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Sustainable futures: policies for global development

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Abstract

Global sustainable development is the overarching challenge for social and economic policy today. The paper elaborates the concept of sustainable development, identifies some of the levers and policies that might help attain it, describes a modeling system used for analysis, and presents the results of evaluating the impacts of policies and an integrated scenario built upon them.

Particular attention is given to measures related to research, technology development and the wider use of networking technologies, and to the hypothesis that investments in these areas offer a 'triple-win' opportunity for growth, greater equity and resource-efficiency. We show that the combination of policy initiatives in these areas can offer a valuable alternative and/or complement to constraints on businesses and life-styles that are commonly proposed for sustainable development.
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1. The goal: what do we mean by sustainable development?

There is no greater or more pressing challenge than that of a transition to sustainable development. It is the overarching transition that may well ultimately characterize the century for historians in the distant future. It could largely occur in this century. And it may also fail.

We have taken as a starting point the Brundtland definition for sustainable development [30] that "Current generations should meet their needs without compromising the ability of future generations to meet theirs." However, and in the light of the debates at the Millennium Summit [31] and at the World Summit on Sustainable Development in 2002,

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[1] The views expressed are those of the co-author and do not necessarily reflect those of the European Commission.

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we have recognised that sustainable development is now as much about social equity—for current generations—as about efficient resource-use and conservation of natural resources for future ones.

Sustained growth is the key to greater social equity. We need economic growth that does not leave large segments of humanity behind. Non-inflationary growth of about 2–3% per year in OECD countries is needed to maintain high-levels of employment. To enable substantial convergence with the developed countries, most developing countries will need to sustain GDP growth of 6–8% per year over the next 3–4 decades. China has succeeded in this since 1990, and India is now getting on track.

Yet, European and American life-styles cannot be adopted by a global population even of the current size without destroying the environmental systems of the planet. Economic growth is now increasing the world's environmental burdens much faster than population growth.

We therefore address sustainability through three major components: continued economic growth and human development, protection and extension of social capital with a special emphasis on social equity, and protection of the natural environment.

2. The strategy: European policies and approaches

Sustainable development is now a Treaty objective of the European Union. In this, the social and economic dimensions of sustainable development are as important as the environmental dimension.

One pillar of a European strategy to reach this objective was adopted at the Lisbon Summit in March 2000, which called for *Europe to become the most dynamic and competitive Knowledge economy in the world, with sustained growth, more and better jobs, and greater social cohesion*. This complemented a focus on increasing participation in employment with measures to ensure cheaper and secure access to the Internet; to strengthen investment in people and skills; and to stimulate use of the Internet. Initial targets were met in 2002 and targets for 2005 are being pursued with actions to promote wider use of broadband access and to stimulate networked access to government, learning, health and secure business services.

In May 2001, the European Commission proposed [6], and in June 2001, the European Council in Göteborg adopted further measures that became the basis for Europe's contribution to the World Summit on Sustainable Development in 2002 [7]. This thrust complements 'Lisbon strategy' measures with other social and environmental policies [9] aimed at economic growth, social cohesion and environmental protection. The integrated result is a strategy for new technology and more investment, offering a transition away from old, environmentally unfriendly technologies and low quality jobs.

This linking of sustainable development to technology development, and to a knowledge society, was also explored at the World Summit on the Information Society in December 2003. If the knowledge economy can be both more prosperous *and* more sustainable, then the best route to global sustainable development could be through accelerated technology development, business innovation and structural change. The revolution in ICTs is accelerating the shift to a service-dominated economy, in which more

'value' is associated with immaterial features and knowledge.[2] This offers an opportunity for continued economic growth, without increasing material use [3]. Effective use of ICT could allow process improvement, product improvement, product-to-service conversion and/or structural change [8]. ICTs also have the potential to dramatically improve our ability to access existing knowledge and to accelerate creation of still more knowledge [11]. Sustainable development could then become a triple-win process of improving resource-use efficiencies, improving the quality-of-life and equity in attaining it, and sustaining growth through innovation in work and business processes [19].

We therefore explore the hypothesis that the best strategy for sustainable development might be to pursue policies for more rapid development of a globally networked knowledge economