being prepared for IFs; they will change the base unit of account for economic data from 1995 dollars to 2000 dollars). The general point is that the forecasts here are the product of both a living model and an evolving database. Thus they will change somewhat as GEO-4 progresses. After the update of 2000 dollars and the WDI 2005 values, database changes should not substantially affect forecast values. The most significant ongoing changes will then be in response to feedback from GEO-4 team members, including the regional representatives.



World Population

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	WPOP[2]	WPOP[3]	WPOP[4]	WPOP[5]
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
2000	6,096	6,096	6,096	6,096
2050	9,265	8,567	9,859	7,902
2100	9,820	8,008	11,644	6,124

The most rapidly growing population in the above graph is that of Security First. Growth in the scenario steadily slows, but it never ceases.

The second most rapidly growing scenario of population is Markets First. This scenario generates high incomes that cause global populations to peak and decline with fertility reductions linked to those incomes. But the scenario posits no particular policy attention to fertility reduction; nor does it include initiatives that increase incomes in developing countries at accelerated rates. Thus the slowing of fertility is not as great as in either Policy First or Sustainability First.

In the Policy First scenario there are explicit initiatives to control population growth. In the Sustainability First scenario there is change in paradigm (values and behavior) that sharply decreases fertility rates.

To put the above forecasts in some broader context, the 2002 Revision of the UN's *World Population Prospects* provided high, medium, and low forecasts. The medium variant

forecast was for a global population of 8.9 billion in 2050. High and low forecasts were 10.6 and 7.4 billion, respectively. The equivalent numbers in the 2004 revision were 9.1, 10.7 and 7.7 billion, a small increase over 2002 estimates.[4] The UN's high forecast uses constant fertility rates and must be considered a truly extreme and improbable value.

Until the 2004 Revision, the UN forecasts have regularly been reduced, because they earlier failed to anticipate the rate of decline of fertility around the world. The median forecast for 2050 in 1994 was 9.8 billion, in 1996 it was 9.4 billion, and in 2000 it was 9.3 billion. Other forecasters, including IFs and IIASA, more accurately anticipated the declines in fertility during the 1980s and 1990s.

The UN forecasts through 2300 (produced for the first time in 2003) provide a very useful basis for examining the IFs base case through 2100. In the median variant global population rises to a peak of 9.2 billion in 2075 and declines to 8.3 billion in 2175. India will likely pass China to become the most populous country in the world around 2050.

Assumptions about life expectancy have an impact on very long range forecasts. The assumptions in the UN median forecast are for continued but slowing increases to 97 years in 2300 (108 years for Japanese females).

It is, however, fertility assumptions that most significantly shape long-term demographic forecasts. The key long-term question is whether global fertility rates will level off around the replacement rate of 2.1 (the UN median scenario assumption) or at values above or below replacement. The UN high scenario for the very long term is ¼ child above replacement (2.35) and the low scenario is ¼ child below replacement (1.85). Already by 2100 these different assumptions for post 2050 rates give rise to a range of global population from a low of 5.5 billion, through a medium variant of 9.1 billion, to a high of 14 billion. The IFs GEO-4 scenarios for 2100 range from 6.1 to 11.6 billion.

The 2002 Revision brought the UN forecasts more in line with those of IIASA in 2001.[5] IIASA then forecast that the world's population could peak by 2070 at about 9 billion, declining to 8.4 billion in 2100.

Discussion in Chapter 4 will compare and contrast these implementations within IFs of the GEO-4 scenarios with those of GEO-3, the Global Scenario Group(GSG)/Stockholm Environment Institute (SEI), and the Millennium Ecosystem Assessment (MA).

Continuing to provide historic context, the figure below shows the underlying global population growth rates in the four scenarios and shows them as extensions to historic data. Although not as clear below as in a forecast to 2100, all four scenarios exhibit slowing of rates of decrease as they approach and/or fall below rates of 0.0%.

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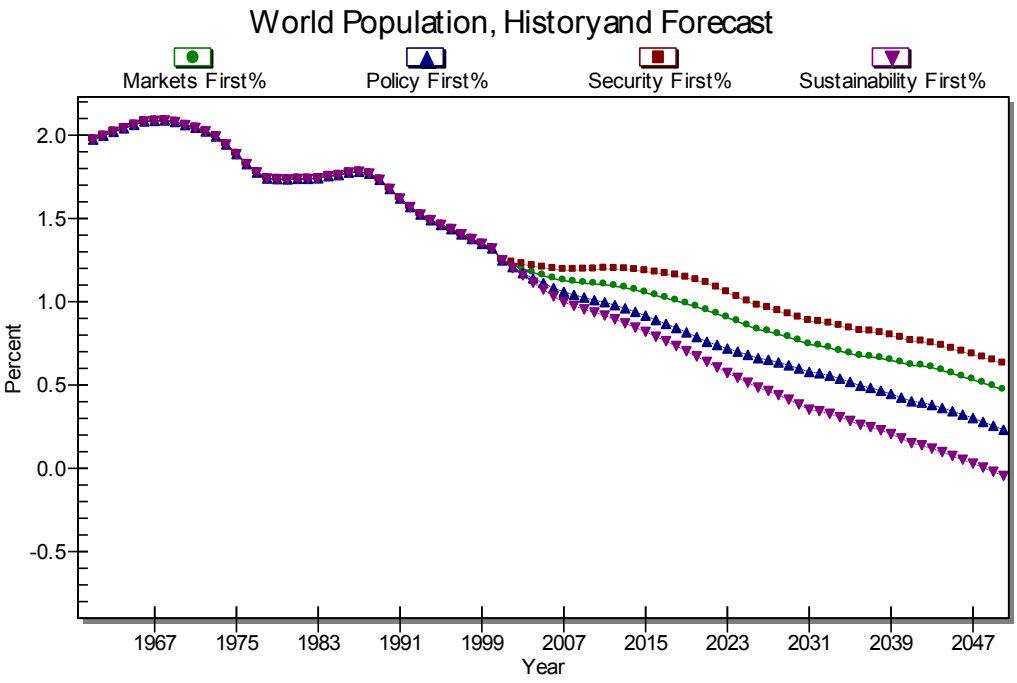
[4] In slight contrast with the UN, the US Census Bureau's forecast in late 2003 for global population in 2050 was 9.1 billion (http://www.census.gov/ipc/www/worldpop.html; January 9, 2004).

[5] As reported in Nature http://www.nature.com/nsu/010802/010802-10.html; January 9, 2050.



World Population Growth Rate

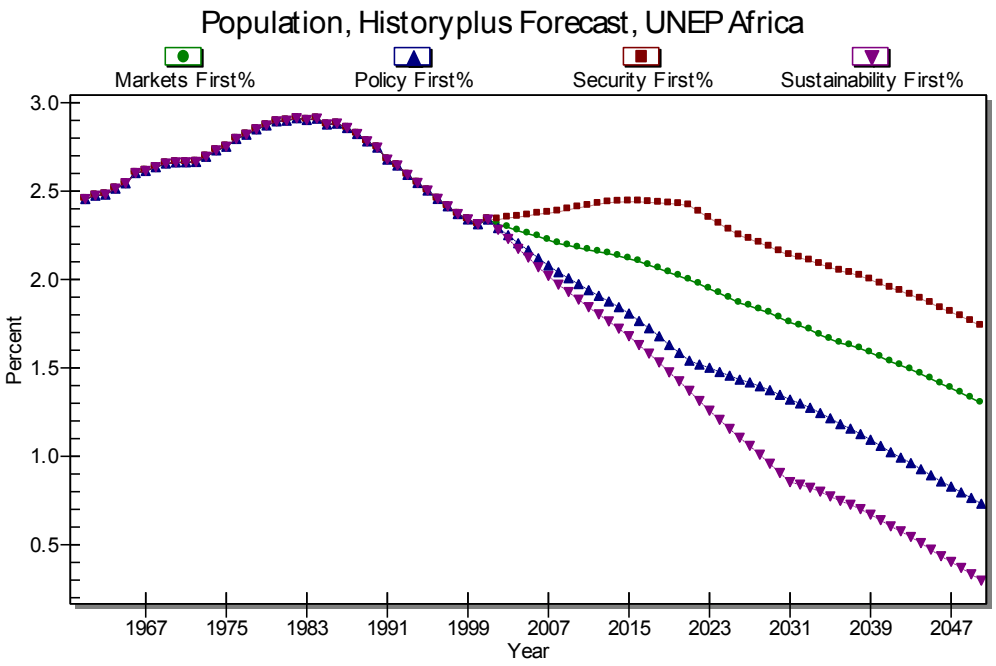
Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	WPOPR[2]	WPOPR[3]	WPOPR[4]	WPOPR[5]
	Percent	Percent	Percent	Percent
Year	Markets	Policy	Security	Sustain
2000	1.2278	1.2278	1.2278	1.2278
2050	.4356	.1906	.5901	-.0928

3.2 Regional Overview: Population

To provide some regional elaboration, and continuing to provide historic context, the figures below show the population growth rates for each UNEP region in the four scenarios as extensions of historic data (followed by tables showing absolute population values). The graphs should make clear that the GEO scenario set as a whole is subject to some considerable long-term uncertainty with respect to the continued fertility reduction that occurs in all four. No one can know how fast that will proceed, whether population growth rates will fall below zero even in developing regions, or whether some areas of the world might experience reversals in the trends. The band of uncertainty appears considerably safer through 2050 (the UNEP GEO-4 horizon) than through 2100 (not shown, but available in the forecast set).

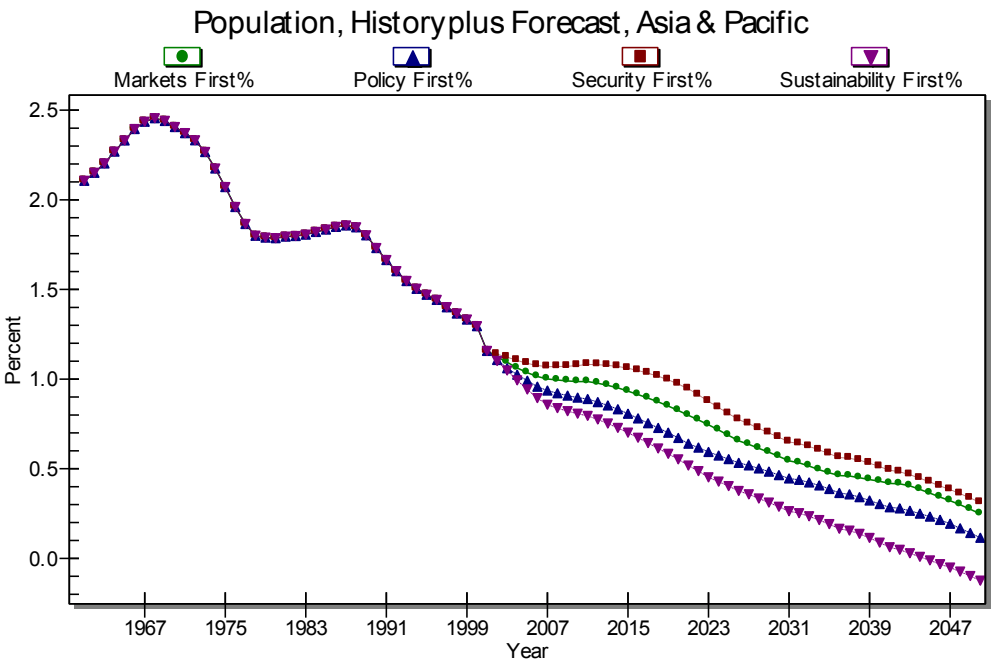
The regions which exhibit the greatest spread of rates across the four scenarios are those in which the historic and initial rates of growth, like Africa, are highest. Regions, like Europe, with low initial rates have much tighter patterns across scenarios.



Population, History plus Forecast, UNEP Africa

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

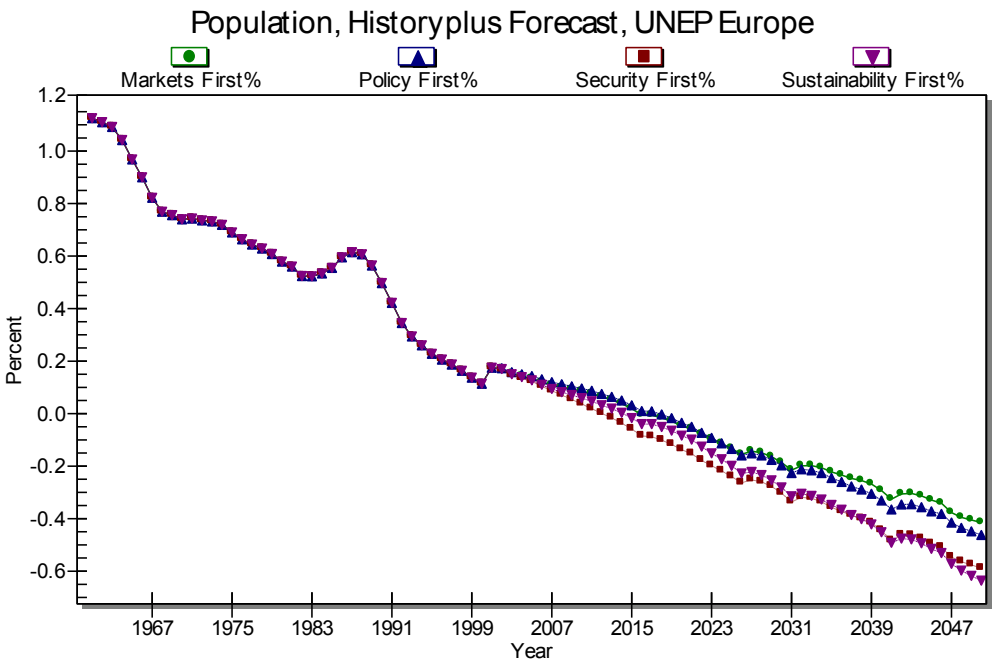
	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP Africa	UNEP Africa	UNEP Africa	UNEP Africa
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	276.9	276.9	276.9	276.9
2010	993.4	983.3	1,005	978.9
2050	2,009	1,668	2,366	1,458



Population, History plus Forecast, Asia & Pacific

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

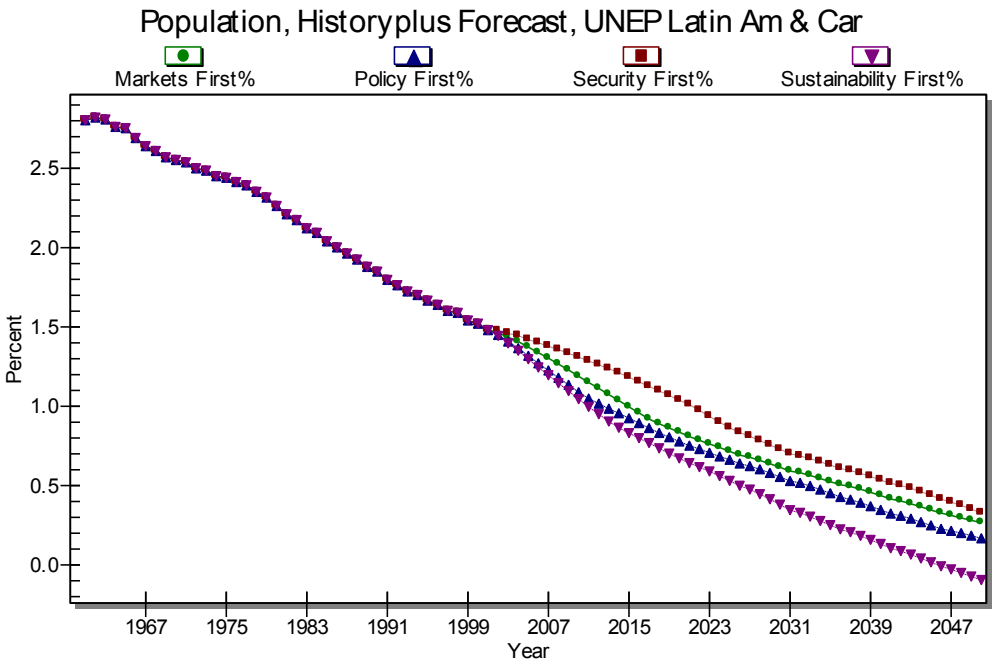
	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	1,665	1,665	1,665	1,665
2010	3,936	3,916	3,957	3,897
2050	5,009	4,740	5,246	4,399



Population, History plus Forecast, UNEP Europe

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

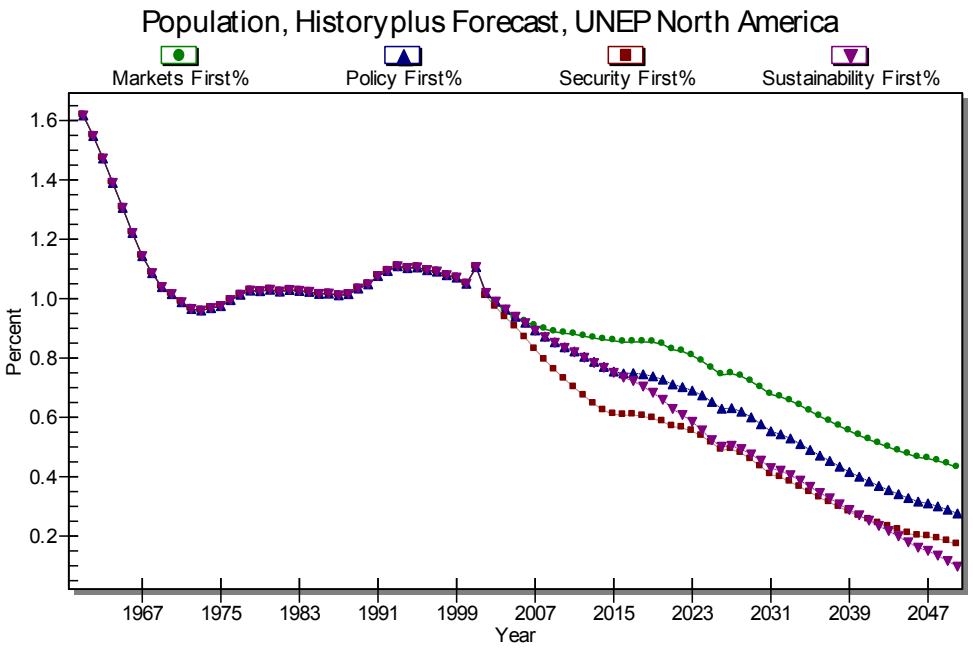
	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP Europe	UNEP Europe	UNEP Europe	UNEP Europe
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	645.1	645.1	645.1	645.1
2010	829.3	830.1	827.9	828.5
2050	771.9	768.2	734.1	739.1



Population, History plus Forecast, UNEP Latin Am & Car

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	217.3	217.3	217.3	217.3
2010	593.2	589.9	596.5	588.5
2050	766.0	738.5	814.3	691.3

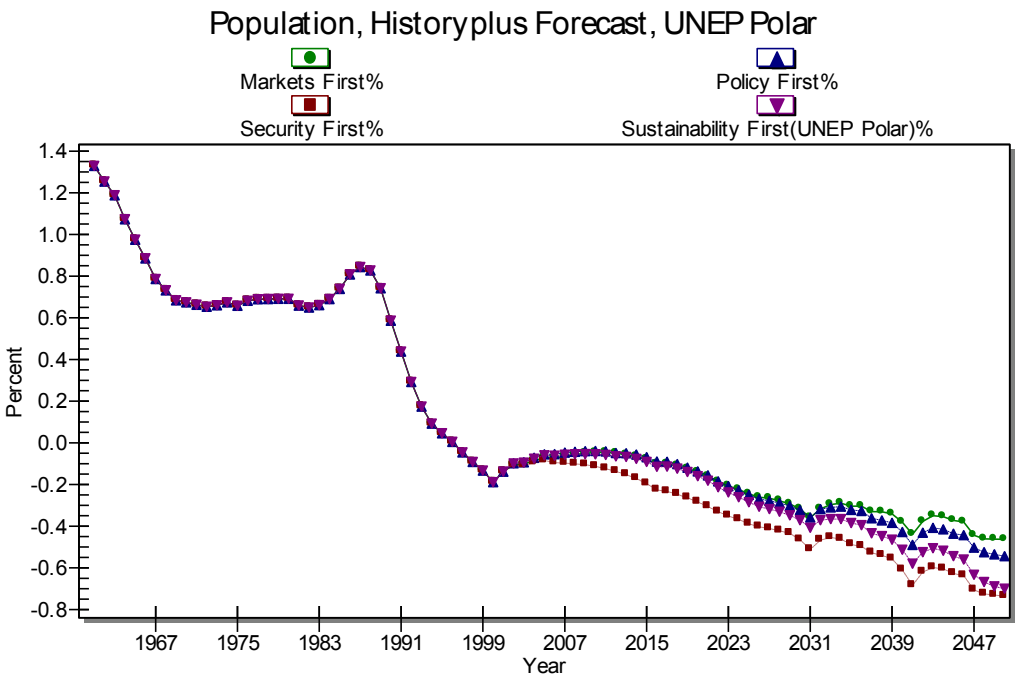


Population, History plus Forecast, UNEP North America

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP North Am	UNEP North Am	UNEP North Am	UNEP North Am
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	204.1	204.1	204.1	204.1
2010	347.1	346.7	345.0	346.7
2050	455.0	432.6	408.1	415.1

An important note with respect to the above graph is that in North America, unlike other regions of the world, the Security First scenario actually exhibits lower growth than other scenarios. The reason lies in the much reduced migration assumptions in the implementation of that scenario and the importance of immigration (not just from Mexico) to historic population growth in both Canada and the United States.

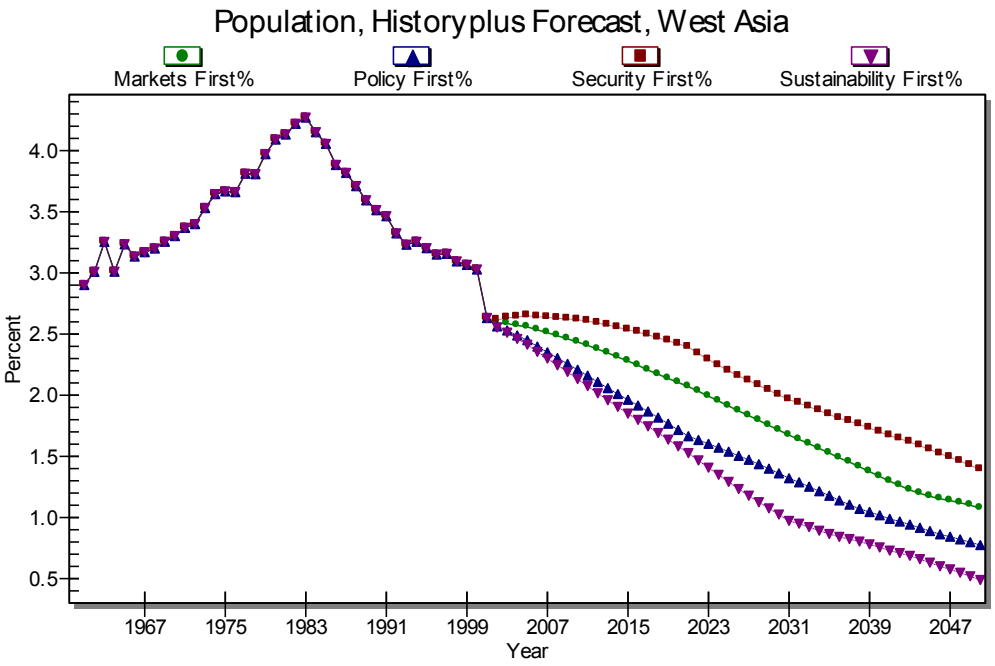


Population, History plus Forecast, UNEP Polar

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP Polar	UNEP Polar	UNEP Polar	UNEP Polar
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	153.5	153.5	153.5	153.5
2010	193.4	193.6	192.9	193.5
2050	173.5	172.4	161.2	168.1

The above graph is somewhat unusual because of its irregularities in pattern and its initially negative growth rates. Demographically Russia dominates the Polar region.



Population, History plus Forecast, West Asia

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

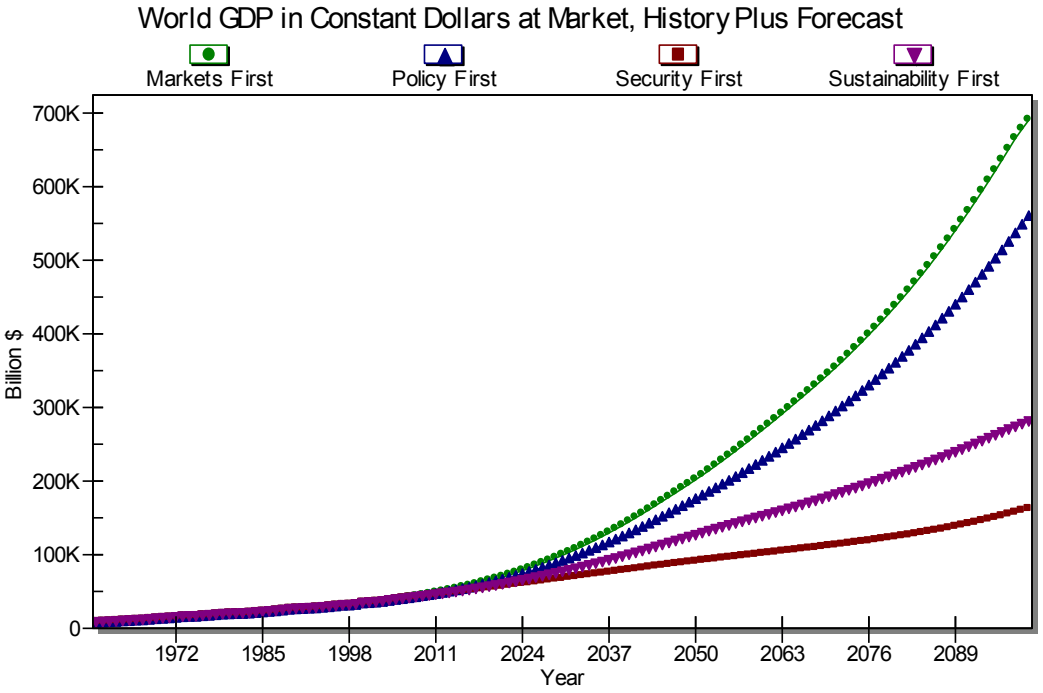
	POP[2]	POP[3]	POP[4]	POP[5]
	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
1960	25.76	25.76	25.76	25.76
2010	129.2	127.7	130.4	127.2
2050	254.4	219.9	290.5	199.2

3.3 Global Overview: GDP and GDP per Capita

Turning from population to GDP, it is useful simultaneously to review the forecasts of the four scenarios for GDP and for GDP per capita, and also to look both at overall magnitudes, and as for population, to consider trajectories of growth rates. Further, it is important to consider GDP at both market exchange rates (MER) and purchasing power parity (PPP).

The two figures below show forecasts for global GDP at market and PPP, respectively. Both are shown as extension of the historic series, but that series for PPP is neither as lengthy nor as well accepted as for MER. As with population, these initial figures present the forecasts through 2100, primarily to place the UNEP GEO horizon initially in a longer context, but also because some GEO analyses will want to look beyond 2050. The screen captures following the figures show the actual numerical values in billion dollars at 50-year intervals.

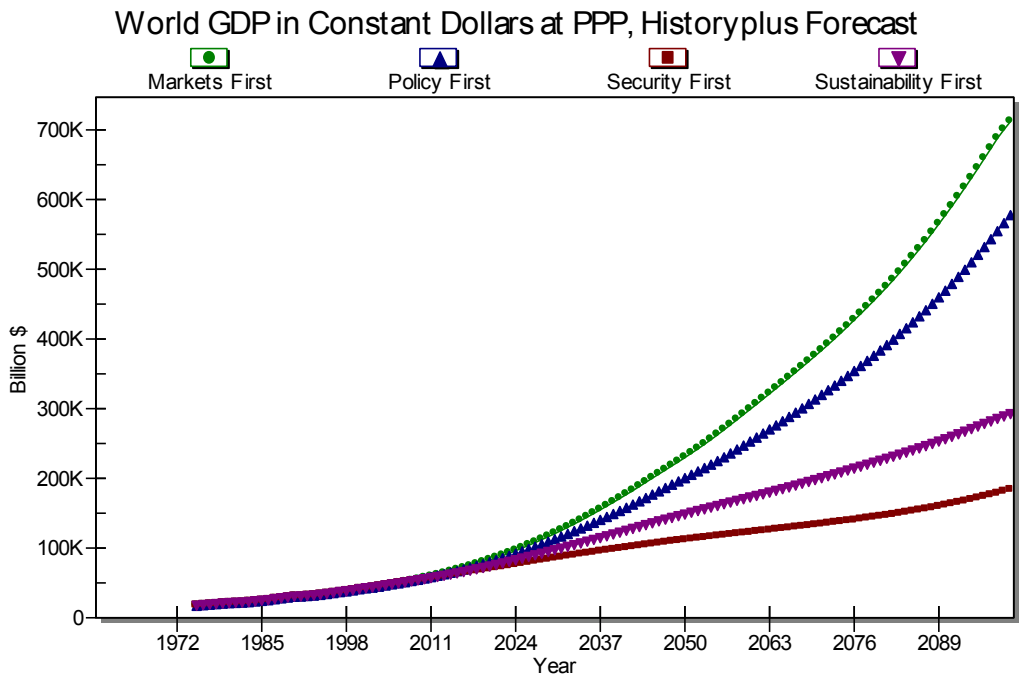
Although the values for global GDP in 2000 are quite different at MER and PPP, by 2100 the two series have largely converged. This is because the gap between the two valuations tends to close quite rapidly with higher levels of economic development.



World GDP in Constant Dollars at Market

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	WGDP[2]	WGDP[3]	WGDP[4]	WGDP[5]
	Billion $	Billion $	Billion $	Billion $
Year	Markets	Policy	Security	Sustain
2000	34,281	34,281	34,281	34,281
2050	201,768	176,154	90,112	126,403
2100	690,384	560,648	161,761	280,901

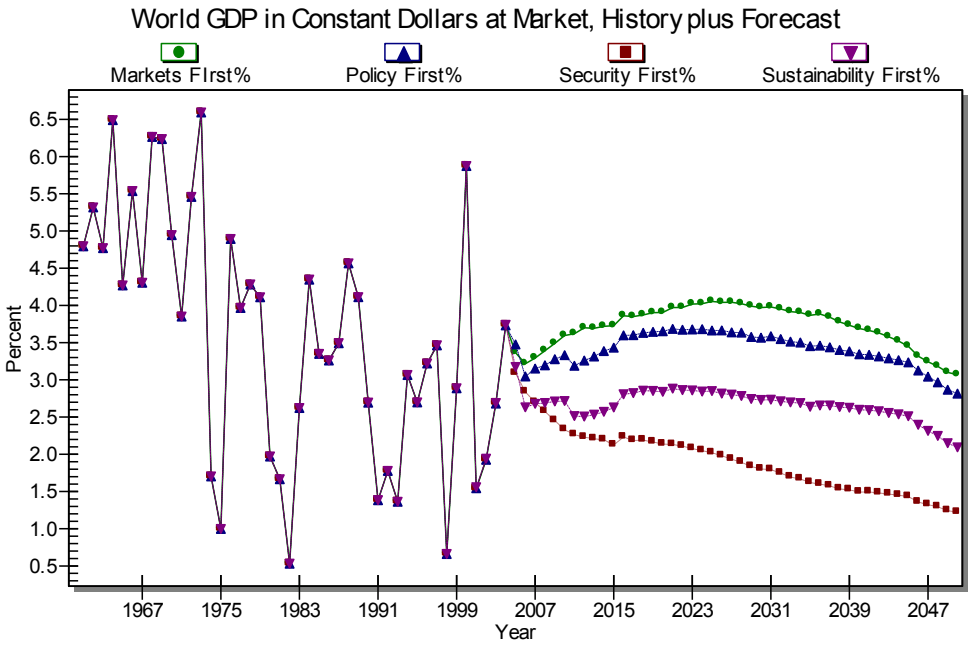


World GDP in Constant Dollars at PPP

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	GDPP[2]	GDPP[3]	GDPP[4]	GDPP[5]
	World	World	World	World
	Billion $	Billion $	Billion $	Billion $
Year	Markets	Policy	Security	Sustain
2000	40,975	40,975	40,975	40,975
2050	229,811	200,354	110,733	148,023
2100	712,109	577,699	182,900	292,009

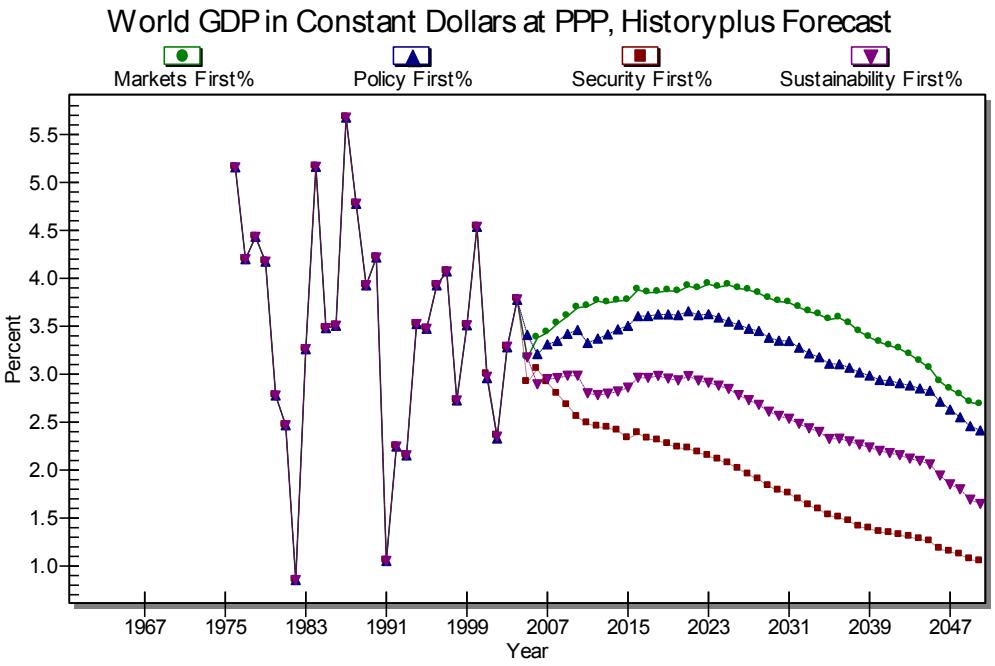
The next two graphs show the same series as above, converted to annual growth rates. The screen capture following each shows the average rates of growth between 2000 and 2050. In the figure immediately below, note the two distinct historical periods. The first period is what Angus Maddison called the "Golden Era" of global economic growth. The average rates in that historic period were very considerably higher, averaging 4.9% annually, than those of the following 30 years. It is obvious from the figure below that the forecasts of the four scenarios fall closer to the range of second period than to that of the first. It is important also to remember, however, that global population growth rate in the 1960s peaked at just over 2.0%, about a full percent higher than those that will characterize the end of the current decade. That subsequent drop in population growth rates alone would be expected to considerably shift down the rate of global GDP growth and reinforces the importance of turning next to GDP per capita.



World GDP in Constant Dollars at Market

Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	WGDP[2]	WGDP[3]	WGDP[4]	WGDP[5]
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
2000	.00	.00	.00	.00
2050	3.609	3.328	1.952	2.644



World GDP in Constant Dollars at PPP

Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

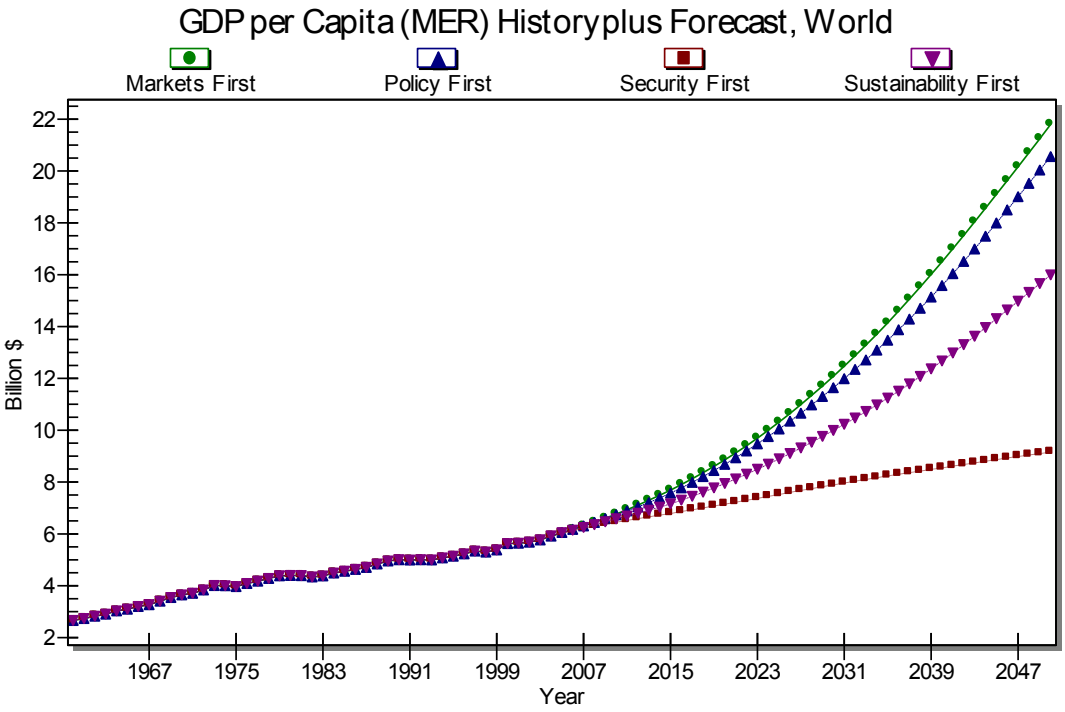
	GDPP[2]	GDPP[3]	GDPP[4]	GDPP[5]
	World	World	World	World
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
2000	.00	.00	.00	.00
2050	3.509	3.225	2.008	2.602

As we turn to GDP per capita, it is useful to begin with market exchange rate values, because they provide a longer historic series. The two graphs below show the absolute values in the four scenarios and the rates of growth in GDP per capita, respectively, both as extensions of history.

From both graphs it becomes apparent that, in contrast to the appearance from the graphs of GDP by itself, the economic growth rates in the scenarios are not especially low. The screen capture after the graph of growth rates shows the 50 year average growth rates (rates at PPP would be about 0.1% lower on average).

The growth rates of GDP per capita are more clustered than those of GDP by itself. This is because a considerable portion of the lower growth in the GDP scenarios of Policy First and, especially Sustainability First, relative to Markets First, is because of lower population growth rates. It is important to remember, however, that the scenarios get to their per capita and total growth rates in very different ways. In Markets First, the total economic growth is highest and is driven by market liberalization and globalization on

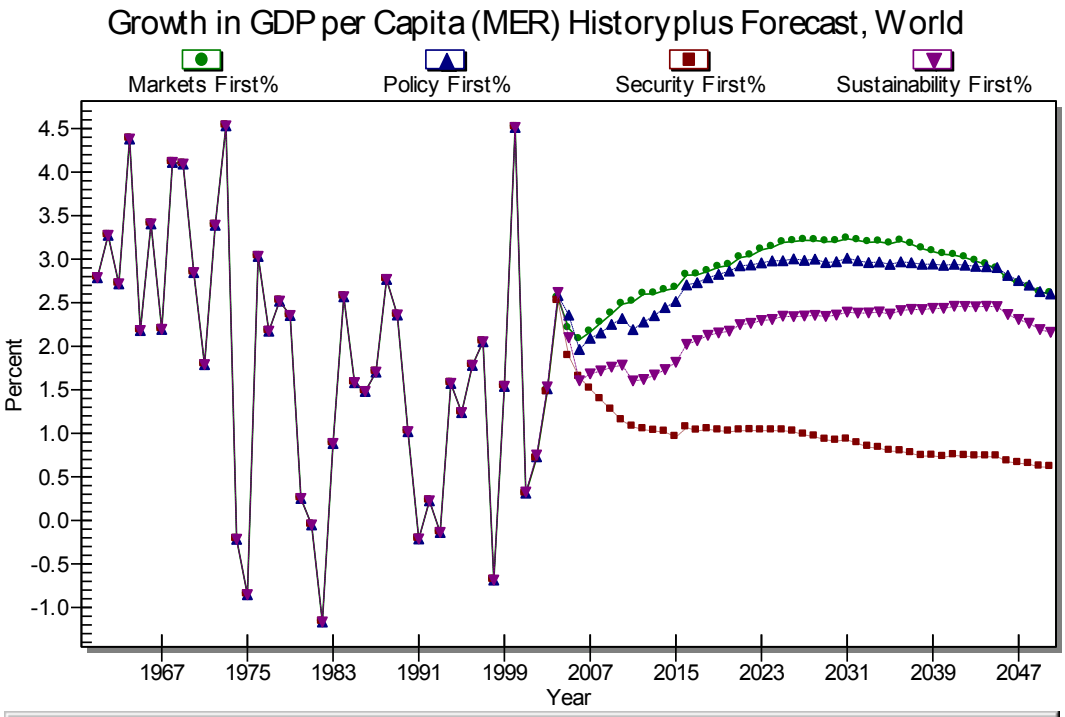
top of population growth rates that slow significantly but remain higher than in Policy First or Sustainability First. In Policy First, the economic and population growth are both lower (resulting in roughly the same GDP per capita), but the drivers of per capita economic growth are investments in human capital and some environmental protection (including more efficient energy usage and greater development of renewable forms). The Sustainability First scenario produces a lower overall GDP per capita than Markets First and Policy First, but because of much more substantial fertility reduction, the level is still quite high. In fact, in some country sets, including Sub-Saharan Africa, the per capita growth rates in Policy First exceed those in Markets First because of the growth enhancing impact of investments in human capital, of foreign aid, and of other policy interventions such as improved governance.



GDP per Capita (MER) History plus Forecast, World

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	GDPPCHF	GDPPCHF	GDPPCHF	GDPPCHF
	World	World	World	World
Year	Markets	Policy	Security	Sustain
1960	2.661	2.661	2.661	2.661
2010	6.723	6.698	6.414	6.54
2050	21.20	20.00	8.90	15.55



World GDP per Capita (Market) in 1000 Constant $

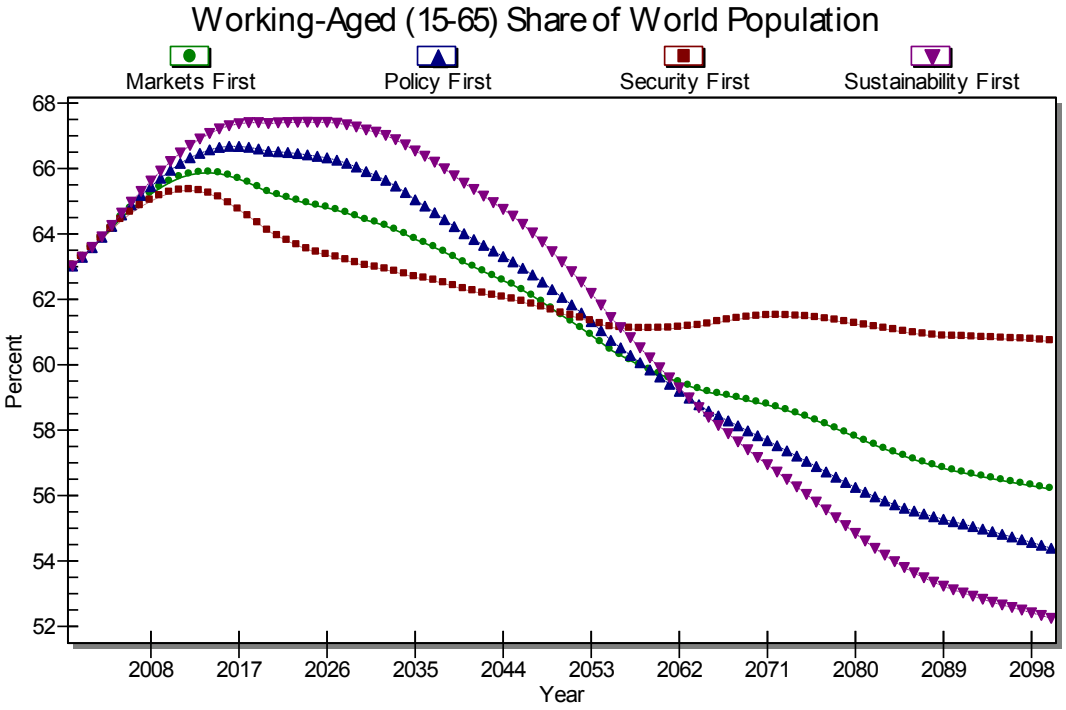
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDPPC[2]	GDPPC[3]	GDPPC[4]	GDPPC[5]
	World	World	World	World
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
2000	.00	.00	.00	.00
2050	2.755	2.634	.987	2.12

Some readers might wonder why the forecasts of GDP and GDP per capita do not exhibit smooth patterns. For instance, in the figure immediately above, there is something of a bulge in growth rates for three of the scenarios in the 2015-2040 period (and if the graph were extended, it would show continuing rate declines after 2050). Obviously, the historic rates are much more irregular, but we have become accustomed to forecasts of rates that are essentially constant over time or monotonically and slowly changing. The fundamental reason for the irregularities in forecasted rates are that the GDP forecasts in IFs are endogenously computed and are affected by literally almost everything else represented in the model. For instance, in the production function, labor, capital, and endogenous representation of MFP affect growth, but so too do plus price effects within and across sectors. The energy and agricultural submodels of IFs represent commodities that are subject to considerable production level and price variation over time, and these tend to add some irregularities to the aggregate growth patterns.

The figure below shows one such important driver, namely the share of the labor force, represented by those between 15 and 65 years of age, relative to the total population.

Note that in the scenarios with the slowest population growth, especially Sustainability First and Policy First, the portions of population in that growth-enhancing age category bulge considerably in the early years of that period. This "demographic dividend" is well recognized as a driver of growth (Krugman 1994), and is one of the reasons also that the per capita rates in those two scenarios get pushed up towards those of market first. The graph below has been extended through 2100 to show that the effects of the demographic dividend actually reverse about mid-century with population aging. Interestingly, the Security First scenario benefits relatively on this particular economic input after 2050.



Working-Aged (15-65) Share of World Population

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

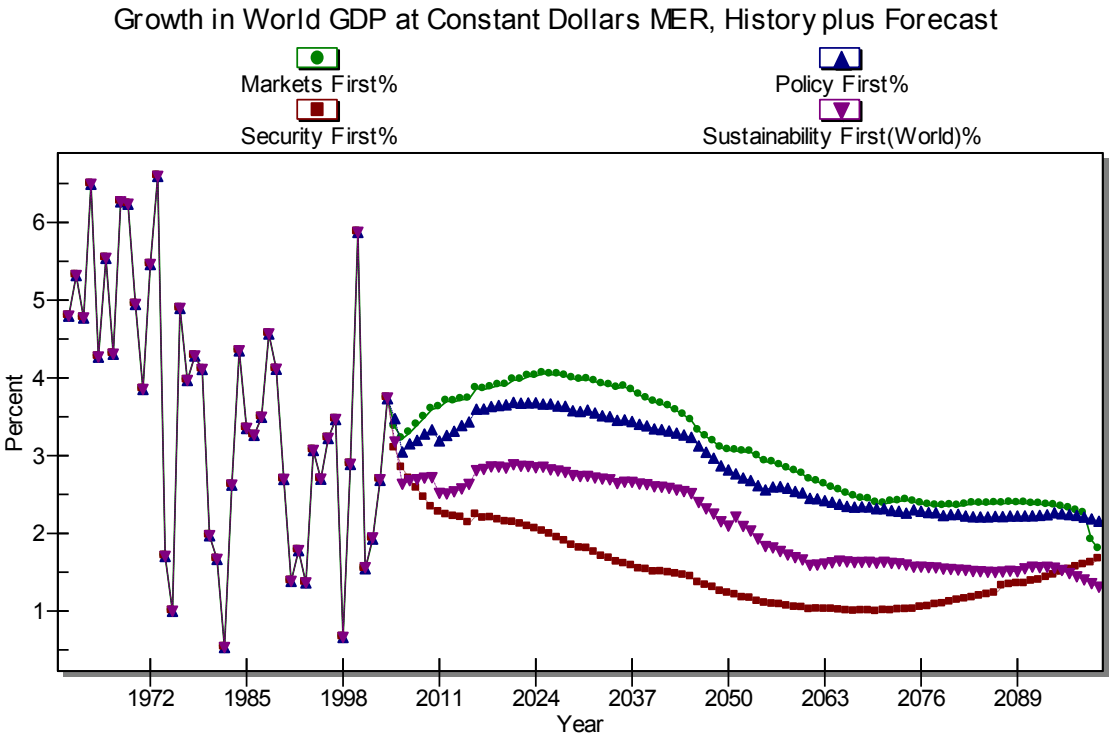
	PopWorking World	PopWorking World	PopWorking World	PopWorking World
Year	Markets	Policy	Security	Sustain
2000	63.0164	63.0164	63.0164	63.02
2050	61.5381	62.1230	61.6082	63.24
2100	56.2322	54.3963	60.8055	52.19

To provide some historic context for the above long-term forecasts, Angus Maddison (2001: 126; see also Maddison 1995) estimates that the world economy grew at a rate of 1.6% from 1820-1950, an increase by a factor of 7.9 over 130 years. At a rate of 3%, which is what the global economy achieved between 1973 and 1998, a century would produce a 19-fold increase. At 4.9%, the rate of the "Golden Age" for the world

economy from 1950-73, the world economy would grow by a factor of 120 in a century. In general, the growth rate of the world economy has quite steadily accelerated since the beginning of the industrial revolution. The great surge from 1950-73 and the fall-off thereafter, however, add uncertainty to forecasting in the 21st century. The graphs and tables above show that the four scenarios (at PPP) result in global GDP increases for the century ranging from factors of 4.5 to 17.4 (at market prices from 4.7 to 20.3).

It is important to remember that forecasts for the twenty-first century are scenarios for a century in which population growth rates are expected to continue a fairly substantial decline across all scenarios, in contrast to the history of the twentieth century, which included a rapid rise, peaking, and then some important initial decline in population growth rates. Thus even if per capita GDP growth rates were to remain strong or even rise somewhat (to which we return below), total GDP increases face some constraints from substantially slowing labor force growth, especially in the second half of the century.

The figure below looks again at annual growth rates in the four scenarios, providing historical rates since 1960 for context, but extending the look through the century. Note that the scenario rates in the first half of the century span a range from roughly 1.5% to 4% per year, bracketing nicely the 3% average of the late twentieth century. All scenarios except Security First exhibit substantial declines in the second half of century, after the demographic dividend (substantial work forces in many developing countries relative to dependent populations) plays out. Security First maintains relatively constant growth.



World GDP in Constant Dollars at Market, History plus Forecast

Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	World	World	World	World
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	3.537	3.519	3.45	3.462
2060	3.545	3.22	1.605	2.455
2100	2.525	2.348	1.078	1.684

How do the IFs growth patterns above compare with other long-range forecasts that have been made? IIASA/WEC produced three long-term scenarios of GWP (Nakićenović, Grübler, and McDonald 1998: 6). The forecasts for 2050 range from 75 to 100 trillion 1990 dollars (relative to 20 trillion in 1990), implying annual growth rates of 2.2% and 2.7%, respectively. In 2100 the forecasts range from 200 to 300 trillion 1990 dollars, implying century-long growth rates of 2.1% and 2.5%, respectively. The forecasts over the twenty-first century involve a bit less than 10-15 fold increases.

The IPCC scenarios from the third assessment report, again in 1990 dollars, range for 2050 from 82 to 187 trillion (annualized growth rates of 2.4% and 3.8%) and in 2100 from 235 to 550 trillion (annualized growth rates of 2.3% and 3.05%). Century-long increases are 12-30 fold.[6] Just as the recent World Bank forecasts have become more optimistic, so have the more recent IPCC forecasts; the "new economy" experience of the late 1990s has begun to shape such analyses.

The GEO scenarios above appear generally within the range of these alternative scenarios and benchmark computations. And again, they can be fairly easily altered as needed and desired.

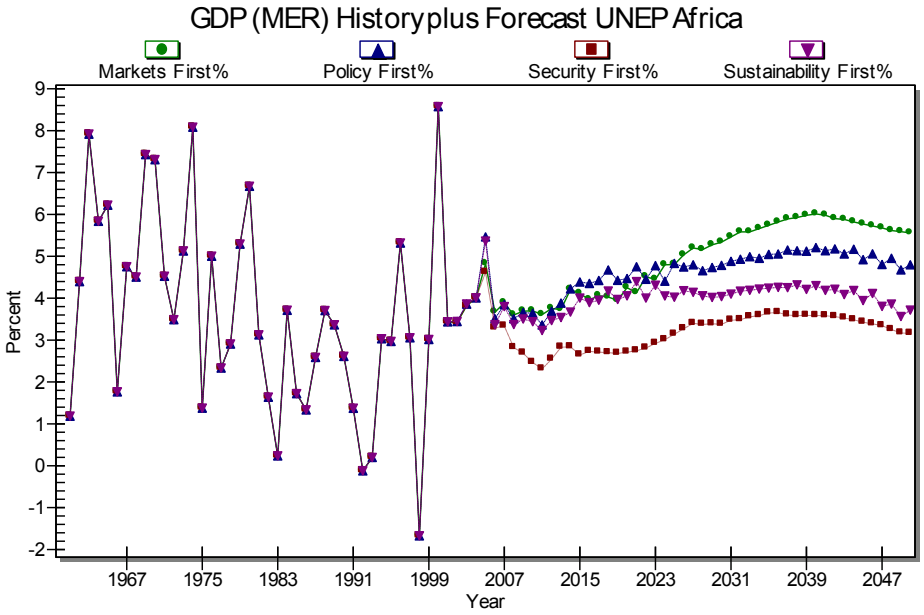
3.4 Regional Overview: GDP

As useful as the above global aggregates are in framing the larger picture of the scenarios, it is important to move to regional disaggregations. The seven figures below show historic plus forecast GDP growth rates for each of the UNEP regions. The figures present GDP at MER because the historic series are longer and the values are less controversial. The tables following each figure present the average GDP growth rates across the interval preceding the year shown, and also show GDP per capita.

Each region reacts to the scenarios in somewhat different ways. Obviously, those regions with declining populations and labor forces are more likely to show GDP growth rate declines (see Europe, North America, and the Polar region), while those with

[6] For comparison, the 2nd IPCC report forecast a 24-fold increase globally, with industrial countries growing by a factor of 13 and developing countries growing by 69 times (IPCC, 1995, Volume 2: 590)

demographic dividends unfolding are more likely to have increases (see Africa). Similarly, different patterns of connection to world trade, dependence on energy imports or exports, and evolving stocks of human capital will react differently to changes in assumptions about such variables.



GDP (MER) History plus Forecast UNEP Africa

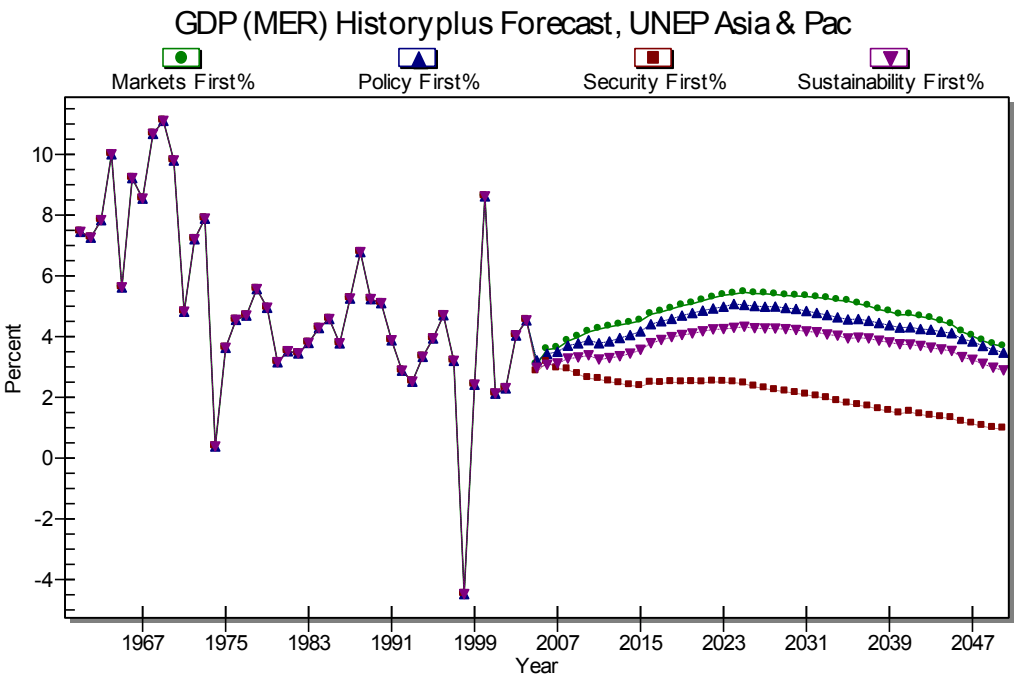
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP Africa	UNEP Africa	UNEP Africa	UNEP Africa
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	3.657	3.663	3.573	3.647
2050	4.828	4.547	3.233	3.973

GDP per Capita (MER) History plus Forecast, UNEP Africa

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter
Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP Africa	UNEP Africa	UNEP Africa	UNEP Africa
Year	Markets	Policy	Security	Sustain
1960	.513	.513	.513	.513
2010	.861	.872	.817	.869
2050	3.095	3.26	1.221	2.83



GDP (MER) History plus Forecast, UNEP Asia & Pac

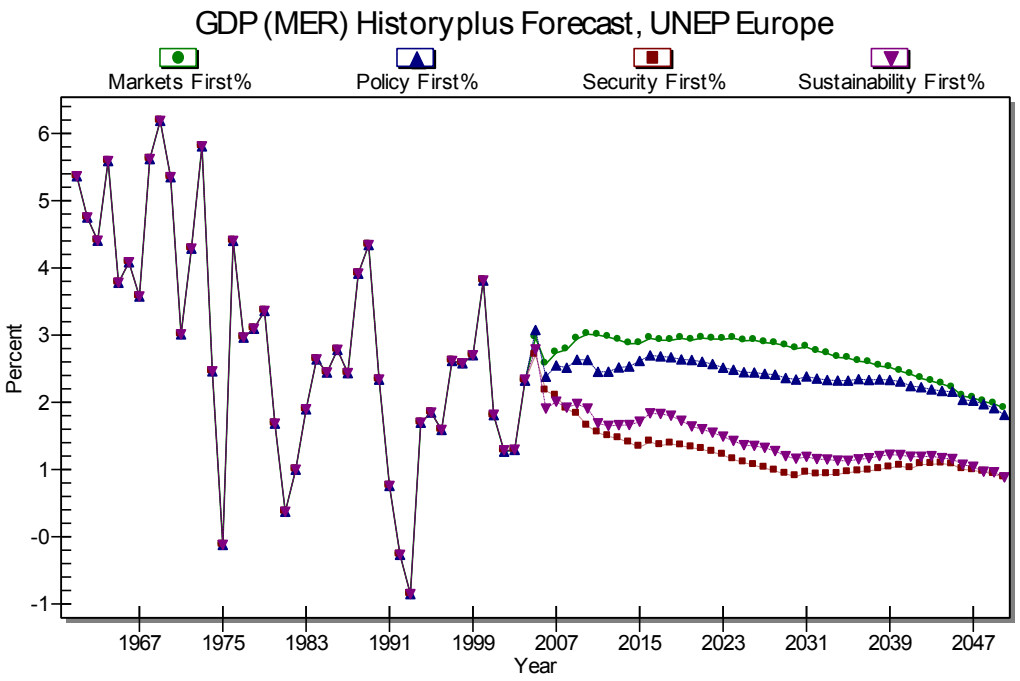
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	4.891	4.876	4.789	4.828
2050	4.564	4.243	2.169	3.693

GDP per Capita (MER) History plus Forecast, UNEP Asia & Pac

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter
Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa	UNEP Asia & Pa
Year	Markets	Policy	Security	Sustain
1960	.775	.775	.775	.775
2010	3.571	3.562	3.383	3.499
2050	18.49	16.75	5.542	13.85



GDP (MER) History plus Forecast, UNEP Europe

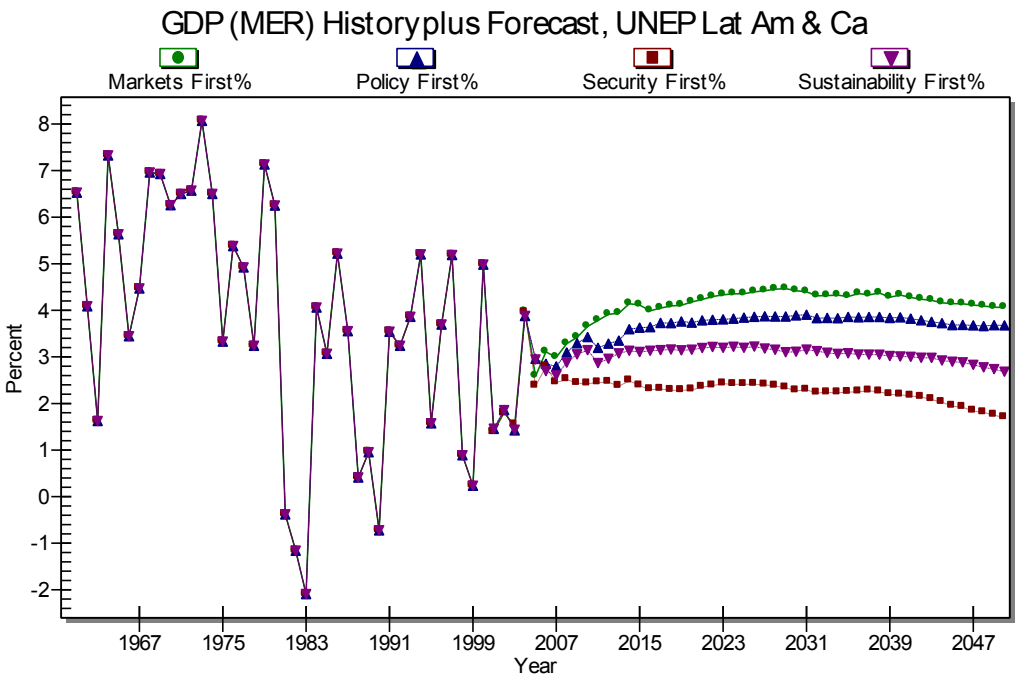
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP Europe	UNEP Europe	UNEP Europe	UNEP Europe
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	2.867	2.843	2.773	2.778
2050	2.60	2.341	1.275	1.453

GDP per Capita (MER) History plus Forecast, UNEP Europe

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter
Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP Europe	UNEP Europe	UNEP Europe	UNEP Europe
Year	Markets	Policy	Security	Sustain
1960	5.529	5.529	5.529	5.529
2010	17.67	17.45	16.92	16.94
2050	54.22	48.01	29.77	32.29



GDP (MER) History plus Forecast, UNEP Lat Am & Car

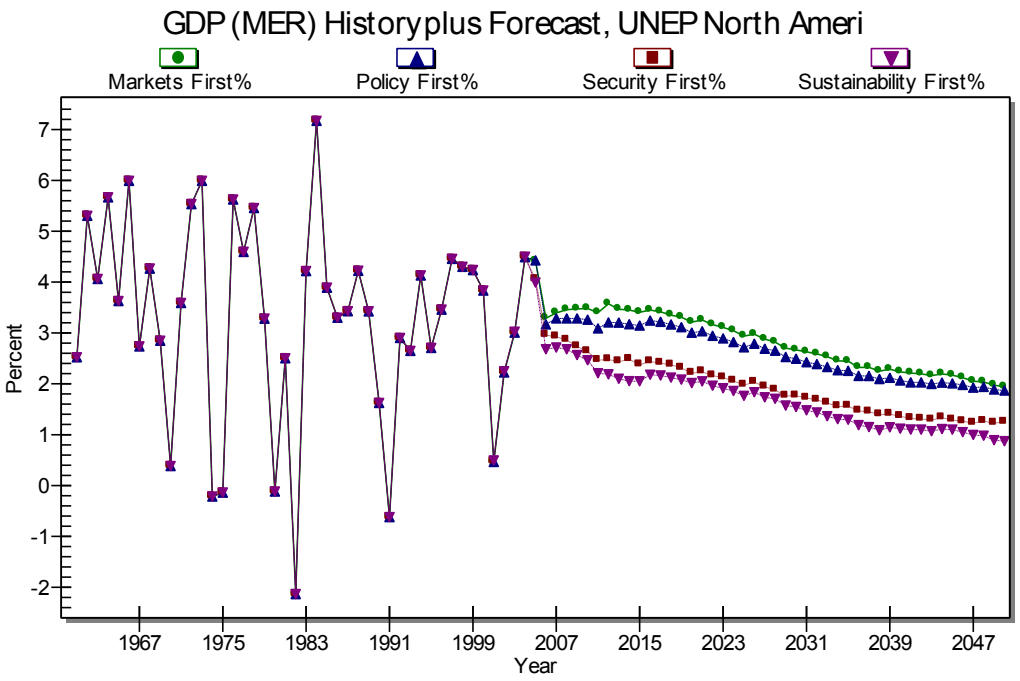
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	3.603	3.59	3.522	3.568
2050	3.877	3.481	2.203	2.906

GDP per Capita (MER) History plus Forecast, UNEP Lat Am & Car

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &	UNEP Lat Am &
Year	Markets	Policy	Security	Sustain
1960	2.061	2.061	2.061	2.061
2010	4.433	4.428	4.237	4.391
2050	17.59	15.07	7.343	12.19



GDP (MER) History plus Forecast, UNEP North America

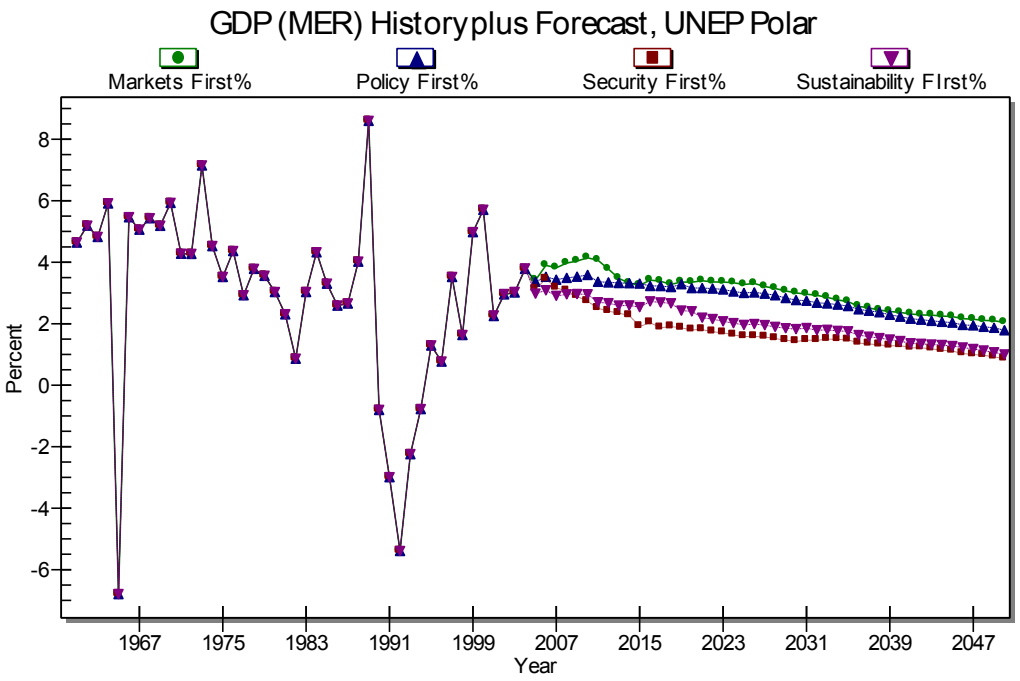
Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP North Am	UNEP North Am	UNEP North Am	UNEP North Am
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	3.311	3.295	3.245	3.224
2050	2.806	2.637	2.003	1.783

GDP per Capita (MER) History plus Forecast, UNEP North America

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter
Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP North Am	UNEP North Am	UNEP North Am	UNEP North Am
Year	Markets	Policy	Security	Sustain
1960	12.68	12.68	12.68	12.68
2010	38.01	37.76	37.02	36.49
2050	84.71	82.08	63.81	56.32



GDP (MER) History plus Forecast, UNEP Polar

Continue Refresh Graph Print Save Whole Cumulative Filter Display Run Horizon

	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP Polar	UNEP Polar	UNEP Polar	UNEP Polar
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	3.058	3.011	2.962	2.951
2050	3.015	2.812	1.838	2.09

GDP per Capita (MER) History plus Forecast, UNEP Polar

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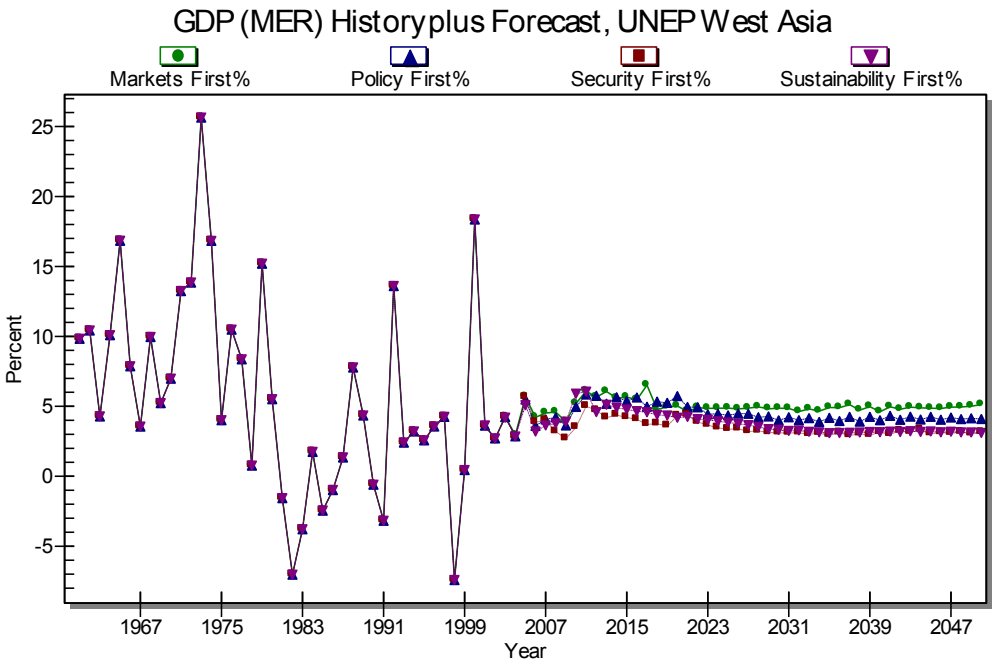
Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP Polar	UNEP Polar	UNEP Polar	UNEP Polar
Year	Markets	Policy	Security	Sustain
1960	3.63	3.63	3.63	3.63
2010	12.99	12.68	12.43	12.33
2050	45.22	41.25	27.39	29.73



GDP (MER) History plus Forecast, UNEP West Asia

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	GDP[2]	GDP[3]	GDP[4]	GDP[5]
	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.
	% Change	% Change	% Change	% Change
Year	Markets	Policy	Security	Sustain
1960	.00	.00	.00	.00
2010	5.35	5.305	5.241	5.294
2050	4.866	4.418	3.49	3.744

GDP per Capita (MER) History plus Forecast, UNEP West Asia

Continue Refresh Graph Print Save Percent Cumulative Interval Average Filter Display Run Horizon

	GDP per Capita	GDP per Capita	GDP per Capita	GDP per Capita
	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.	UNEP West Asi.
Year	Markets	Policy	Security	Sustain
1960	1.485	1.485	1.485	1.485
2010	4.01	3.971	3.772	3.966
2050	14.58	13.61	6.594	10.88

3.5 Some Thoughts on Technology and Productivity

The scenarios of GEO-4 have implicit assumptions about the advance of technology and productivity imbedded deeply in them. Given the importance of the advance of technology and productivity for economic growth and environmental impact, scenario developers should make those assumptions explicit whenever possible. This section is an attempt to do so with respect to the above discussion of economic growth differences across scenarios.

Conceptually it is important to distinguish between technology and productivity, with the former contributing heavily to the latter. Technology is often defined as the application of science or knowledge. Specific technologies commonly have an upper limit of efficiency, such as that involved in the production of grain from a specific biological strain or of electricity from a specific type of photovoltaic material. Technological advance in a more aggregate form, but still within a particular technological arena, can also run up against upper limits, such as those that solar influx per unit of surface area impose on both photosynthesis and photovoltaic processes. Obviously, it might take considerably longer to reach these more broadly defined limits as technological advances occur. (The Millennium Ecosystem Assessment (MA)'s conceptualization of technological trends appears related to such broader processes and limits; see Figure 9.1 in Volume II of Chapter 9, below).

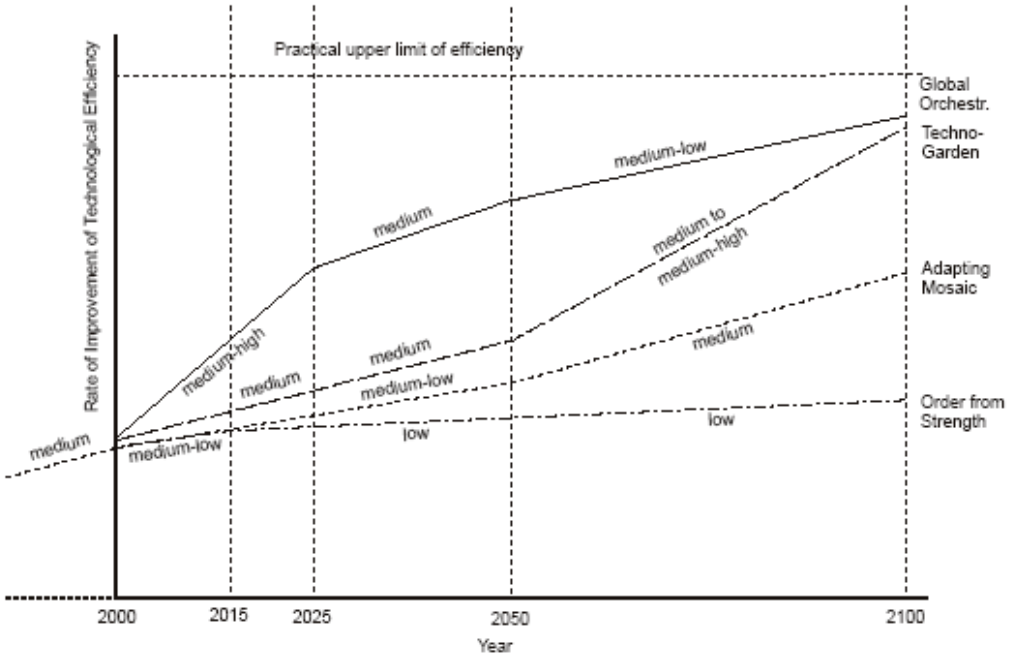

Figure 9.1 Global Trends of Technological Efficiencies in the MA Scenarios. Depicted are the qualitative assumptions made for changes in technological efficiency under the four MA scenarios. "Technological efficiency" refers, for example, to the conversion efficiency of power plants, or the yield of crops per hectare. As a reference point for the scenarios, we designate the current rate of improvement of all technologies as "medium". Therefore, a "high" scenario implies an acceleration, and a "low" scenario a slowing of the current rate of improvement. These qualitative assumptions are used for setting technology-related parameters in the models used for quantifying the scenarios (e.g. the rate of increase of crop yield due to technological improvements in crops). For the Techno-Garden scenario a faster rate of improvement than shown in the curve was assigned to the technologies directly related to pollution control such as air pollution filtering devices. This is consistent with the storyline of the scenario which specifies that the environmental orientation of TechnoGarden leads to a faster improvement in pollution control technologies than under the Global Orchestration scenario, but a slower improvement in all other technologies.

Still more broadly, technological shifts can occur in the satisfaction of human needs that move up an envelope curve of prospective limits. For instance, the movement in energy systems from human and animal power to the use of fossil fuels constituted such as shift and fusion power could conceivably create another (substituting matter-energy conversion limits for those of fossil energy conversion).

Economic multifactor productivity gains benefit from an aggregation of technological advance and technological shifts, in combination with the advance of human capital and social organization, as well as suffering from the drawing down of natural capital like those fossil fuels. Economic productivity globally has had a long run of relatively consistent growth over the last couple of centuries and may or may not be facing any imminent limits to that pattern. Complicating matters further, some have argued that long technological waves have supported that growth (Freeman and Louçã 2001), although those looking for waves often find them in price data rather than growth rates – aggregate economic productivity gains of advanced or leading countries have been remarkably steady, roughly in range of 1-2% annually; follower countries have ranged more widely, with catch-up rates from perhaps 0-4% annually.

Because of the definitional or conceptual distinctions sketched briefly here, and because different models and tools work at different levels of aggregation, the making explicit and reconciliation of forecasts of technological and productivity advance will necessarily be a collective exercise of the quantitative/modelling teams of GEO-4. For instance, the base case assumption within IFs of change in energy intensity is a 1.0% annual decline of energy usage per dollar of GDP, but it is unclear how this relates to assumptions in other models. As an initial contribution to this collective activity, this section provides some information on the aggregate economic productivity representation of the IFs model.

IFs uses a Cobb-Douglas production function in which labor and capital are combined with constant returns to scale. As Solow (1956) pointed out, however, most economic growth, especially in more developed countries, tends not to be explained by increases in labor or capital, but by what was once seen to be the constant multiplier in front of those terms. That multiplier term has come to be known as multi-factor productivity (MFP) or total factor productivity (TFP). Increasingly, endogenous economic growth theory focuses on understanding the factors that drive changes in MFP (Romer 1994). The IFs model uses a structural representation that endogenously ties changes in human, social, built, and natural capital, as well as spending on knowledge development and diffusion to the level of MFP. Thus the scenario implementation, which Chapter 2 described, influenced the drivers of MFP and therefore the growth patterns.

What are the MFP forecasts that resulted from the four sets of interventions? The table below shows those for each UNEP region and each scenario over the 2000-2050 period (from the variable MFPTOT in IFs). Although annual rates can vary considerably from year to year as the numerous driving forces shift them, the long-term averages distinguish much of the economic performance of countries and regions and the performance across scenarios. (Do not forget that labor force size, as driven by the population model and labor participation rate forecasts, and capital stock, as computed from investment in the economic model, also significantly affect economic performance.) For reference, the table below also shows the numbers in the IFs base case – these heavily reflect tuning to past patterns and assorted forecasts by others, but are also relevant for comparison with the emerging forecasts in support of the OECD Environmental Outlook to 2030 (to be discussed later).

	Markets First	Policy First	Sustainability First	Security First	IFs Base
Africa	2.38	2.01	1.62	0.88	1.71
Asia&Pac	2.15	2.11	1.83	0.53	1.68
Europe	2.27	2.28	2.02	1.22	1.88
LatAm&C	2.71	2.56	2.12	1.07	1.99
NorthAm	1.46	1.47	1.38	0.75	1.09
Polar	2.17	2.07	1.8	1.15	1.66
West Asia	2.63	2.27	1.75	0.95	1.88

Because the numbers in the above table are computed from the model interventions and structure, their interpretation is not always obvious. Some patterns are clear:

- North America tends to have lower rates than other regions because the U.S. has been the technological leader; although there are times (like the late 1990s) when

its productivity growth may be faster than other countries, under normal circumstances other countries can achieve more rapid productivity advance by adopting/adapting technology and converging with the leader. The U.S. Bureau of Labor Statistics (2005: 5) reported that the annual rate of U.S. MFP from 1948-2002 was 1.4%, around which three of the above scenarios cluster.

- Productivity growth rates do not vary as much across the scenarios as do economic growth, because demographic factors also strongly influence them.

- In general, productivity growth rates are fastest in Markets First, with Policy First close behind. The interventions posited that technological advance would be fastest in Markets First (globalization processes inherently facilitate considerable technology transfer), although Policy First is close behind, largely on the strength of its investment in human capital. Technological and productivity advance is also quite strong in sustainability first because of human capital investment. Security First introduces many elements of economic and political autarky that severely limit economic convergence.

- Some specific values can be surprising until given some thought. West Asia does especially well in Markets First. That is a result of high energy revenues and considerable investment of those in social purposes, as well as the potential for substantial gains of the region from economic and socoio-political liberalization. It loses relatively more than other regions from Security First. Productivity gains in Asia and the Pacific are not as high as might be expected in most scenarios. But Krugman and others have pointed out that much of the region's growth has been capital intensive rather than productivity enhancing. Africa does perhaps better than expected, in part because its very low levels of initial productivity provide substantial head-room for advance based on technological convergence.

The reality, however, is that the forecasts of MFP growth in the above table should be considered highly uncertain; that is, of course, the reason for multiple scenarios.

Consideration of productivity by economic sector begins to move us from the most aggregate level towards specific technologies or at least technology categories. As with national level MFP, there is a surprisingly weak empirical foundation to draw upon. U.S. statistics are both relatively good and particularly useful given the country's share in the global economy and its historic position of technological leadership. The table below provides some sectoral statistics that correspond roughly to the economic sectors represented in IFs: agriculture, energy, other materials, manufactures, services, and information/communications technology (ICT) broken out from manufactures and services. It draws on two sources, the Bureau of Labor Statistics and Bosworth and Triplett (2003).

	1988-92	1993-97	1987-95	1995-2001
Agriculture/Farms	2.40	1.20		
Agricultural Services			-1.12	0.56
Private NonFarm Bus			0.56	1.44
Good Producing			1.23	1.31
Mining (incl Enegy)			2.12	-1.57
Oil and Gas			0.82	-4.15
Metal Mining			8.64	13.81
Nonmetal Minerals, except fuels			0.32	2.81
Construction			0.37	-0.95
Manufacturing			1.70	2.77
Electronic			6.03	9.61
Services			0.33	1.48
Communications			2.56	0.40

Sources: Agriculture/Farms from the Bureau of Labor Statistics;
Others from Bosworth and Triplett 2003: Table A-2

Among the interesting conclusions that can be drawn from the above table are:

- Productivity appears highly variable across time as well as sectors, sometimes in unbelievable fashion. For instance, Bosworth and Triplett express scepticism concerning negative productivity, especially in a sector like construction.

- Although the gain in services productivity in the late 1990s was very great, the rate still remained below manufacturing. In terms of economic growth patterns, these two numbers are the most important because the sector sizes, especially services, dominate the economies of the world.

It is not easy from numbers as variable and uncertain as those above to choose figures for forecasting. For the forecasts of IFs, the numbers below were used to represent sectoral patterns of productivity growth. The sectoral numbers are scaled within IFs by the overall national rates, and it is the overall national rates not sectoral variation that really determines model forecasts.

Agriculture	1.5
Energy	1.0
Materials (ex Energy)	1.3
Manufacturing	2.0
Services	1.3
ICT	6.0

Because of the exceptionally high rate of growth in the ICT sector, it is unsustainable over long periods of time. IFs makes the arbitrary assumption that the rate will converge by mid-century to the rate in the broader economy.

The table below is from an OECD working paper (2005) in support of the effort to be able to forecast through 2030 for the OECD's forthcoming Environmental Outlook. It's labor productivity rates were not used in the most recent revision of the IFs base case and scenarios, but should be reviewed for the next revision.

Table A4. **OECD sectoral labour productivity growth (1980-2001)**

	Agriculture	Forestry, Fishing	Energy†	Non-durables	Durables	Trade, Transport	Services
Australia	3.2%	3.5%	4.3%	1.5%	2.0%	0.9%	-0.5%
Austria	5.2%	5.1%	3.2%	4.1%	4.1%	2.4%	1.9%
Belgium	4.2%	5.7%	2.4%	2.8%	5.0%	1.1%	1.2%
Canada	2.5%	-1.3%	1.5%	1.2%	2.8%	1.3%	-0.5%
Czech Rep.*	5.9%	7.7%	-4.5%	11.3%	4.9%	4.8%	1.6%
Denmark	7.3%	1.0%	8.0%	1.6%	2.2%	2.9%	-0.1%
Finland	2.1%	4.1%	3.2%	4.5%	3.0%	-0.2%	-0.4%
France	6.1%	-0.9%	3.0%	0.9%	3.7%	2.9%	0.9%
Germany	5.8%	2.8%	0.4%	1.3%	5.1%	3.0%	0.7%
Greece	1.7%	1.1%	5.3%	3.1%	0.7%	1.1%	-1.7%
Hungary*	5.6%	6.1%	-0.3%	-1.0%	12.1%	3.3%	-1.3%
Ireland	1.4%	0.2%	na	3.5%	7.4%	0.1%	-1.9%
Italy	4.6%	5.2%	1.2%	1.6%	-2.3%	-3.6%	-6.2%
Japan	3.0%	1.0%	2.1%	0.0%	3.8%	2.9%	2.0%
Luxembourg	5.4%	6.6%	5.5%	-0.4%	5.0%	4.0%	0.0%
Mexico*	2.0%	0.0%	2.0%	2.0%	2.0%	1.0%	0.0%
Netherlands	3.4%	2.0%	2.6%	3.7%	3.9%	2.6%	1.7%
Norway	4.1%	5.7%	2.9%	0.2%	2.1%	4.0%	-2.5%
Poland*	2.2%	8.3%	1.5%	11.5%	11.2%	4.3%	0.0%
Portugal	4.7%	4.0%	-4.4%	1.9%	3.6%	1.9%	1.5%
Korea	7.1%	4.2%	10.2%	4.2%	9.6%	3.9%	1.0%
Slovak Rep.*	5.8%	5.8%	1.2%	-2.0%	-1.0%	0.3%	7.1%
Spain	5.4%	3.5%	2.7%	2.0%	2.7%	1.5%	0.2%
Sweden	2.0%	5.3%	0.5%	2.1%	2.0%	0.8%	0.8%
UK	3.0%	1.4%	5.6%	2.5%	4.7%	7.2%	-2.5%
US	4.4%	1.1%	2.1%	0.5%	4.9%	4.0%	0.8%

Source: OECD STAN database, Groningen Growth and Development Centre database.
† Data periods for energy are variable
* Periods as follows: Poland (1994-2001), Mexico (1988-2001), Czech (1993-2001), Hungary (1993-2001), Slovakia (1993-2001)

As indicated at the beginning of this section, technological assumptions are obviously very important in the forecasts of drivers. Yet as this section has indicated, they are extremely complicated to forecast. We conclude with two overall conclusions:

- The effort to specific technological assumptions should continue to receive careful attention by all modelers in GEO-4. Transparency of assumptions and computations is especially important.

- The approach within IFs, of computing initial magnitudes of economic productivity from the patterns of GDP growth (after removing the contributions of labor and capital growth) and then endogenizing change to those productivity rates over time as a function of known drivers (such as human and social capital patterns) has considerable merit relative to an attempt to forecast productivity change *de novo* and impose it on the model.

3.6 Supply-Side Sectoral Divisions: Value Added

Although total GDP is an important driver of most global forecasting models, environmental impact can also be highly variable by sector of the economy. IFs generates sectoral values as well as the total GDP.

As indicated earlier, there are six sectors in IFs: agriculture, energy, other materials, manufactures, services, and information/communications technology (ICT), which is broken out from manufactures and services. The model computes value added in each sector. As a general economic rule, the demand for agricultural and other primary goods tends to decline as a portion of GDP as economies become richer (they are "inferior" goods), as does the demand for manufactured goods at higher levels of income. The service sector continues to grow in share, although its composition changes.

This pattern tends to characterize forecasts in IFs as well, in all scenarios. The two figures below arbitrarily represent Markets First, and focus for clarity on relative sector sizes rather than absolute numbers. For further clarity they show only the three traditional sectors of focus: agriculture, manufacturing, (industry would combine energy, minerals, and manufactures) and services. Finally, they show only the OECD and non-OECD countries in aggregate, to indicate the different patterns that characterize more and less developed countries. IFs provides absolute sectoral sizes (all 6 sectors) for each of the UNEP regions and sub-regions.

The first figure, for OECD countries, shows the continued decline in share of the agricultural sector, already starting from relatively low levels at the beginning of the century. The figure indicates also the relative decline of manufacturing and the continued rise of services. The shifts of patterns in the IFs forecasts over the next 50 years, however, is not nearly as marked as that in historic data for the last 40 years and may underestimate the rate of future change. Yet the high relative size of the service sector in OECD countries suggests that some saturation in the trend pattern should be expected. By 2050 the forecast below takes OECD countries generally to about U.S. levels in 2000.

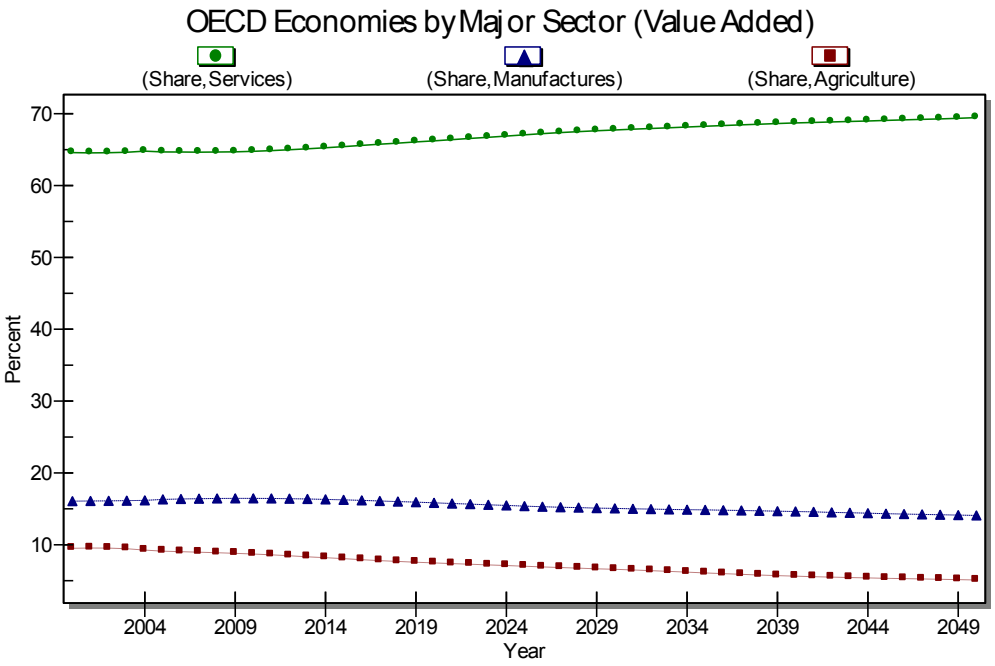

Table Display

Continue Refresh Graph Print Save Percent Cumulative Filter

Display Run Horizon

	VADD[0]/GDP[(	VADD[0]/GDP[(	VADD[0]/GDP[(
	OECD/OECD*	OECD/OECD*	OECD/OECD*
	Services/	Manufactures/	Agriculture/
	Billion $/Billion	Billion $/Billion	Billion $/Billion
Year	Working	Working	Working
2000	64.59	16.0651	9.5183
2050	69.46	14.0748	5.0946

In fairly substantial contrast to the OECD pattern, the non-OECD forecast below is for more rapid decline from higher initial levels of agriculture, growth rather than shrinkage of manufacturing as the South continues to consolidate its role as the global workshop (although manufacturing saturates by mid-century and beings to decline thereafter), and also substantial rise in the service share from considerably lower levels than in the OECD countries.

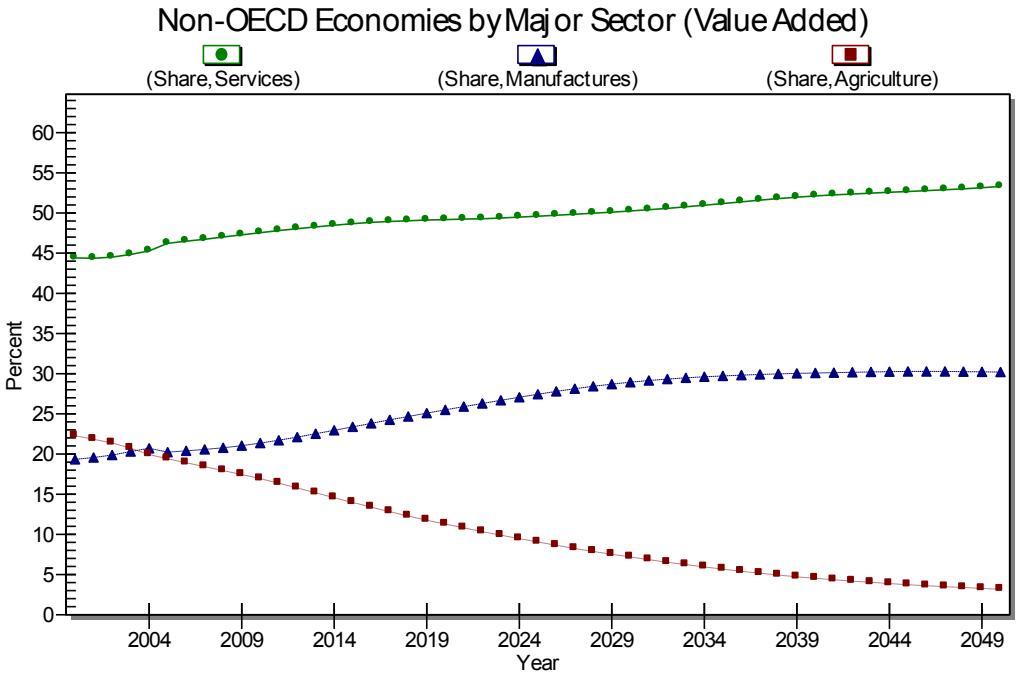

Table Display

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	VADD[2]/GDP[2 non-OECD/non-Services/ Billion $/Billion	VADD[2]/GDP[2 non-OECD/non-Manufactures/ Billion $/Billion	VADD[2]/GDP[2 non-OECD/non-Agriculture/ Billion $/Billion
Year	Markets	Markets	Markets
2000	44.41	19.33	22.2778
2050	54.42	30.04	2.4117

3.7 Expenditure Components: Household Consumption Share

In addition to division of the economy by share of value added (a supply-side portrayal), it is useful to look at the share of the economy going to households (an expenditure component or demand-side portrayal). In Bangkok the IFs team was asked to prepare such forecasts as well. The tables in the two screen-shots below show the percentage of GDP taken by household consumption, Markets First and Security First, respectively.

There are some obvious variations across regions. For instance, European countries and Polar countries tend to have larger governmental shares and therefore lower household or private consumption shares. That is even more exaggerated in West Asia where energy revenues feed large governmental budgets. Asia and the Pacific tends to have high savings or investment levels, also reducing household budgets. In contrast, North America, Latin America, and Africa tend to privilege household consumption relative to government (and frequently relative to investment).

Table Display

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	Con Share	Con Share	Con Share	Con Share	Con Share	Con Share	Con Share
	UNEP Africa	UNEP Asia & Pa	UNEP Europe	UNEP Lat Am &	UNEP North Am	UNEP Polar	UNEP West Asi.
Year	Markets	Markets	Markets	Markets	Markets	Markets	Markets
2000	64.82	56.5253	58.5497	63.99	69.5182	52.66	49.26
2050	67.76	50.3684	56.2340	64.52	62.0432	56.11	54.61

Table Display

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	Con Share	Con Share	Con Share	Con Share	Con Share	Con Share	Con Share
	UNEP Africa	UNEP Asia & Pa	UNEP Europe	UNEP Lat Am &	UNEP North Am	UNEP Polar	UNEP West Asi.
Year	Security	Security	Security	Security	Security	Security	Security
2000	64.82	56.5253	58.5497	63.99	69.5182	52.66	49.26
2050	69.26	55.7477	55.6909	68.05	62.2674	55.77	54.60

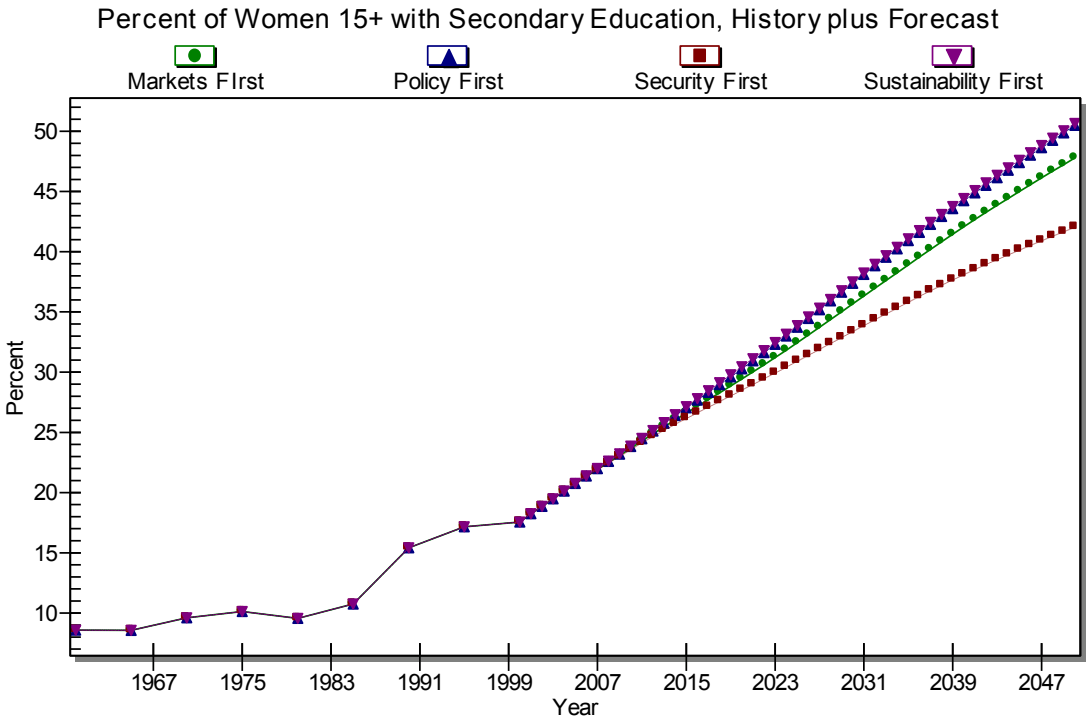
One interesting aspect of the two tables above is that for less developed countries (look at Africa, Asia & Pacific and Latin America and the Caribbean), the Security First scenario results in somewhat higher consumption shares compared to the Markets First scenario, a pattern which does not tend to be true in Europe or North America. The reason is obvious: lower economic growth results in less capacity to build governmental consumption share or savings rates, as well as more need to maintain the household consumption share.

3.8 Education: The Attainment by Women of Secondary Education

Still another variable of importance for the GEO-4 modeling and quantification work is education. Mohammod T. Irfan has steadily developed the education submodel of IFs. That model represents primary, secondary, and tertiary education, with differentiation by sex, and is integrated with the demographic model so that it is possible to examine the gradual accumulation by a population of educational credentials as those who graduate at increasingly higher rates age and replace population cohorts with lesser levels of education. Data come heavily from the collection of Barro and Lee (2000) with initial inputs and supplementary series from UNESCO.

The figure below shows the portion of global female population above 15 years of age that has a secondary education, across the four GEO scenarios. This is a variable of great importance because of the impact that secondary education of women has on variables such as fertility, health, and economic vitality. Since the 1980s, that rate has begun to climb significantly, due to substantial and increasing investments in education around the world in the last 3-4 decades. There will, however, also be some saturation effect as rates in increasingly numbers of countries approach 100 percent.

Not surprisingly, the emphasis of the Policy First and Sustainability First scenarios on investment in human capital pushes the rates in those scenarios above that of Markets First and especially above that of Security First.

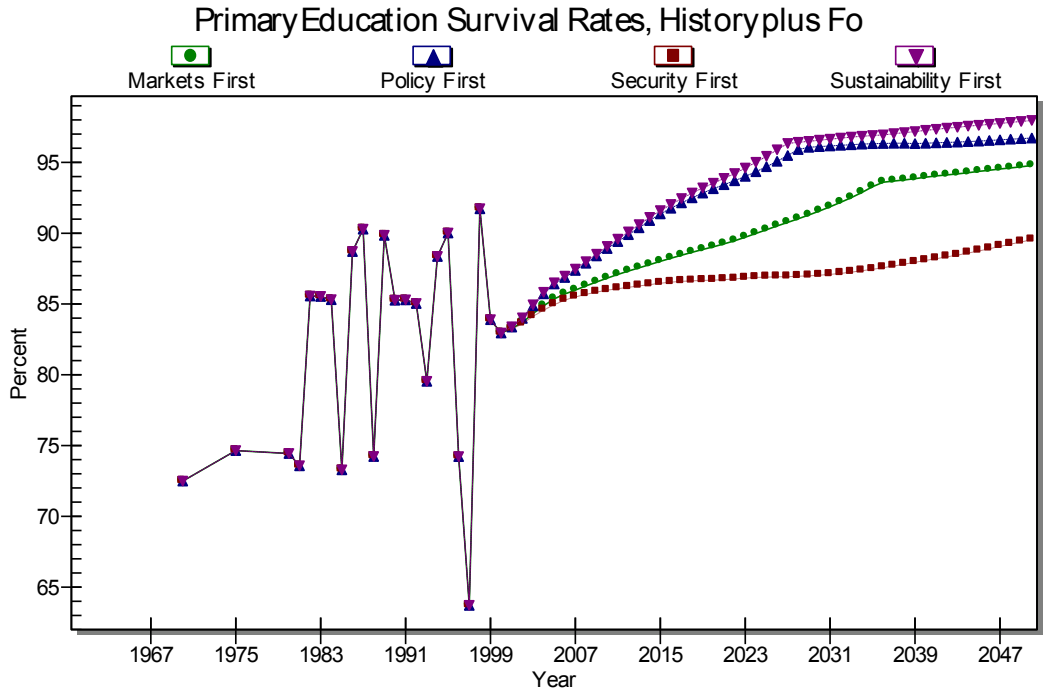


Secondary Education Years of Women 15+, History plus Forecast, Wo

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	EDSECPER[2]	EDSECPER[3]	EDSECPER[4]	EDSECPER[5]
	World	World	World	World
	Female	Female	Female	Female
	Percent	Percent	Percent	Percent
Year	Markets	Policy	Security	Sustain
1960	8.577	8.577	8.577	8.577
2010	23.69	23.83	23.56	23.86
2050	47.80	50.49	42.03	50.65

Some readers will have been surprised to see that the levels of female secondary education in the global population do not vary dramatically across scenarios that in many other areas do exhibit great differences. One of the reasons is, of course, the cohort structure of populations and the slowness of spread up age levels of higher educational attainment. The figure below shows the survival (graduation) rate of the primary-aged student population, rather than education levels across the entire population. Note that the scenarios exhibit considerably greater spread. (The fluctuations in historic values represent skimpy data and therefore variable country sets in those years, so the data can provide only a general sense of the past trend).

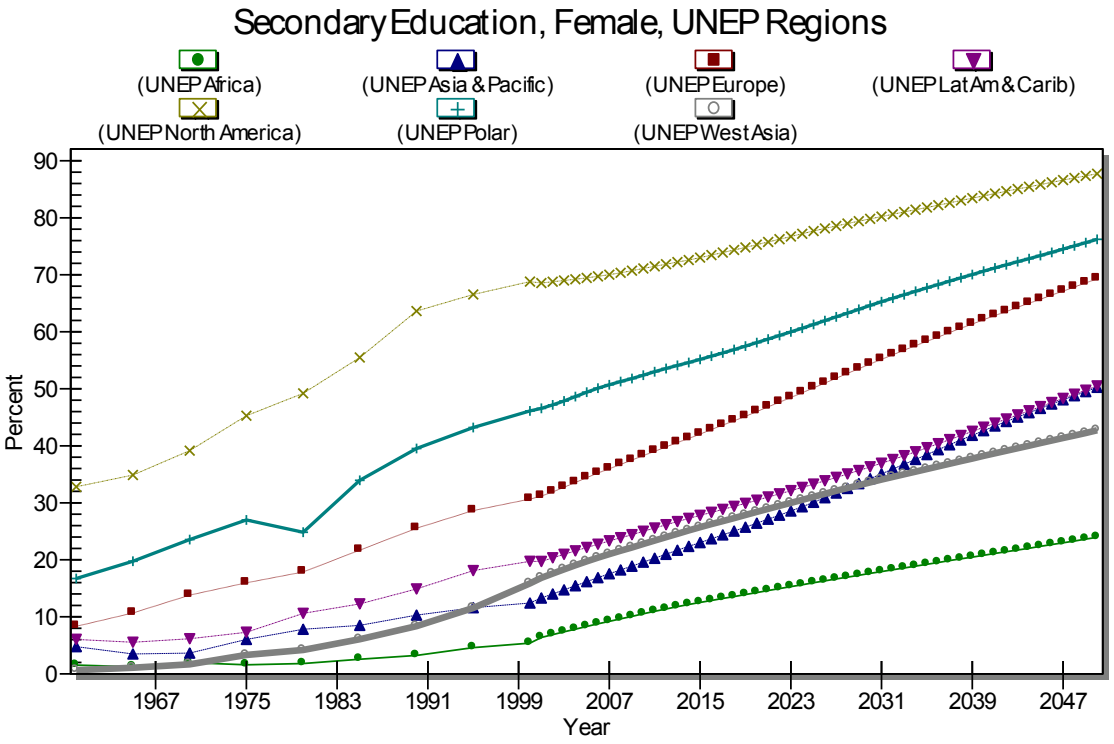


Primary Education Survival Rates, History plus Forecast, World

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	EDPRISUR[2]	EDPRISUR[3]	EDPRISUR[4]	EDPRISUR[5]
	World	World	World	World
	Total	Total	Total	Total
	Percent	Percent	Percent	Percent
Year	Markets	Policy	Security	Sustain
1960				
2010	86.59	88.68	85.73	88.82
2050	94.54	96.48	89.30	97.72

The figure below looks only at the Markets First scenario, but shows historic and forecast levels of secondary education for females across all UNEP regions. As indicated in the figures above, other scenarios will differ somewhat, but not greatly.



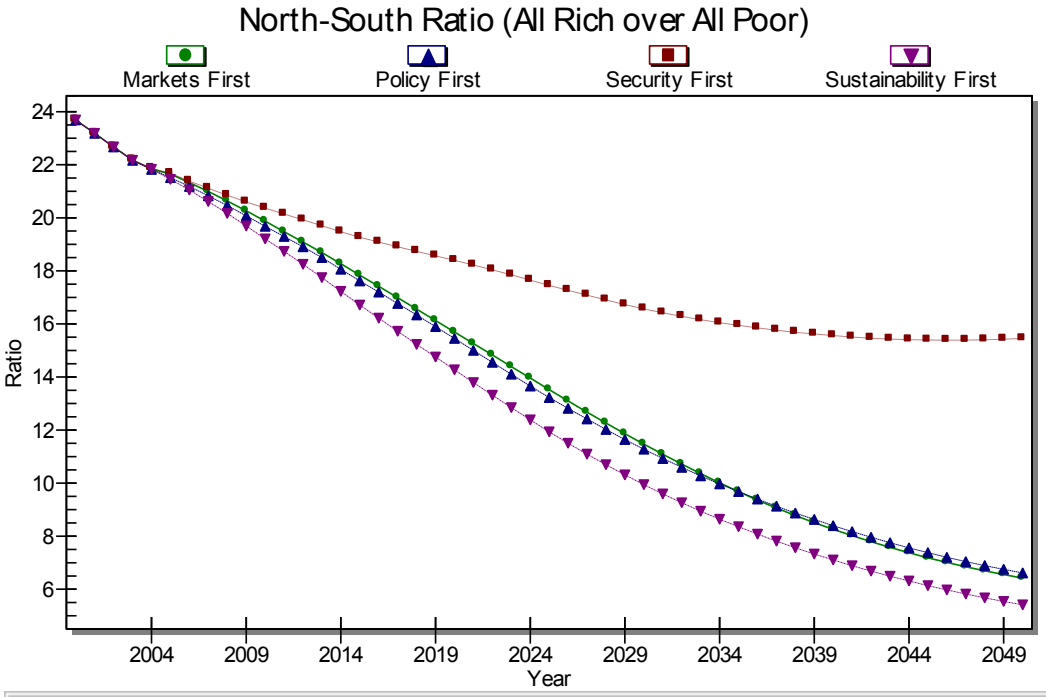
Secondary Education, Female, UNEP Regions

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	EDSECPER[2]	EDSECPER[2]	EDSECPER[2]	EDSECPER[2]	EDSECPER[2]	EDSECPER[2]	EDSECPER[2]
	UNEP Africa	UNEP Asia & Pa	UNEP Europe	UNEP Lat Am &	UNEP North Am	UNEP Polar	UNEP West Asi
	Female	Female	Female	Female	Female	Female	Female
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Year	Markets	Markets	Markets	Markets	Markets	Markets	Markets
1960	1.53	4.77	8.322	6.033	32.81	16.73	.643
2010	10.53	19.59	38.27	25.00	71.10	52.40	22.77
2050	23.95	50.27	69.29	50.50	87.73	76.23	42.72

3.9 Income Distribution: Global Patterns

There are three standard ways of thinking about the global distribution of income. One is in terms of the ratio of GDP per capita in richer and poorer societies. The second way of thinking about distribution is in terms of the absolute income gaps between the same sets of countries. The third is to look at the very richest globally versus the very poorest. The three graphs below show all three perspectives (using current OECD and non-OECD countries as proxies for global rich and poor in the first two).[7]



North-South Ratio (All Rich over All Poor)

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

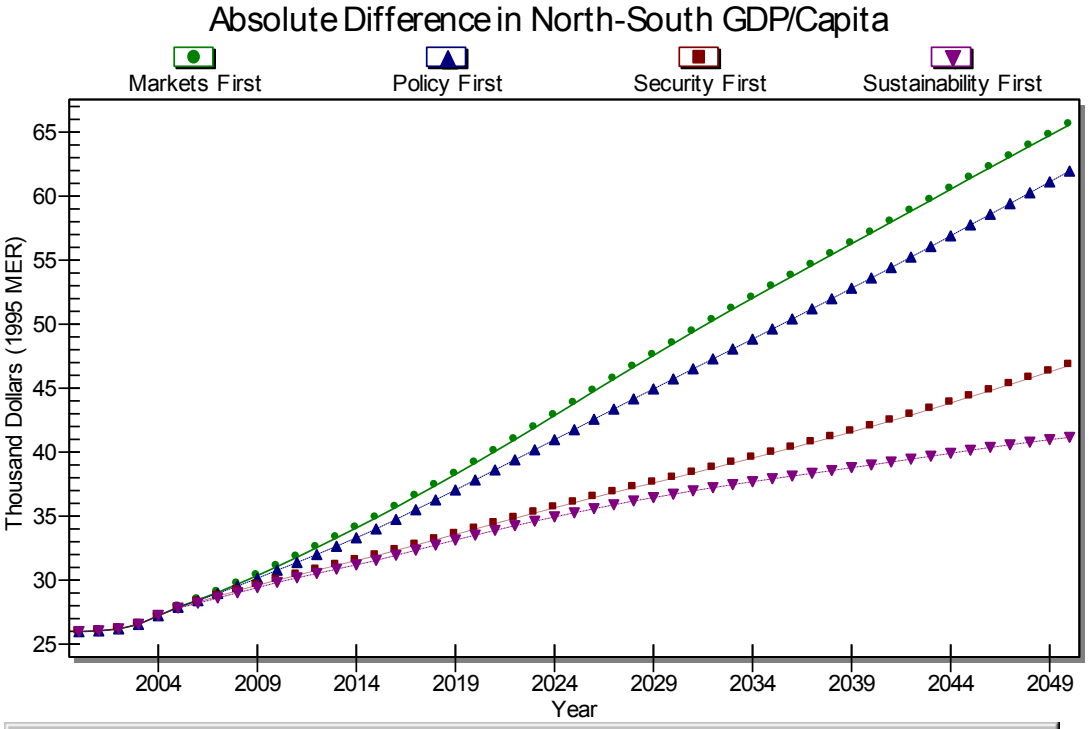
	NSGAPR[2]	NSGAPR[3]	NSGAPR[4]	NSGAPR[5]
	Ratio	Ratio	Ratio	Ratio
Year	Markets	Policy	Security	Sustain
2000	23.5868	23.5868	23.5868	23.5868
2010	19.7718	19.5758	20.2632	19.1066
2020	15.5916	15.3536	18.2978	14.1713
2030	11.3683	11.1773	16.4682	9.8414
2040	8.1566	8.2950	15.4626	7.0008
2050	6.3157	6.5128	15.3502	5.3119

The above figure may initially be somewhat surprising because three of the four scenarios exhibit such similar patterns. But what those three are showing is that global

[7] We have used the OECD and non-OECD countries as a quick way of dividing the world into rich and poor, in spite of the accession to OECD membership of some poorer countries such as Mexico.

economic growth is shifting considerably to the South in a process that appears highly likely to accelerate. Only in the Security First scenario is the pattern very different and even there the overall trend is in the same direction.

The next figure shows, however, that below these seeming similarity, and in spite of what appears in the above graph to be growing equality, income gaps are continuing to rise and the scenarios make a considerable difference in the rate and pattern of that rise. In fact, although not shown, the curve of the Sustainability First scenario does bend and begin to reduce the absolute differences in the second half of the century. Also in the longer term, the Policy First scenario begins to diverge more substantially from the Markets First, while the gaps in the Security First scenario climb sharply.

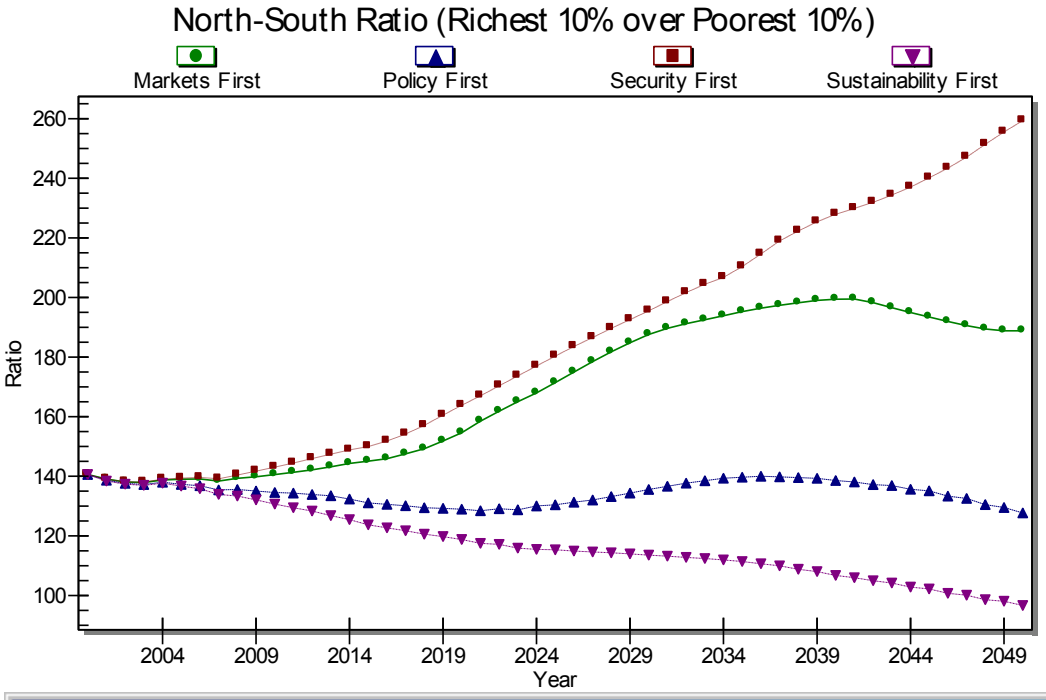


North-South Absolute Difference in 1000 Dollars

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	NSGAPA[2]	NSGAPA[3]	NSGAPA[4]	NSGAPA[5]
	Thousand $	Thousand $	Thousand $	Thousand $
Year	Markets	Policy	Security	Sustain
2000	25.73	25.73	25.73	25.73
2010	30.82	30.53	29.75	29.58
2020	38.89	37.58	33.75	33.26
2030	48.23	45.47	37.73	36.47
2040	56.88	53.36	41.76	38.76
2050	65.33	61.71	46.54	40.91

Moreover, even when a ratio measure is used, if the focus moves to the very richest and poorest, as opposed to the entire OECD an non-OECD aggregates, the scenarios tell quite different stories about gaps in GDP per capita. The figure below shifts to the focus on the very richest and poorest. It is interesting that the Sustainability First scenario begins to reduce the absolute GDP/capita gap between the two groups almost immediately, the Policy First scenario mostly stabilizes it, the Markets First scenario begins to bend the curve before mid-century, but the Security First (or Fortress First/gated community) scenario just keeps increasing the gap.



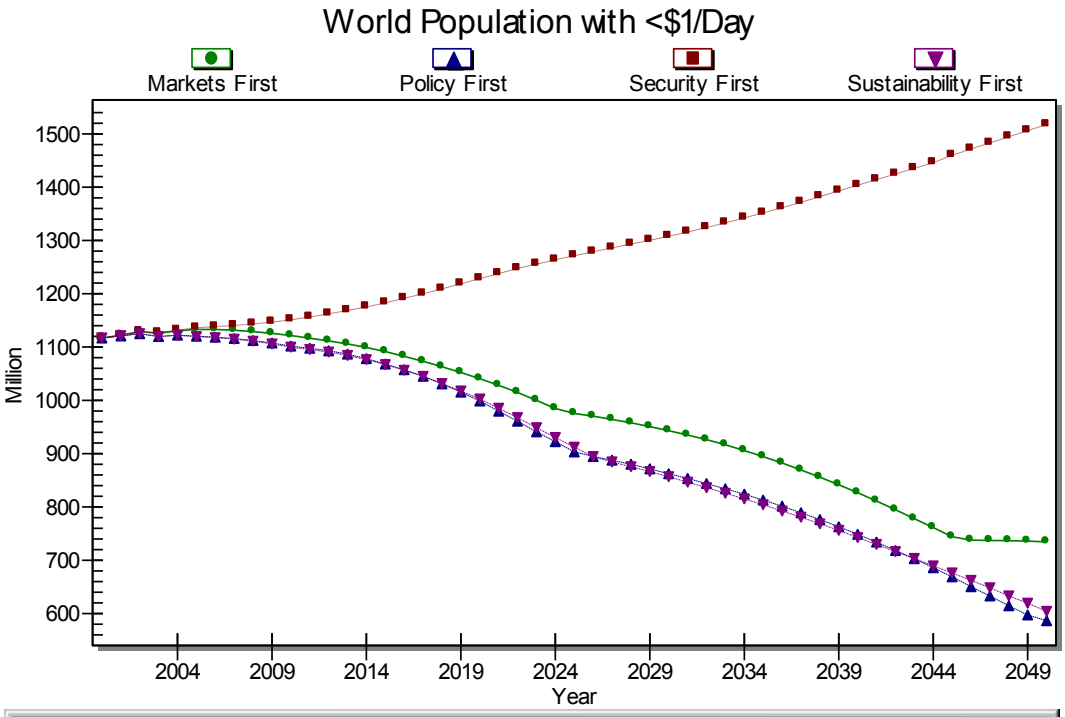
North-South Ratio (Richest 10% over Poorest 10%)

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	NSGAPRTB[2]	NSGAPRTB[3]	NSGAPRTB[4]	NSGAPRTB[5]
	Ratio	Ratio	Ratio	Ratio
Year	Markets	Policy	Security	Sustain
2000	140.6	140.6	140.6	140.6096
2010	140.6	134.6	143.0	130.6730
2020	154.6	129.0	163.8	118.7970
2030	187.6	135.6	195.6	113.5644
2040	199.4	138.6	227.9	106.7443
2050	188.8	127.7	259.3	96.6459

With the advent of the Millennium Development Goals (MDGs), attention is increasingly being given to other measures of global distribution and well-being. The graph below shows forecasts of those living on less than $1 per day. All scenarios except Security

First eventually show significant progress (although progress in Markets First begins to significantly slow by mid century).



World Population with <$1/Day

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

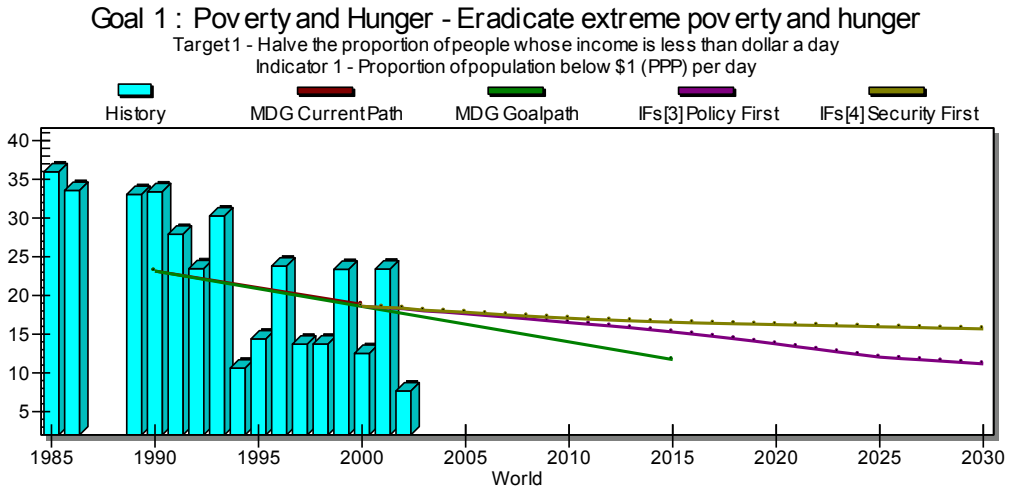
	INCOMELT1[2]	INCOMELT1[3]	INCOMELT1[4]	INCOMELT1[5]
	World	World	World	World
	Mil People	Mil People	Mil People	Mil People
Year	Markets	Policy	Security	Sustain
2000	1,117	1,117.0700	1,117	1,117.0700
2010	1,122	1,101.8330	1,151	1,099.8080
2020	1,041	998.8875	1,228	1,002.7190
2030	943.2	862.3522	1,308	856.5952
2040	826.7	748.7963	1,404	742.4981
2050	734.6	586.5989	1,517	604.2151

The figure below goes one step further by showing forecasts of progress towards the first Millennium Development Goal (MDG) of reducing the portion of those in poverty by 50% between 1990 and 2015. It portrays forecasts only for the Policy First and Security First scenarios (which defined the broadest range in the figure above). The figure extends the forecast horizon past the goal horizon because the forecasts suggest the goal will not be met by 2015.

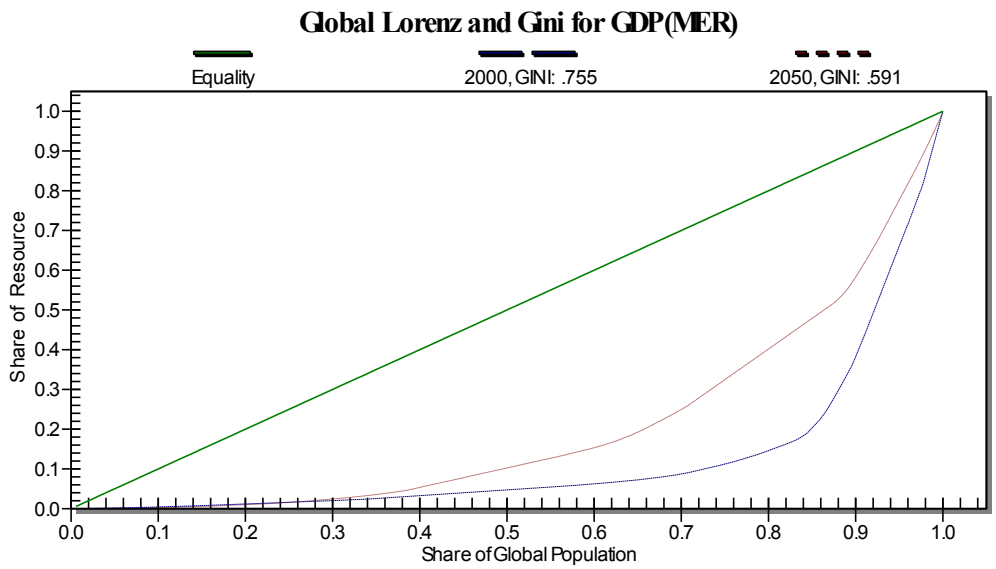
Those with special interest in the MDGs may be interested in looking also at the historic pattern on the graph below, shown as bars. It is difficult to reconstruct the global history

because the surveys on which poverty estimates are based are not done with great frequency or at regular intervals. The bars in the figure show the population-weighted calculations for all countries reporting in each year. Interestingly, the bars show much progress in the late 1990s relative to the late 1980s and early 1990s, but they hint at slowing progress in the late 1990s, as do both forecasts portrayed (largely because the most rapid progress in China with respect to absolute numbers is now behind us).

It is important, however, to recognize the great debates even over current poverty levels, much less those in future years. Some (most forcefully Bhalla 2003) argue that survey-based analysis has underestimated recent poverty reduction and that the MDG poverty goal has already been reached. The IFs project is now undertaking a substantial review of the poverty measurement and forecasting literature in order to enhance its own analysis and forecasting in this area.



At the risk of adding confusion, but for the sake of showing capability for elaborating the scenarios, the graph below shows the global Lorenz Curve and associated Gini Index of global GDP in the Sustainability First scenario for 2000 and 2050. Note the obvious growth of the "global middle class," clearly consisting in substantial part of the growth in large countries like China and India.


Global Lorenz and Gini for GDP(MER)
Equality
2000, GINI: .755
2050, GINI: .591
Share of Resource
Share of Global Population
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

3.10 UNEP Region Detail: Summary Reference Tables

The tables below show some of the above forecasts numerically by UNEP region. Much more detailed and extensive UNEP sub-region and country-specific tables are being provided as Excel files with this document. See the next section for detail on those files.

Population in Millions

	Year	2000	2010	2020	2030	2050	2100
UNEP Africa	Markets	794.6	993.4	1224	1477	2009	2874
UNEP Africa	Policy	794.6	983.3	1173	1355	1668	1816
UNEP Africa	Security	794.6	1005	1278	1603	2366	4124
UNEP Africa	Sustain	794.6	978.9	1153	1291	1458	1220
UNEP Asia & Pacific	Markets	3547	3936	4311	4611	5009	4755
UNEP Asia & Pacific	Policy	3547	3916	4235	4471	4740	4202
UNEP Asia & Pacific	Security	3547	3957	4389	4754	5246	5299
UNEP Asia & Pacific	Sustain	3547	3897	4170	4335	4399	3301
UNEP Europe	Markets	819.3	829.3	830.1	819.2	771.9	597.5
UNEP Europe	Policy	819.3	830.1	831.9	820.8	768.2	586.6
UNEP Europe	Security	819.3	827.9	822.4	802.9	734.1	546.7
UNEP Europe	Sustain	819.3	828.5	826.5	810	739.1	497.9
UNEP Lat Am & Carib	Markets	518.6	593.2	655.2	703.3	766	732.1
UNEP Lat Am & Carib	Policy	518.6	589.9	646.5	690.2	738.5	678.8
UNEP Lat Am & Carib	Security	518.6	596.5	671.3	733.1	814.3	824.9
UNEP Lat Am & Carib	Sustain	518.6	588.5	639.5	674.1	691.3	546.3
UNEP North America	Markets	315.8	347.1	378.1	408.1	455	525.2
UNEP North America	Policy	315.8	346.7	374.1	399.1	432.6	468.3
UNEP North America	Security	315.8	345	367.2	386.3	408.1	423
UNEP North America	Sustain	315.8	346.7	373.3	393.6	415.1	366.9
UNEP Polar	Markets	195.2	193.4	191.6	186.9	173.5	134.9
UNEP Polar	Policy	195.2	193.6	192	187.2	172.4	129.7
UNEP Polar	Security	195.2	192.9	188.9	181.6	161.2	115.7
UNEP Polar	Sustain	195.2	193.5	191.5	186.1	168.1	112.2
UNEP West Asia	Markets	100.6	129.2	161.4	194.8	254.4	336.2
UNEP West Asia	Policy	100.6	127.7	154.6	179.7	219.9	256.2
UNEP West Asia	Security	100.6	130.4	167.2	207.6	290.5	426
UNEP West Asia	Sustain	100.6	127.2	152.3	172.6	199.2	191.6

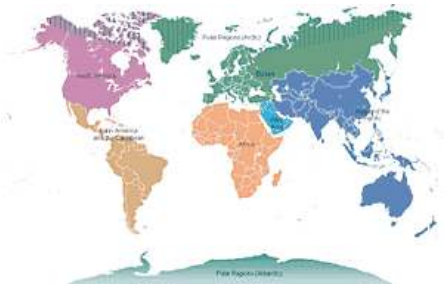
Population Growth Rate, Percent Annual

	Year	2010	2020	2030	2050	2100
UNEP Africa	Markets	2.258	2.109	1.896	1.433	0.335
UNEP Africa	Policy	2.153	1.784	1.452	0.883	-0.131
UNEP Africa	Security	2.373	2.439	2.287	1.863	0.649
UNEP Africa	Sustain	2.108	1.652	1.139	0.458	-0.715
UNEP Asia & Pacific	Markets	1.046	0.915	0.677	0.351	-0.278
UNEP Asia & Pacific	Policy	0.996	0.786	0.543	0.212	-0.417
UNEP Asia & Pacific	Security	1.1	1.043	0.8	0.409	-0.125
UNEP Asia & Pacific	Sustain	0.947	0.679	0.389	-0.03	-0.812
UNEP Europe	Markets	0.121	0.009	-0.132	-0.355	-0.499
UNEP Europe	Policy	0.131	0.022	-0.134	-0.398	-0.534
UNEP Europe	Security	0.104	-0.067	-0.239	-0.521	-0.467
UNEP Europe	Sustain	0.112	-0.025	-0.201	-0.546	-0.82
UNEP Lat Am & Carib	Markets	1.353	1	0.71	0.339	-0.319
UNEP Lat Am & Carib	Policy	1.297	0.92	0.657	0.239	-0.378
UNEP Lat Am & Carib	Security	1.411	1.188	0.884	0.43	-0.136
UNEP Lat Am & Carib	Sustain	1.274	0.834	0.528	0.005	-0.727
UNEP North America	Markets	0.95	0.86	0.766	0.478	0.139
UNEP North America	Policy	0.939	0.764	0.649	0.327	0.033
UNEP North America	Security	0.89	0.625	0.509	0.21	0.008
UNEP North America	Sustain	0.938	0.742	0.533	0.175	-0.515
UNEP Polar	Markets	-0.09	-0.094	-0.248	-0.414	-0.456
UNEP Polar	Policy	-0.078	-0.085	-0.251	-0.476	-0.548
UNEP Polar	Security	-0.117	-0.211	-0.394	-0.67	-0.442
UNEP Polar	Sustain	-0.085	-0.106	-0.287	-0.593	-0.882
UNEP West Asia	Markets	2.531	2.255	1.896	1.172	0.253
UNEP West Asia	Policy	2.412	1.934	1.515	0.867	0.064
UNEP West Asia	Security	2.627	2.52	2.185	1.552	0.36
UNEP West Asia	Sustain	2.373	1.818	1.257	0.596	-0.416

Note: Percentages in above table are averaged for the decade preceding the year shown.

GDP at Market Exchange Rates, Billion 1995 Dollars

	Year	2000	2010	2020	2030	2050	2100
UNEP Africa	Markets	589	855	1,261	2,029	6,218	57,555
UNEP Africa	Policy	589	858	1,293	2,045	5,437	38,141
UNEP Africa	Security	589	821	1,069	1,457	2,889	12,964
UNEP Africa	Sustain	589	851	1,235	1,850	4,128	17,430
UNEP Asia & Pacific	Markets	9,941	14,054	22,134	37,301	92,605	362,054
UNEP Asia & Pacific	Policy	9,941	13,951	21,202	34,440	79,384	296,731
UNEP Asia & Pacific	Security	9,941	13,387	17,091	21,580	29,071	43,759
UNEP Asia & Pacific	Sustain	9,941	13,636	19,551	29,653	60,942	168,197
UNEP Europe	Markets	11,599	14,655	19,565	26,047	41,853	86,272
UNEP Europe	Policy	11,599	14,483	18,701	23,844	36,886	71,706
UNEP Europe	Security	11,599	14,004	16,102	17,948	21,854	29,141
UNEP Europe	Sustain	11,599	14,032	16,641	19,072	23,863	32,329
UNEP Lat Am & Carib	Markets	2,011	2,629	3,884	5,929	13,472	65,477
UNEP Lat Am & Carib	Policy	2,011	2,612	3,689	5,350	11,131	51,511
UNEP Lat Am & Carib	Security	2,011	2,528	3,176	3,997	5,980	14,258
UNEP Lat Am & Carib	Sustain	2,011	2,585	3,485	4,741	8,425	26,421
UNEP North America	Markets	9,662	13,192	18,437	24,671	38,544	85,614
UNEP North America	Policy	9,662	13,092	17,865	23,445	35,510	72,089
UNEP North America	Security	9,662	12,775	16,191	19,724	26,041	43,771
UNEP North America	Sustain	9,662	12,650	15,596	18,631	23,378	30,731
UNEP Polar	Markets	1,777	2,512	3,532	4,861	7,844	19,406
UNEP Polar	Policy	1,777	2,456	3,390	4,556	7,110	16,208
UNEP Polar	Security	1,777	2,398	2,949	3,457	4,416	6,165
UNEP Polar	Sustain	1,777	2,385	3,083	3,755	4,999	8,493
UNEP West Asia	Markets	345	518	892	1,431	3,709	26,465
UNEP West Asia	Policy	345	507	864	1,336	2,993	16,701
UNEP West Asia	Security	345	492	742	1,044	1,916	6,109
UNEP West Asia	Sustain	345	504	803	1,163	2,166	8,194



GDP at Purchasing Power Parity, Billion 1995 Dollars

	Year	2000	2010	2020	2030	2050	2100
UNEP Africa	Markets	1,507	2,076	2,859	4,099	9,668	64,122
UNEP Africa	Policy	1,507	2,076	2,882	4,075	8,408	42,042
UNEP Africa	Security	1,507	2,027	2,611	3,416	5,982	20,944
UNEP Africa	Sustain	1,507	2,064	2,790	3,783	6,653	20,014
UNEP Asia & Pacific	Markets	14,303	21,360	33,856	54,474	115,510	374,729
UNEP Asia & Pacific	Policy	14,303	21,266	32,641	50,591	99,114	307,802
UNEP Asia & Pacific	Security	14,303	20,510	27,202	34,327	43,990	54,540
UNEP Asia & Pacific	Sustain	14,303	20,979	30,853	44,949	78,024	175,679
UNEP Europe	Markets	11,578	14,672	19,340	25,496	41,132	87,010
UNEP Europe	Policy	11,578	14,516	18,551	23,443	36,139	72,343
UNEP Europe	Security	11,578	14,065	16,150	17,979	21,739	29,474
UNEP Europe	Sustain	11,578	14,115	16,693	19,099	23,724	32,694
UNEP Lat Am & Carib	Markets	3,366	4,171	5,582	7,688	15,075	66,397
UNEP Lat Am & Carib	Policy	3,366	4,151	5,361	7,073	12,658	52,219
UNEP Lat Am & Carib	Security	3,366	4,067	4,894	5,881	7,891	15,344
UNEP Lat Am & Carib	Sustain	3,366	4,119	5,133	6,438	9,927	26,956
UNEP North America	Markets	9,780	13,335	18,617	24,892	38,798	85,689
UNEP North America	Policy	9,780	13,233	18,038	23,648	35,738	72,149
UNEP North America	Security	9,780	12,912	16,342	19,881	26,190	43,804
UNEP North America	Sustain	9,780	12,786	15,749	18,790	23,528	30,757
UNEP Polar	Markets	2,223	2,999	3,998	5,234	8,066	19,591
UNEP Polar	Policy	2,223	2,939	3,857	4,942	7,316	16,362
UNEP Polar	Security	2,223	2,882	3,420	3,876	4,681	6,239
UNEP Polar	Sustain	2,223	2,871	3,568	4,187	5,229	8,577
UNEP West Asia	Markets	529	765	1,206	1,806	4,268	27,090
UNEP West Asia	Policy	529	751	1,166	1,689	3,454	17,140
UNEP West Asia	Security	529	736	1,065	1,449	2,476	6,855
UNEP West Asia	Sustain	529	748	1,103	1,500	2,561	8,459

GDP at Purchasing Power Growth Rate, Percent per Year

	Year	2010	2020	2030	2050	2100
UNEP Africa	Markets	3.26	3.25	3.67	4.44	3.73
UNEP Africa	Policy	3.25	3.34	3.53	3.71	3.34
UNEP Africa	Security	3.01	2.57	2.72	2.76	2.49
UNEP Africa	Sustain	3.20	3.06	3.09	2.78	2.30
UNEP Asia & Pacific	Markets	4.09	4.71	4.87	3.39	1.99
UNEP Asia & Pacific	Policy	4.05	4.38	4.48	3.10	2.10
UNEP Asia & Pacific	Security	3.67	2.86	2.35	0.94	0.49
UNEP Asia & Pacific	Sustain	3.90	3.93	3.84	2.47	1.39
UNEP Europe	Markets	2.40	2.80	2.80	2.22	1.54
UNEP Europe	Policy	2.29	2.48	2.37	2.09	1.43
UNEP Europe	Security	1.97	1.39	1.08	0.97	0.72
UNEP Europe	Sustain	2.00	1.69	1.36	1.05	0.75
UNEP Lat Am & Carib	Markets	2.17	2.96	3.25	3.46	2.64
UNEP Lat Am & Carib	Policy	2.12	2.59	2.81	2.97	2.62
UNEP Lat Am & Carib	Security	1.91	1.87	1.85	1.33	1.60
UNEP Lat Am & Carib	Sustain	2.04	2.23	2.29	2.16	1.77
UNEP North America	Markets	3.15	3.39	2.95	2.09	1.64
UNEP North America	Policy	3.07	3.15	2.75	1.96	1.41
UNEP North America	Security	2.82	2.38	1.98	1.27	1.40
UNEP North America	Sustain	2.72	2.11	1.78	1.02	0.35
UNEP Polar	Markets	3.04	2.92	2.73	2.02	1.96
UNEP Polar	Policy	2.83	2.75	2.51	1.80	1.91
UNEP Polar	Security	2.63	1.73	1.26	0.83	0.88
UNEP Polar	Sustain	2.59	2.20	1.61	0.94	1.41
UNEP West Asia	Markets	3.76	4.66	4.12	4.47	3.46
UNEP West Asia	Policy	3.56	4.50	3.77	3.70	3.07
UNEP West Asia	Security	3.36	3.76	3.13	2.70	1.71
UNEP West Asia	Sustain	3.53	3.95	3.13	2.74	2.21

Note: Percentages in above table are annualized for the decade preceding the year shown.

GDP per Capita at Purchasing Power, $1,000 1995 Dollars

	Year	2000	2010	2020	2030	2050	2100
UNEP Africa	Markets	1.89	2.09	2.34	2.79	4.83	22.32
UNEP Africa	Policy	1.89	2.11	2.46	3.02	5.06	23.17
UNEP Africa	Security	1.89	2.01	2.04	2.14	2.54	5.08
UNEP Africa	Sustain	1.89	2.11	2.42	2.94	4.59	16.42
UNEP Asia & Pacific	Markets	4.11	5.52	7.96	11.93	23.16	78.89
UNEP Asia & Pacific	Policy	4.11	5.52	7.81	11.44	21.01	73.31
UNEP Asia & Pacific	Security	4.11	5.27	6.28	7.30	8.44	10.29
UNEP Asia & Pacific	Sustain	4.11	5.47	7.50	10.48	17.81	53.24
UNEP Europe	Markets	13.81	17.36	22.91	30.64	52.51	145.70
UNEP Europe	Policy	13.81	17.16	21.93	28.14	46.36	123.40
UNEP Europe	Security	13.81	16.68	19.32	22.08	29.28	53.92
UNEP Europe	Sustain	13.81	16.72	19.89	23.27	31.69	65.72
UNEP Lat Am & Carib	Markets	6.42	6.96	8.44	10.83	19.51	90.66
UNEP Lat Am & Carib	Policy	6.42	6.97	8.22	10.16	17.01	76.90
UNEP Lat Am & Carib	Security	6.42	6.75	7.23	7.97	9.64	18.60
UNEP Lat Am & Carib	Sustain	6.42	6.93	7.95	9.48	14.25	49.33
UNEP North America	Markets	30.80	38.23	49.02	60.76	85.03	163.10
UNEP North America	Policy	30.80	37.98	48.00	59.02	82.37	154.00
UNEP North America	Security	30.80	37.24	44.31	51.27	64.01	103.50
UNEP North America	Sustain	30.80	36.70	42.01	47.55	56.53	83.79
UNEP Polar	Markets	11.56	15.74	21.08	28.15	46.36	145.70
UNEP Polar	Policy	11.56	15.40	20.30	26.58	42.36	126.60
UNEP Polar	Security	11.56	15.16	18.33	21.54	29.12	53.97
UNEP Polar	Sustain	11.56	15.06	18.90	22.77	31.25	76.77
UNEP West Asia	Markets	5.08	5.75	7.31	9.10	16.52	80.36
UNEP West Asia	Policy	5.08	5.70	7.38	9.21	15.47	66.69
UNEP West Asia	Security	5.08	5.48	6.21	6.83	8.35	16.08
UNEP West Asia	Sustain	5.08	5.71	7.08	8.53	12.68	44.05

Percentage of Female Population (Aged 15+) with Secondary Education

	Year	1960	2000	2010	2020	2030	2050	2100
UNEP Africa	Markets	1.53	5.38	10.53	14.27	17.61	23.95	42.78
UNEP Africa	Policy	1.53	5.38	10.73	15.47	20.16	28.23	50.71
UNEP Africa	Security	1.53	5.38	10.47	13.71	16.29	20.37	32.19
UNEP Africa	Sustain	1.53	5.38	10.74	15.53	20.26	28.81	51.74
UNEP Asia & Pacific	Markets	4.77	12.42	19.59	26.42	34.23	50.27	81.28
UNEP Asia & Pacific	Policy	4.77	12.42	19.71	27.22	35.76	51.87	83.46
UNEP Asia & Pacific	Security	4.77	12.42	19.50	25.59	31.96	44.58	64.19
UNEP Asia & Pacific	Sustain	4.77	12.42	19.73	27.43	35.78	51.45	83.54
UNEP Europe	Markets	8.32	30.66	38.27	46.00	54.36	69.29	94.09
UNEP Europe	Policy	8.32	30.66	38.27	45.97	54.29	69.19	93.31
UNEP Europe	Security	8.32	30.66	38.24	45.61	53.47	67.69	89.06
UNEP Europe	Sustain	8.32	30.66	38.26	45.96	54.10	68.88	92.03
UNEP Lat Am & Carib	Markets	6.03	19.73	25.00	30.45	36.29	50.50	82.70
UNEP Lat Am & Carib	Policy	6.03	19.73	25.10	31.05	37.63	52.40	83.82
UNEP Lat Am & Carib	Security	6.03	19.73	24.95	29.83	34.45	44.10	67.02
UNEP Lat Am & Carib	Sustain	6.03	19.73	25.11	31.12	37.62	51.68	82.23
UNEP North America	Markets	32.81	68.81	71.10	75.28	79.81	87.73	98.28
UNEP North America	Policy	32.81	68.81	71.13	75.42	79.96	87.90	98.66
UNEP North America	Security	32.81	68.81	70.98	74.60	78.79	86.96	98.61
UNEP North America	Sustain	32.81	68.81	71.10	75.15	79.76	87.77	99.67
UNEP Polar	Markets	16.73	46.12	52.40	58.10	64.63	76.23	97.09
UNEP Polar	Policy	16.73	46.12	52.37	57.95	64.31	75.64	96.62
UNEP Polar	Security	16.73	46.12	52.39	57.91	64.28	75.52	94.09
UNEP Polar	Sustain	16.73	46.12	52.35	57.88	64.20	75.44	96.23
UNEP West Asia	Markets	0.64	15.86	22.77	28.41	33.59	42.72	66.83
UNEP West Asia	Policy	0.64	15.86	22.93	29.26	34.91	44.29	66.97
UNEP West Asia	Security	0.64	15.86	22.64	27.34	31.52	38.58	52.04
UNEP West Asia	Sustain	0.64	15.86	22.94	29.37	35.03	44.34	65.07

3.11 List of Excel Files Provided as Supplement to this Text

All driver files are provided from 2000 through 2100 unless otherwise indicated. History plus forecast files have data values before 2000 as well. Unless otherwise indicated, all tables include annual output. At this point the base unit of account for economic data remains 1995 dollars. Current files are:

Population (History plus Forecast): By country within scenario

Population (Forecast): By UNEP region and subregion, decomposed by country, by scenario

Population Growth Rates (Forecast): By UNEP region decomposed by country, displayed in decades (rates for decades preceding display year).

Population (Forecast): By IMAGE region decomposed by country.

Population Growth Rates (Forecast): By IMAGE region displayed in decades (rates for decades preceding display year).

GDP MER (History plus Forecast): By country within scenario

GDP MER (Forecast): By UNEP region and subregion, decomposed by country, by scenario

GDP MER Growth Rates (Forecast): By UNEP region and subregion decomposed by country, displayed in decades (rates for decades preceding display year).

GDP PPP (Forecast): By UNEP region and subregion, decomposed by country, by scenario

GDP PPP Growth Rates (Forecast): By UNEP region and subregion decomposed by country, displayed in decades (rates for decades preceding display year).

GDP per capita PPP (Forecast): By country within scenario

GDP per capita PPP (Forecast): By UNEP region, decomposed by country, by scenario

Education, secondary, of women (History plus Forecast): As measured by % of 15+ with completed secondary level; by UNEP region, decomposed by country, by scenario.

Value Added MER as % of GDP (Forecast): By UNEP region, decomposed by country, by scenario; only through 2050 because Agric value added is dropping

too fast in LDCs in the longer term. [Should we add value added absolute numbers?]

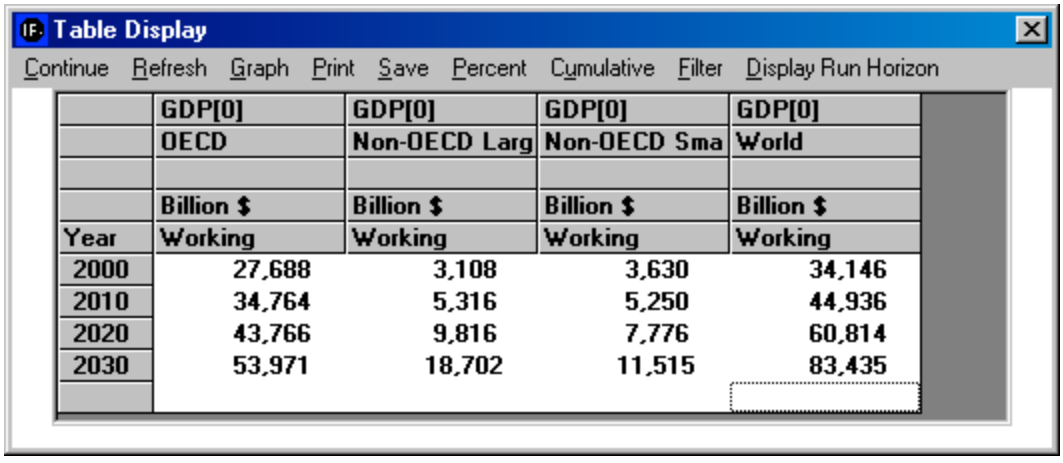
Household Consumption MER as % of GDP (Forecast): By UNEP region, decomposed by country, by scenario. [Should we add household consumption absolute numbers?]

3.12 Coordination with Other Projects Including the OECD

The OECD Environmental Outlook intends to use a forecast horizon of 2030 and to consider a world divided into three general groupings of countries: the OECD member set, a set of economically larger non-OECD countries (Brazil, China, Russia, India, Indonesia, and perhaps South Africa), and the rest of the non-OECD world.

The OECD (2005) project anticipates using an approach to forecasting that begins with a base case and then considers a range of policy interventions. Further, it will use an approach that focuses heavily on the forecasting of labor productivity changes or labor-augmenting technical change, looking at labor change endogenously and productivity exogenously.

How then can the GEO-4 project, seemingly so different in its approach of multiple scenarios, cooperate and coordinate with that effort? As a step in that direction, we have set up the three OECD groupings for output from IFs – because IFs computes forecasts by country, aggregation into display groupings can be flexible. The tables below show the IFs base case around which the four GEO-4 scenarios were generated, using the groupings of the Environmental Outlook 2030. Perhaps these forecasts of GDP at MER and PPP can be helpful as a benchmark for comparison of the two projects.



	GDP[0]	GDP[0]	GDP[0]	GDP[0]
	OECD	Non-OECD Larg	Non-OECD Sma	World
	Billion $	Billion $	Billion $	Billion $
Year	Working	Working	Working	Working
2000	27,688	3,108	3,630	34,146
2010	34,764	5,316	5,250	44,936
2020	43,766	9,816	7,776	60,814
2030	53,971	18,702	11,515	83,435

Table Display

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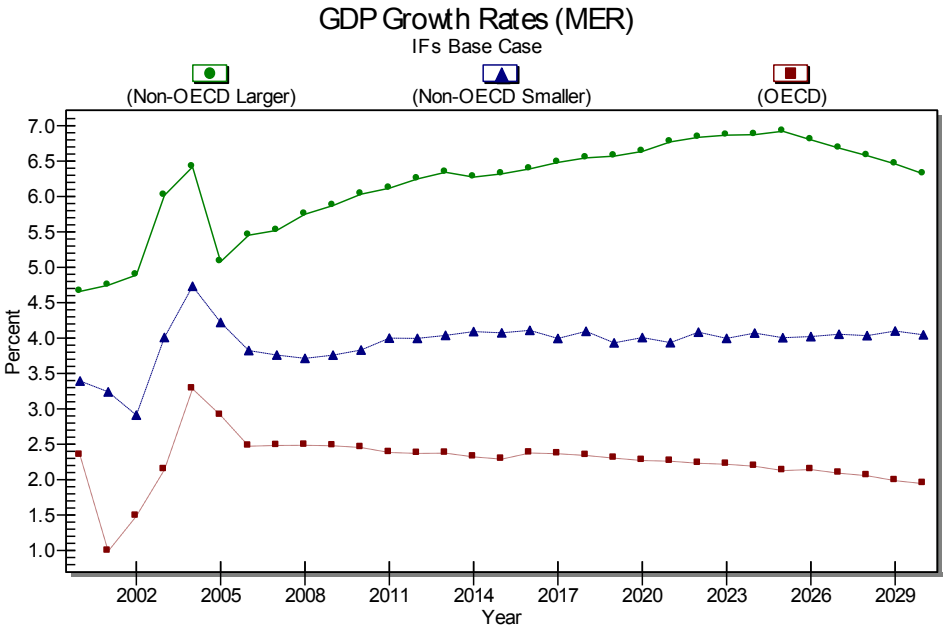
	GDPP[0]	GDPP[0]	GDPP[0]	GDPP[0]
	OECD	Non-OECD Larg	Non-OECD Sma	World
	Billion $	Billion $	Billion $	Billion $
Year	Working	Working	Working	Working
2000	24,405	9,883	7,176	40,975
2010	31,490	14,710	9,719	55,311
2020	40,530	22,629	13,288	75,687
2030	50,792	35,244	18,091	103,172

Source: IFs for GEO-4. IFs Base Case, v5.22 (October, 2005).

Further, the IFs project has introduced an enhanced endogenization of the technical progress term, linking it to expenditures on education, health, and R&D; to governance quality and character; and to other drivers (looking at many sources for assistance with structure and parameterization, including OECD 2003 and 2004). Refinement of this approach will continue over the next two years.

The graphs below suggest how important such productivity analysis is to the forecasting of the OECD. The first shows the annual growth rates that lie behind the above GDP forecasts of the IFs base case at market exchange rates. The initial values (which look like transients) are empirical values; the remaining values are driven by the IFs base-case forecasts of multifactor productivity, as well as by the forecast of labor force growth from the cohort-component population model and by endogenous forecasts of capital stock growth.



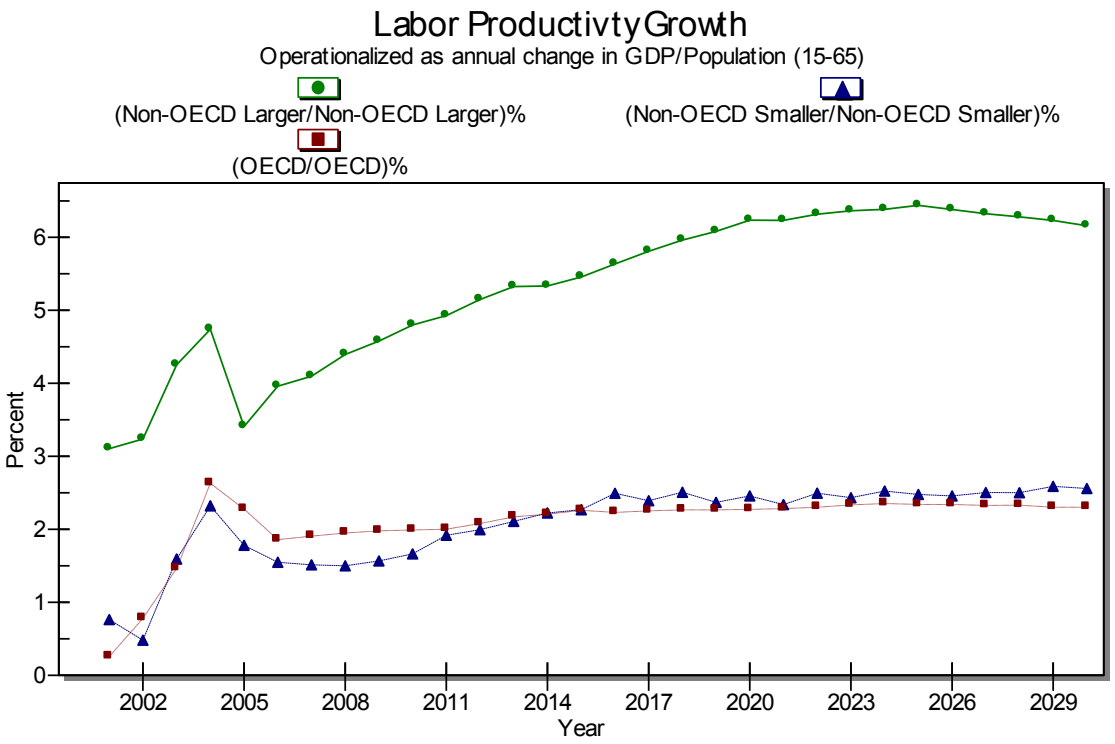
The OECD forecasting approach, however, relies heavily on exogenous and trend-based assumptions of labor productivity growth, linked to forecasts of labor force size. The graph below therefore looks at a comparable concept in IFs, namely the annual growth in GDP per unit of labor, operationalized as the population from 15-65 years of age (and temporarily ignoring issues of changing participation rates, although IFs does represent sex-based and retirement age-based changes in its forecasts).

The figure below begins to suggest some of the complications in reconciling the OECD and IFs approaches. The OECD anticipates labor productivity growth for the OECD countries to be at the 1.7% historic average and posits that non-OECD countries will converge at 2% per year to the OECD growth rates (NOT to the OECD productivity levels). The OECD approach has a couple of important ramifications:

- because productivity growth rates of all non-OECD countries converge to 1.7%, in non-OECD countries where labor productivity is initially above OECD rates, productivity growth can only decline

- LDCs with very low initial productivity growth rates will converge to 1.7% from below, but their absolute growth can never close per capita GDP differences with rich countries.

The graph below also shows that labor productivity growth in OECD countries is quite flat over time, although closer on average to 2% than 1.7%.. But in contrast to the implications of the OECD assumptions, the IFs graph actually show a very substantial and increasing labor productivity growth rate in the large emerging countries. The IFs productivity function involves many factors, but the pay-off of investments in human capital and an inverted U-shaped curve linking technological transfer with GDP per capita mean that productivity growth in many of these countries can accelerate rather than slow, with slowing only as convergence in absolute GDP per capita with system leaders begins to occur.



In support of the IFs approach, the OECD actually makes somewhat similar inverted U-shaped assumptions for many countries it forecasts explicitly. In Table 6 (OECD 2005: 14) it indicates that a number of specific countries, both in the OECD and outside of it, will have higher labor productivity growth in 2007 than in 2002. For instance, the rate in Poland rises from 1.4% to 4.2% and that in Indonesia from 2.8% to 3.4%. These rates above the 1.7% level (based on historic patterns for the specified countries) do allow convergence towards lead country levels, not just convergence on growth rates.

It is almost certain that the UNEP GEO-4 project can greatly benefit from OECD expertise in building their Environmental Outlook base case, and we would hope that the GEO project can contribute something in return to OECD analysis.

4. Context for GEO 4 Scenarios: Foundational Work

We began the work that led to the elaborations of scenarios and drivers in Chapter 2 and the analysis of the scenarios in Chapter 3 by looking for as much information as we could find on expectations for the GEO scenarios. We looked especially at the following possible sources:

> United Nations Environment Programme (UNEP). 2002. *Global Environment Outlook 3: Past, Present, and Future Perspectives.* London and Sterling, VA: Earthscan Publications Ltd.
>
> UNEP and SEI. 2004. *Global Environment Outlook Scenario Framework: Background Paper for UNEP's Third Global Environment Outlook (GEO-3)*. Nairobi and Boston.
>
> Potting, José and Jan Bakkes, eds. 2004. *The GEO-3 Scenarios: 2002-2032: Quantification and Analysis of Environmental Impacts.* United Nations Environment Programme (UNEP) and National Institute for Public Health and the Environment (RIVM), Netherlands. Available at http://www.rivm.nl/bibliotheek/rapporten/402001022.html
>
> Raskin, Paul, Tariq Banuri, Gilberto Gallopín, Pablo Gutman, Al Hammond, Robert Kates, Rob Swart. 2002. *Great Transition: The Promise and Lure of the Times Ahead.* Boston: Stockholm Environmental Institute (SEI). www.sei.se
>
> Global Scenario Group Scenarios at http://www.gsg.org/QuantChoices.html. See tables on key variables across the four scenario families at http://www.gsg.org/gsgdata/scen_data_selector.cgi.
>
> The Millennium Ecosystem Assessment, Global Modeling Group. See http://www.usf.uni-kassel.de/ma-gmgroup/ At that site there are both population and economic forecasts.
>
> Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: Synthesis*. Washington, D.C.: World Resources Institute.

If other partners are aware of additional sources that should be examined, please bring them to our attention.

We have been in touch with Jan Bakkes on behalf of the OECD's project to create a new OECD Environmental Outlook with a 2032 horizon. In addition, we have had interactions with the projects of the International Assessment of Agricultural Science and Technology for Development (IAASTD) at http://www.agassessment.org/ and the Global Environmental Change and Food Systems (GECAFS) at http://www.gecafs.org/ The former project will use primarily the MA scenarios (with the possible addition of a new "rosy" scenario) and the latter (with limited geographic scope) is likely to use the GEO scenarios. A meeting of principals from both of these projects was held in Rome during

July 2005 with representatives from GEO in attendance (and another IIASTD meeting was held in Washington, D.C., in October 2005). As we proceed to refine and elaborate drivers, we will want to maintain contact and share ideas with all of these projects.

4.1 The GEO-3 Scenarios

We sought as much information as possible about the GEO-3 scenarios, understanding that they were prepared under great time pressure and that different groups with different tools consequently gave rise to some variation in them. Moreover, there was inadequate time in the GEO-3 project for full coordination with regional team members, something we intend to remedy in GEO-4,

The two tables below, from the report on quantification and analysis of the GEO-3 sceanrios (Potting and Bakkes 2004) provide considerable insight with respect to those scenarios.

Table 2.3: Assumed annual average population growth 2002 - 2032

	Markets First	Policy First	Security First	Sustainability First
	% per year			
North America	0.6 – 0.7	0.6 – 0.7	0.9	0.4 – 0.7
Latin America and the Caribbean	1.0 – 1.1	1.0	1.4 – 1.6	0.8 – 1.0
Europe*	-0.1 – 0.2	-0.1 – 0.2	0.2 – 0.4	-0.2 – 0.2
West Asia*	1.7 – 2.2	1.7 – 2.1	2.3 – 2.5	1.7 – 2.0
Africa*	1.9	1.8 – 1.9	2.2	1.7 – 1.9
Asia and the Pacific*	0.7 – 0.8	0.7	1.2 – 1.3	0.6 – 0.7
World	0.9	0.8 – 0.9	1.3 – 1.4	0.7 – 0.9

*The regional definitions differ between the tools involved; see table 7.1

Table 2.2: Assumptions for growth rates of per capita Gross Domestic Product (GDP) 2002 - 2032

	Markets First	Policy First	Security First	Sustainability First
	% per year; GDP expressed in purchasing power parity			
North America	1.7 – 2.1	1.0 – 1.7	0.6 – 0.9	0.4 – 1.5
LatinAmerica and the Caribbean	2.0 – 2.4	2.4 – 2.5	1.6 – 1.8	2.7 – 3.1
Europe*	2.0 – 2.5	1.7 – 2.4	0.8 – 1.2	1.4 – 2.1
West Asia*	2.2 – 2.3	2.4 – 2.8	1.4 – 1.8	3.0 – 4.1
Africa*	1.6 – 2.5	2.7 – 3.0	2.1 – 3.6	3.5 – 3.8
Asia and the Pacific*	2.2 – 3.6	2.7 – 3.5	1.4 – 2.2	3.0 – 3.1

*The regional definitions differ between the tools involved; see table 7.1

Source: José Potting and Jan Bakkes, eds. (2004: 35).

Among the insights that can be drawn from the above tables are the following:

- The ranking of global population in 2032 across the scenarios, from top to bottom, was Security First, Markets First, Policy First, and Sustainability First, with Security First leading to a considerably larger global population than the other three scenarios, which do not differ a great deal.
- The differences in population forecasts between the Sustainability First and other scenarios show up, as one would expect, largely in the developing regions of the world.
- The ranking of GDP per capita in 2032 across the scenarios, from top to bottom, in *developed regions* was Markets First, Policy First, Sustainability First, and Security First. In *developing regions* the ranking was Sustainability First, Policy First, Markets First, and Security First.

With respect to the above insights, the representations of population in the Fourth Draft Revision of the IFs scenarios for GEO-4 are much the same (as they were in the Third). Specifically, IFs again puts Security First at the top. The other three scenarios have the same ordering in IFs for GEO-4 as in GEO-3. But they exhibit considerably more variation than they did in GEO-3 where they were nearly identical (for reasons related to their preparation, not because of the storylines).

With respect to the representations of economic growth here, there are general similarities but also some important differences:

- With respect to GDP per capita for *developed regions*, the GEO-4 scenarios are mostly the same in ordering; it is important to note, however, that the Sustainability Scenario has been brought down from well above the Security First scenario in the Third Revision to approximately the same level in this draft (for reasons discussed below).

- With respect to GDP per capita for *developing regions*, GEO-4 places Market First above Policy First for all regions except Africa, followed by Sustainability First, and then Security First at the bottom. This is a change from the Third Revision for reasons discussed below.

For the Fourth and Fifth Revisions the per capita economic growth assumptions of Policy First and especially of Sustainability First were lowered from the Third Revision; doing so created the changes noted above relative to both the Third Revision and the GEO-3 representation. The reason for this change was that, in discussion among members of the modeling group, one strong argument was that the Sustainability First scenario, in spite of its lower population growth, is subject to substantial costs in the pursuit of environmental and equity goals and that these costs would necessarily reduce economic growth per capita. Moreover, many of the same constraints were attributed to the Policy First scenario.

In addition to the growth rates reported in the above GEO-3 technical report (which appears to be the most definitive report on the quantification of GEO-3), there are some sources of absolute numbers that can be useful. For instance, there are some numbers in the UNEP GEO background paper for the Market Forces [Markets First] and Policy Reform [Policy First] scenarios for the world, UNEP regions and UNEP sub-regions. The numbers in that source for the world reinforce the above ranking of Markets First above Policy First for both population and total GDP (p. A-55). The table below reproduces the numbers. The differences across the two scenarios are very small; the average annual rates differ by less than 0.1% in the case of both population and GDP.

	1995	2032	2032/1995	Annual Growth
Population				
Market Forces	5659	8207	1.45	1.0101
Policy Reform	5659	8000	1.41	1.0094
GDP (PPP)	1995	2030		
Market Forces	32247	100605	3.12	1.0312
Policy Reform	32247	99319	3.08	1.0309

Source: Built from UNEP and SEI 2004: A55.

In addition, Paul Lucas from RIVM kindly provided a file of forecasts from the IMAGE implementation of the GEO-3 scenarios. The table below shows the global population in millions from each in 1995 and 2100.

	1995	2050	2100
Markets First	5,706	8,716	7,070
Policy First	5,706	8,716	7,070
Security First	5,706	11,309	15,085
Sustainability First	5,706	8,716	7,070

Source: Built from file provided by Paul Lucas, RIVM.

Three of the scenarios are identical, because in the IMAGE implementation the GEO scenarios were somewhat matched to the IMAGE-IPCC scenarios as indicated below;[8] the A1 and B1 scenarios of IPCC apparently had the same population forecasts.

GEO 3	Image	
Markets First	A1b*	*adjustments in economic development
Policy First	A1b** with Climate Policy	**additional adjustment for storyline
Security First	A2	
Sustainability First	B1*	

Turning to the global economy, the numbers in the file provided by Paul Lucas are GDP per capita. These could be multiplied by populations and summed for the world, but we

[8] Jan Bakkes has pointed out that this matching does not do justice to the GEO scenarios that were ultimately developed. It is shown only because it was apparently a starting point for some of the GEO development activity.

have not done that. Instead we pulled out the biggest country in the world in 1995 (USA) and almost certainly the biggest region in the world in 2100 (East Asia, presumably including China) for detailed analysis. The final column shows the ratio of values in 2100 relative to 1995, so as to provide a sense of the magnitude of GDP growth anticipated.

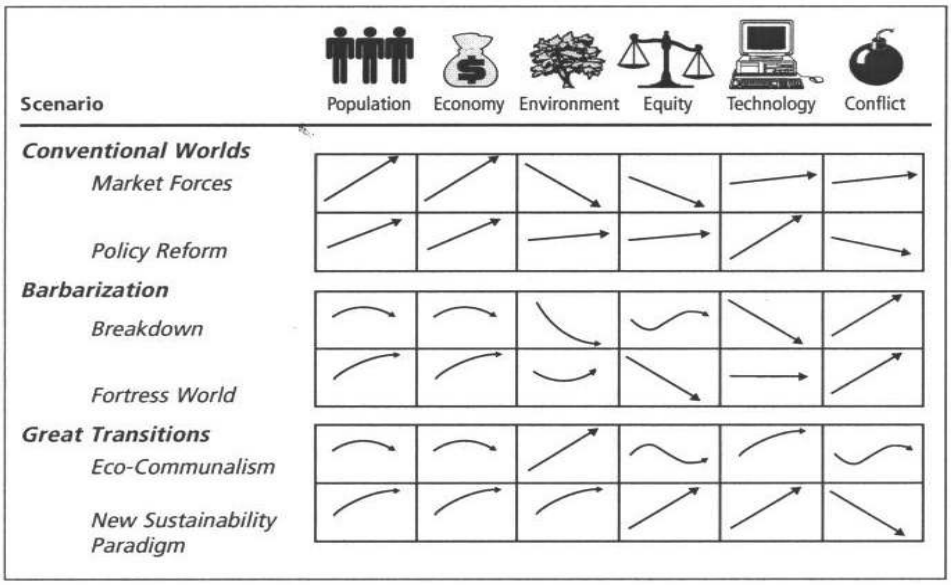
GDP/Capita USA	**1995**	**2050**	**2050/1995**	**2100**	**2100/1995**
Markets First	26,316	72,256	2.7	*	
Policy First	26,316	69,070	2.6	*	
Security First	26,316	47,766	1.8	67,536	2.6
Sustainability First	26,316	59,880	2.3	92,086	3.5
GDP/Capita E Asia	**1995**	**2050**		**2100**	**2100/1995**
Markets First	1,360	26,218	19.3	*	
Policy First	1,360	24,385	17.9	*	
Security First	1,360	4,891	3.6	9,951	7.3
Sustainability First	1,360	17,372	12.77	57,659	42.4

Source: Built from file provided by Paul Lucas, RIVM. *No computation of change after 2050.

4.2 Alternative Conceptualizations of the GEO-3 and Related Scenarios

There are a number of other scenario reports and exercises with which it was possible to compare and contrast the GEO-3 effort as we prepared the driver forecasts for GEO-4. These include the Stockholm Environmental Institute's (SEI) PoleStar versions of the Global Scenario Group scenarios, from which the GEO-3 scenarios were derived. They also include the more recent Millennium Ecosytem Assessment (MA) scenarios, which have the additional advantage of drawing on IIASA population forecasts.

The figure below shows the ordering intended by the Global Scenario Group, the originators of the scenarios. Interestingly, the ordering of population and economy are identical and, from top to bottom, appear to be Market Forces, Policy Reform (slightly lower), Fortress World and New Sustainability Paradigm (with clear saturating tendencies), and Breakdown and Eco-Communalism (with downturns indicated after initial growth).



Source: Gallopín et al. (1997)

Source: Raskin, et al 2002: 16.

Although we obviously recognize these to be highly stylistic, they are nonetheless useful because they are associated with elaborated scenario story lines in the report by Raskin, et. al. Because forecasts from IFs are rooted in scenarios also, the scenario story elements of the GSG can help implement the IFs version of the scenarios.[9]

Fortunately, it is not necessary to rely too heavily on the stylized representation above, because the GSG project, with the help of PoleStar, provided an online source of numerical forecasts for their scenarios. The tables below reproduce those forecasts for population, GDP at purchasing power parity, and GDP at market exchange rates.

[9] Relating the GSG scenarios to the four GEO scenarios, the above stylized behavioral representations suggest that, from top to bottom, the population and GDP forecasts of those scenarios might well be Market Forces, Policy Reform, and then some uncertain ranking of Security First and Sustainability First. Because the Sustainability First scenario of UNEP GEO seems closer in description (UNEP GEO 2002) to the New Sustainability Paradigm, while the Security First scenario of UNEP GEO seems to be some combination of Fortress World and Breakdown, we might expect the bottom of the GEO ranking to be Security First. We have seen above that Security First does rank at the bottom of the GEO-3 economic forecasts, but not at the bottom of their population forecasts. Although the first draft of this report made more of the stylized reactions, the numerical values used in this draft are much more useful.

Population (millions)

		Market Forces		Policy Reform		Fortress World		Great Transition	
	1995	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**
North America	301	368	397	368	397	396	470	353	351
Pac OECD	150	153	142	153	142	160	158	148	128
Western Europe	468	492	467	492	467	520	547	477	422
OECD regions	**919**	**1014**	**1005**	**1014**	**1005**	**1076**	**1174**	**978**	**902**
Eastern Europe	99	94	83	92	79	102	104	92	73
FSU	292	295	284	289	270	319	349	283	254
Transitional regions	**391**	**389**	**367**	**381**	**348**	**421**	**452**	**374**	**327**
Africa	697	1298	1766	1272	1678	1390	2102	1244	1581
China+	1330	1639	1660	1607	1577	1718	1910	1587	1486
Latin America	476	692	804	678	764	751	988	656	704
Middle East	173	327	433	321	411	353	518	310	383
South Asia	1228	1834	2162	1797	2054	1987	2658	1739	1894
Southeast Asia	453	630	713	618	677	683	872	598	631
Developing regions	**4357**	**6421**	**7537**	**6292**	**7161**	**6882**	**9047**	**6134**	**6680**
World	**5666**	**7824**	**8909**	**7688**	**8514**	**8379**	**10674**	**7486**	**7909**

Source: Eric Kemp-Benedict, Charles Heaps, Paul Raskin. 2002. *Global Scenario Group Futures: Technical Notes Online Annex*. PoleStar Series Report no. 9. Stockholm: Stockholm Environment Institute. Found at http://www.gsg.org/gsgdata/scen_data_selector.cgi.

The above table suggests that Fortress World (root of Security First) will exhibit the most rapid population growth, followed by Market Forces (Markets First), Policy World (Policy First), and Great Transition (Sustainability First). This is very much like the scenarios of GEO-3/4, except that the gap between Fortress World and the other GSG scenarios is not nearly as large as that shown earlier between Security First and the other GEO-3 scenarios. As with the GEO-3 scenarios, there is relative small variation across the other scenarios, but the rank ordering of the other three is consistent with the story lines.

GDP_{PPP} (10^{12} $PPP)

		Market Forces		Policy Reform		Fortress World		Great Transition	
	1995	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**
North America	8.0	18.2	28.4	13.1	16.7	13.2	17.9	10.7	10.9
Pac OECD	3.2	6.2	8.5	4.8	5.4	4.3	4.6	3.9	3.6
Western Europe	8.1	16.0	23.1	13.5	16.0	11.4	13.4	11.1	10.9
OECD regions	**19.3**	**40.3**	**60.0**	**31.3**	**38.1**	**29.0**	**35.9**	**25.6**	**25.4**
Eastern Europe	0.6	0.9	1.2	1.0	1.4	1.0	1.4	1.2	1.5
FSU	1.1	2.0	2.7	2.4	3.5	2.2	3.9	2.8	4.1
Transitional regions	**1.6**	**2.9**	**3.9**	**3.4**	**4.8**	**3.2**	**5.2**	**4.0**	**5.6**
Africa	1.4	4.4	9.7	6.4	15.2	4.8	18.5	9.2	21.6
China+	3.9	12.1	21.5	13.1	22.8	12.4	18.8	15.2	24.9
Latin America	2.8	7.3	13.6	7.9	14.8	7.8	12.2	8.9	16.1
Middle East	1.3	4.1	8.1	4.1	8.2	4.3	7.6	4.5	8.8
South Asia	1.9	6.6	14.8	7.9	17.5	7.2	22.1	10.6	23.1
Southeast Asia	2.5	7.5	14.9	8.4	18.3	7.9	11.0	8.1	12.4
Developing regions	**13.7**	**41.8**	**82.6**	**47.9**	**96.7**	**44.4**	**90.1**	**56.5**	**106.9**
World	**34.7**	**85.1**	**146.5**	**82.6**	**139.6**	**76.5**	**131.3**	**86.2**	**137.8**

Source: Same as previous table.

The above table suggests that Fortress World (root of Security First) will exhibit the least economic growth, as was the case in the GEO-3 scenarios. The other scenarios are quite similar in growth rates, but the Great Transition Scenario actually exhibits the greatest growth, followed by Market World and Policy World. Interestingly, this is different from the stylized representation shown earlier.

GDP_{MER} (10^{12} $)

		Market Forces		Policy Reform		Fortress World		Great Transition	
	1995	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**	**2025**	**2050**
North America	7.6	17.4	27.2	12.5	16.0	12.7	17.2	10.2	10.4
Pac OECD	5.6	7.6	10.4	5.8	6.6	5.3	5.6	4.7	4.4
Western Europe	9.5	18.6	26.9	15.7	18.6	13.3	15.6	12.9	12.7
OECD regions	**22.7**	**43.6**	**64.5**	**34.1**	**41.2**	**31.2**	**38.4**	**27.9**	**27.5**
Eastern Europe	0.3	0.5	0.6	0.8	1.2	0.7	1.0	1.1	1.5
FSU	0.6	1.0	1.4	1.6	2.8	1.4	3.0	2.3	4.1
Transitional regions	**0.9**	**1.5**	**2.0**	**2.4**	**3.9**	**2.1**	**4.0**	**3.4**	**5.6**
Africa	0.5	1.4	3.3	3.1	9.4	1.9	12.0	6.2	20.6
China+	0.8	3.2	7.2	5.7	15.6	5.0	9.3	9.6	24.9
Latin America	1.7	4.2	8.5	6.1	14.3	5.8	9.4	8.5	16.1
Middle East	0.7	1.9	3.9	3.0	8.0	3.2	5.8	4.5	8.8
South Asia	0.4	1.8	4.9	3.1	9.6	2.6	12.8	5.9	20.2
Southeast Asia	1.2	4.1	9.6	6.9	18.3	6.0	8.0	7.6	12.4
Developing regions	**5.2**	**16.6**	**37.3**	**27.9**	**75.3**	**24.4**	**57.3**	**42.2**	**103.0**
World	**28.7**	**61.7**	**103.7**	**64.4**	**120.4**	**57.7**	**99.7**	**73.5**	**136.0**

Source: Same as previous table.

The above table suggests that, also at market prices, the Fortress World (root of Security First) will exhibit the least economic growth. The other scenarios are fairly similar in growth rates, but the degree to which growth in the Great Transition Scenario outstrips that in Market World and Policy World is larger than it was at Purchasing Power Parity; also the positions of Market World and Policy World reverse in the above table.

4.3 Millennium Ecosystem Assessment Scenarios

It was suggested in Cambridge (January 2005) and thereafter that we look also to the more recent Millennium Ecosystem Assessment (MA) forecasts. The tables 9-2 through 9-11, in an appendix to this document, are taken from the MA's Draft Chapter 9, which was found on the website of the Center for Environmental Systems Research, University of Kassel (see http://www.usf.uni-kassel.de/ma-gmgroup/). That chapter appears to be dated May, 2004, but as of mid-October 2005, only Chapters 1-8 were shown as final on

the MA website. The utility of the tables from the draft Chapter 9 is that, in addition to showing numerical forecasts, they also indicate many of the assumptions beneath them.

The three tables below are abstracted from that appendix so that general contours of the MA forecasts can be compared with the GEO-3 and GSG scenarios.

MA Population Forecasts – World (Mil)	1995	2050	2100
Global Orchestration	5,701	8,095	6,814
TechnoGarden	5,701	8,821	8,574
Order from Strength	5,701	9,567	10,514
Adapting Mosaic	5,701	9,522	9,830

Source: Extracted from MA Forecasts (see Appendix to this paper).

MA GDP/Capita Forecasts – World ($)	1995	2050	2100
Global Orchestration	5,102	22,286	68,081
TechnoGarden	5,102	16,941	51,546
Order from Strength	5,102	9,838	18,377
Adapting Mosaic	5,102	12,931	32,808

Source: Extracted from MA Forecasts (see Appendix to this paper).

MA GDP/Capita Forecasts – SSS Africa ($)	1995	2050	2100
Global Orchestration	637	3,117	23,035
TechnoGarden	637	2,787	20,629
Order from Strength	637	1,540	4,492
Adapting Mosaic	637	1,997	10,169

Source: Extracted from MA Forecasts (see Appendix to this paper).

The tables above, as well as the descriptions provided for the MA scenarios, suggest that the MA scenarios do not really map that well to the GEO-4 scenarios. The easiest matching is between Security First and Order from Strength. Note that the population forecast for Order from Strength is considerably higher than that of other MA scenarios and that GDP forecasts are strikingly lower than other MA scenarios. This is the same pattern we saw with respect to Security First and other GEO-3 scenarios.

The next easiest may be between Policy First and Global Orchestration, although TechnoGarden also has some of the characteristics of Policy First. And, to complicate things, Global Orchestration assumes high "investments in human capital," giving it some of the characteristics we might also expect in Sustainability First. In fact, the low population forecast of Global Orchestration, as well its high GDP forecasts, suggest that it might also be a potential match for Sustainability First.

There is no MA scenario equivalent to Markets First.

The MA Adapting Mosaic scenario has some similarities to Sustainability First, but as we shall see below, the relatively high population increase assumed in Adapting Mosaic actually makes it quite a different scenario from Sustainability First. It might be somewhat more similar to the Eco-Communalism scenario of the GSG, but does not

really match very well there either. In many respects it is a kind of anti-globalization scenario rather than an environmentally friendly one.

The MA TechnoGarden scenario also does not map well to the GEO-3 scenarios. Although it has some of the global cooperation that we would expect to find in Policy First, it is characterized more heavily by technological optimism with respect to dematerialization than by policy reform. It also lacks the changed lifestyles and values of Sustainability First.[10]

GSG	GEO3	MA
Market Forces	Markets First	
Policy Reform	Policy First	Global Orchestration?
Breakdown		
Fortress World	Security First	Order from Strength
Eco-Communalism		Adapting Mosaic?
New Sustainability	Sustainability First	Global Orchestration?
		Technogarden

Source: Author's Evaluation, Supplemented by that of Dale Rothman

To further illustrate some of the complications of matching the scenarios, the two tables below compare relative ranking (from fastest to slowest) of population and GDP growth across the three scenario sources. The rankings for the GSG scenarios come from the GSG web site, those for GEO come from a combination of the Background volume and the data file provided by Paul Lucas, and the MA rankings come from the draft of Chapter 9.

Population Ranking	(Highest on Top)	
GSG	GEO3	MA
Fortress World	Security First	Order from Strength
Market Forces	[Others tied]	Adapting Mosaic
Policy Reform		Technogarden
Great Transition		Global Orchestration

GDP Growth Ranking			
GSG (PPP)	GSG (MER)	GEO3	MA
Market Forces	Great Transition	Markets First	Global Orchestration
Policy Reform	Policy Reform	Policy First	Technogarden
Great Transition	Market Forces	Sustainability First	Adapting Mosaic
Fortress World	Fortress World	Security First	Order from Strength

[10] An e-mail from Dale Rothman to the GEO-4 modeling group on April 24 suggests that he has come to roughly the same mapping.

4.4 Decision Issues and Directions Taken In Preparing GEO-4 Scenario Drivers

What conclusions can be drawn from the above discussion? With respect to population:

> GEO-3, GSG, and MA presumptions are that the Security First, Fortress World, and Order from Strength scenarios lead to the most rapid population growth. This is because the authors believe that a world in which the developing countries do least well, and that experiences a low level of collaboration in almost all arenas, would be a world in which fertility rates would be high, as is historically typical of populations with low GDP per capita.[11]
>
> There is less clarity with respect to which scenario should produce the lowest population growth. In general, however, scenarios that posit substantial policy intervention and/or value change do so across the three sets. Thus among the GSG scenarios, Great Transition produces the slowest population growth and among the MA scenarios, Global Orchestration does so.

With respect to economic growth:[12]

> The three scenario sets place the Security First, Fortress World, and Order from Strength at the bottom of economic performance as well as at the top of population growth. Clearly, this scenario set describes an undesirable world.
>
> There appears to be ambivalence across the scenario sets (as well as in the real world) about whether markets alone produce the fastest economic growth or whether some set of policy interventions does so.

Although there is much similarity across all of the scenario sets, there are also significant differences.

The tables below add the current working version of the IFs scenarios for GEO-4 to the tables shown above, ranking population and GDP from top to bottom. The scenarios in this version are thus, at least in general terms, faithful to the GEO-4 versions.

---

[11] The stylistic diagram of the GSG scenario analysis appears to put population growth highest in the "conventional world" scenarios of Market World and Policy Reform, more or less equivalent to Markets First and Policy First. They forecast considerably lower rates in their Fortress and especially in their Breakdown worlds, probably because it is posited that such worlds cannot maintain such growth in the face of higher mortality rates resulting from war, disease and famine. They similarly forecast low population growth rates in the Great Transitions scenarios, but for voluntary reasons.

[12] This set of conclusions about GSG and GEO-3 scenarios about GDP growth essentially reverses those of the first draft of this report; the discovery of the GSG web site data and of the error in interpreting GEO-3 scenarios around Markets First and Policy First (described earlier) is the reason for this.

Population Ranking (High to Low)			
GSG	**GEO-3**	**MA**	**IFs for GEO-4**
Fortress World	Security First	Order from Strength	Security First
Market Forces	[Others tied]	Adapting Mosaic	Markets First
Policy Reform		Technogarden	Policy First
Great Transition		Global Orchestration	Sustainability First

GDP Growth Ranking				
GSG (PPP)	**GSG (MER)**	**GEO-3**	**MA**	**IFs for GEO-4**
Market Forces	Great Transition	Markets First	Global Orchestration	Markets First
Policy Reform	Policy Reform	Policy First	Technogarden	Policy First
Great Transition	Market Forces	Sustainability First	Adapting Mosaic	Sustainability First
Fortress World	Fortress World	Security First	Order from Strength	Security First

In the process of implementing the GEO-4 scenarios in IFs, two primary issues arose that merit some comment. The first was around the Security First scenario. Its combination of high population growth with relatively low economic growth is an unhappy one. The combination seems "unsustainable" in a number or respects. This was, of course, partly the intent of the scenario and it was meant to describe a world that is environmentally unsound. In IFs this initially activated some negative feedbacks that allowed high population growth to continue until about mid-century, but then constrained further population growth in Neo-Malthusian manner. For the purposes of implementing the GEO scenario faithfully, however, we have turned off those negative feedbacks, thereby suspending those more Neo-Malthusian elements of the scenario. At some point it might be interesting to develop the alternative in which the feedbacks are allowed to function.

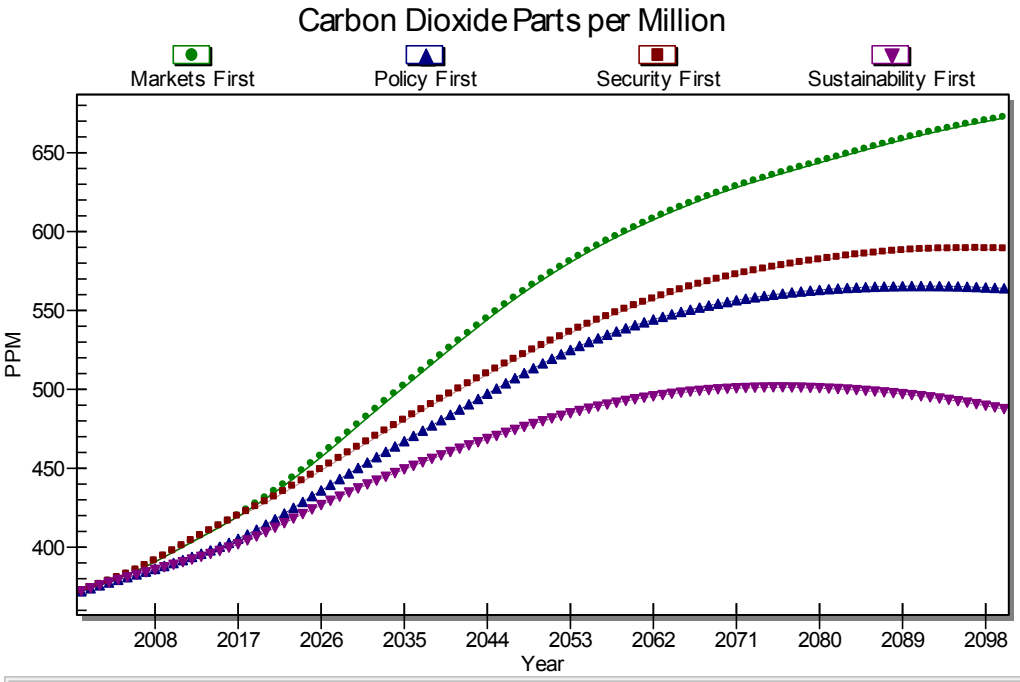
The second issue that arose is that there is, as noted above, some uncertainty concerning the desired ordering of the economic growth patterns of Markets First, Policy First, and Sustainability First. In the various scenario sets, variations of Markets First and Policy First tend to produce the highest global GDP (albeit fairly similar growth patterns), and we have acted to replicate that overall pattern in GEO-4.

The greater difficulty has been in determining GDP per capita patterns. GEO-3 put Sustainability First and Policy First above Markets First for developing regions (see again Section 4.1). Similarly, the human capital-focused interventions in Policy First initially tended to be more beneficial to GDP/capita within IFs than the environmentally-friendly interventions were costly, pushing total GDP for Policy First to and even above the levels in Markets First. Across revisions, discussions within the modeling group led us to bring down the intensity of human capital interventions and thus the per capita growth rates of Policy First. That has led to higher per capita growth rates in Market First (except in Africa) and solidified the position of Market First at the top of the GDP rankings.

5. Forward Linkages

We do not pretend that IFs can feed the demographic and economic drivers through to environmental impacts as well as can a number of partners in the UNEP GEO process. Nonetheless, it should be useful to take a first cut with IFs on some of those forward linkages. In addition, it will be possible during the course of the GEO-4 project to improve such forward linkages within IFs, so as to create an integrated toolkit that can enhance capacity-building and connections to regional team members, thereby supporting analysis on the GEO issues.

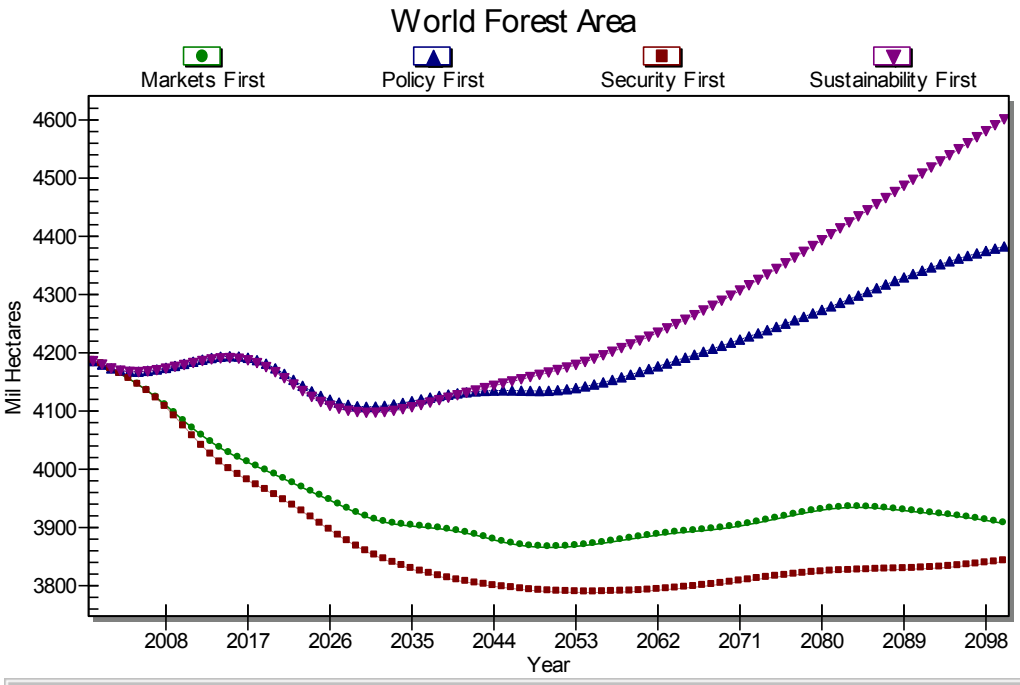
As one example, the graph below looks at a forecast of carbon dioxide in terms of atmospheric parts per million. The one below that shows global forest area. And the third shows forecasts of global freshwater use. All are very crude, first-cut forecasts, offered here without commentary. All show forecasts through 2100 to once again suggest a broader context for the GEO-4 horizon of 2050.



Carbon Dioxide Parts per Million

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

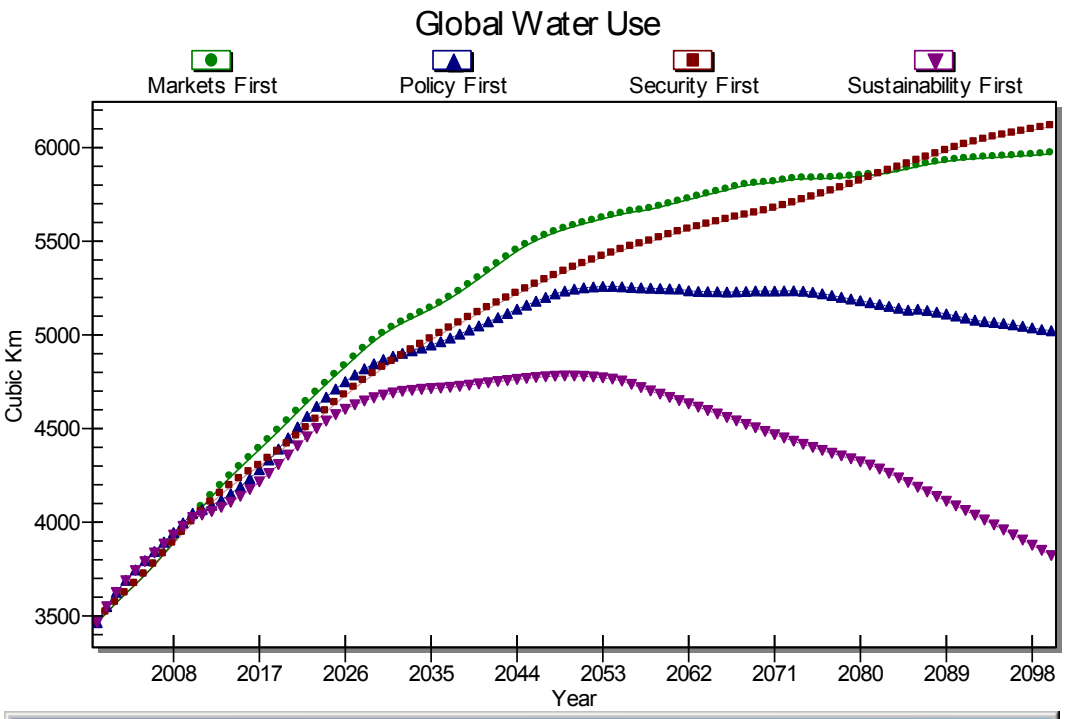
	CO2PPM[2]	CO2PPM[3]	CO2PPM[4]	CO2PPM[5]
	PPM	PPM	PPM	PPM
Year	Markets	Policy	Security	Sustain
2000	372.0	372.0	372.0	372.0
2050	569.5	516.5	527.4	479.8
2100	671.9	564.0	588.6	487.5



World Forest Area

Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	WFORST[2]	WFORST[3]	WFORST[4]	WFORST[5]
	Mil Hectares	Mil Hectares	Mil Hectares	Mil Hectares
Year	Markets	Policy	Security	Sustain
2000	4,186	4,186	4,186	4,186
2050	3,866	4,135	3,790	4,166
2100	3,907	4,383	3,841	4,601



Global Water Use

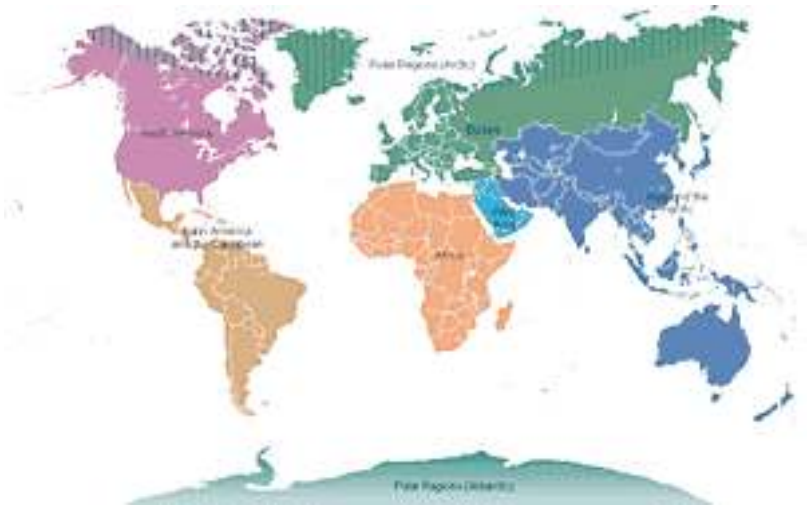
Continue Refresh Graph Print Save Percent Cumulative Filter Display Run Horizon

	WATUSE[2]	WATUSE[3]	WATUSE[4]	WATUSE[5]
	World	World	World	World
	Cubic Km	Cubic Km	Cubic Km	Cubic Km
Year	Markets	Policy	Security	Sustain
2000	3,464	3,464	3,464	3,464
2050	5,579	5,245	5,356	4,781
2100	5,967	5,022	6,112	3,822

6. Next Steps

The DU/IFs team appreciates continued reactions to this document by partners in the UNEP GEO process. The goal for DU/IFs is to produce demographic, economic and other forecasts that can be useful to the broader team and the GEO enterprise.

We hope that these driver forecasts can at least help push forward the broader modeling and scenario activities.



7. Appendix 1: MA Forecasts from Draft Chapter 9

Appendix 1: MA Scenario Descriptions and Results (from Draft Chapter 9)

Table 9-2: Driving forces and their degree of quantification

Quantified drivers	**Unquantified drivers**
Indirect Population growth Economic activities Technology change *Direct* Energy use Emissions of air pollutants (S,N) Emissions of GHG and climate change Land use/cover change Harvest and resource consumption External inputs (irrigation, fertiliser use)	*Indirect* Sociopolitical Culture and religious *Direct* Species introduction / removal

Table 9-3. Fertility, mortality, and migration assumptions for population projections.

Variable	*Global Orchestration*	*Technogarden*	Order From Strength	*Adapting Mosaic*
Fertility	HF: low LF: low VLF: medium	HF: medium LF: medium VLF: medium	HF: high LF: high VLF: low	"Order …" until 2010, deviate to medium by 2050
Mortality	D: low I: low	D: medium I: medium	D: high I: high	"Order …" until 2010, deviate to medium by 2050
Migration	High	medium	low	Low

Notes:
[1] I = Industrialized country regions; D = Developing country regions; HF = High Fertility regions (TFR>2.1 in year 2000); LF = Low Fertility regions (1.5<TFR<2.1); VLF = Very Low Fertility regions (TFR<1.5).
[2] In the IIASA projections, migration is assumed to be zero beyond 2070, so all scenarios have zero migration in the long run.

Table 9-4. Population scenarios (millions of people)

Region	current	Global Orchestration			*Technogarden*			Order from Strength			Adapting Mosaic		
	1995	2020	2050	2100	2020	2050	2100	2020	2050	2100	2020	2050	2100
FSU	285	290	282	245	292	281	252	287	257	216	288	273	246
LAm	477	637	742	681	672	831	950	710	944	1,309	708	933	1,155
MENA	312	478	603	597	509	692	788	539	774	972	537	765	924
OECD	1,020	1,136	1,255	1,153	1,117	1,154	1,077	1,076	998	856	1,079	1,068	978
Asia	3,049	3,861	4,104	3,006	4,039	4,535	3,992	4,210	5,023	5,173	4,201	4,992	4,753
SSA	558	858	1,109	1,132	907	1,329	1,516	956	1,570	1,988	951	1,492	1,775
World	5,701	7,260	8,095	6,814	7,537	8,821	8,575	7,777	9,567	10,514	7,764	9,522	9,830

Table 9-5. Qualitative assumptions for economic growth

	Global Orchestration	*Technogarden*	Order from Strength	Adapting Mosaic
Average Income Growth	High	Somewhat lower than *Global Orchestration*, but catching up	Industrialized countries: medium Developing countries: low	Begins like *Order from Strength*, then increases in tempo
Income distribution	Medium and becoming flatter	Similar to *Global Orchestration*	Income distribution remains similar to today	Begins like *Order from Strength*, then becomes flatter

Table 9-6. Assumptions about economic growth rates (percent per year)

Regio	historic	Global Orchestration			*Technogarden*			Order from Strength			Adapting Mosaic		
	1971 - 2000	1995 - 2020	2020 - 2050	2050 - 2100	1995 - 2020	2020 - 2050	2050 - 2100	1995 - 2020	2020 - 2050	2050 - 2100	1995 - 2020	2020 - 2050	2050 - 2100
FSU	0.4	3.50	4.91	3.14	2.94	4.49	3.14	2.24	2.64	2.72	2.60	4.03	3.08
LAm	1.2	2.80	4.28	2.24	2.36	3.93	2.24	1.78	2.29	1.77	2.06	2.99	2.23
MENA	0.7	1.96	3.42	2.50	1.74	3.27	2.50	1.51	1.75	1.93	1.61	2.43	2.40
OECD	2.1	2.45	1.93	1.34	2.22	1.74	1.35	2.06	1.31	0.86	2.00	1.56	1.19
Asia	5.0	5.06	5.28	3.08	4.24	4.70	3.13	3.22	2.43	2.07	3.76	4.12	2.52
SSA	-0.4	1.69	3.97	4.08	1.44	3.80	4.08	1.02	2.12	2.16	1.21	2.85	3.31
World	1.4	2.38	3.00	2.26	1.90	2.46	2.25	1.39	1.04	1.26	1.46	1.91	1.88

Table 9-7. Future income (GDP/person-year)

Region	current	Global Orchestration			*Technogarden*			Order from Strength			Adapting Mosaic		
	1995	2020	2050	2100	2020	2050	2100	2020	2050	2100	2020	2050	2100
FSU	1,630	3,853	16,223	76,107	3,365	12,560	58,898	2,837	6,198	23,708	3,093	10,109	46,010
LAm	4,337	8,660	30,427	92,226	7,769	24,682	74,738	6,747	13,293	31,952	7,229	17,489	52,575
MENA	2,068	3,363	9,223	31,630	3,186	8,353	28,757	3,010	5,070	13,214	3,085	6,337	20,711
OECD	22,657	41,496	73,607	143,151	39,235	65,876	128,822	37,752	55,734	85,678	37,188	59,114	106,588
Asia	784	2,694	12,600	57,296	2,212	8,781	40,947	1,733	3,564	9,913	1,972	6,612	22,961
SSA	637	969	3,117	23,035	910	2,787	20,629	820	1,540	4,492	860	1,997	10,169
World	5,102	9,190	22,282	68,081	8,162	16,941	51,546	7,204	9,838	18,377	7,338	12,932	32,808

Table 9-8. Qualitative assumptions for technology development

	Global Orchestration	Technogarden	Order from Strength	Adapting Mosaic
Investments into new produced assets	High	High	Industrialized countries: Medium Developing countries: low	Begins like Order from Strength, then increases in tempo
Investments into human capital	High	Medium	Industrialized countries: Medium Developing countries: low	Begins like Order from Strength, then increases in tempo
International relationships (stimulating technology transfer)	High	High	Low (medium among cultural groups)	Low-medium
Overall trend	High	Medium for technology in general; high for environmental technology	Low	Medium-low

Table 9-9. Two examples of indirect drivers.

	Global Orchestration	*Technogarden*	Order from Strength	Adapting Mosaic
International cooperation	Strong	Strong	Weak - international competition	Weak - focus on local environment
Attitude towards environmental policies	Reactive	Proactive	Reactive	Proactive - learning

Table 9-10: Main assumptions for energy under MA scenarios

	Global Orchestration	*Technogarden*	Order from Strength	Adapting Mosaic
SRES scenario	A1b	B1 – but climate policies added	A2	B2
Energy demand	Life-style assumptions and energy efficiency investments based on current Northern American values	Life-style assumptions and energy efficiency investments based on current Japan & Western Europe values	Regionalized assumptions	Regionalized assumptions
Energy supply	Market liberalization; selects least-cost options; rapid technology change	Preference for renewable energy resources + rapid technology change	Focus on domestic energy resources	Some preference for clean energy resources
Climate policy	No	Yes, aims at stabilization of CO_2-equivalent concentration at 550 ppmv	No	No

Table 9-11: Overview of Kyoto-gas greenhouse gas emissions

	1995	2050			
		Global Orchestration	Techno Garden	Order from Strength	Adapting Mosaic
	Emissions in GtC-equivalent				
CO_2	7.3	20.1	15.4	4.7	13.3
CH_4	1.8	3.7	3.3	1.6	3.2

N_2O	0.7	1.1	1.1	0.6	0.9
Other GHG	0.0	0.7	0.5	0.2	0.6
Share of OECD and FSU region in total emissions	48%	30%	34%	22%	29%

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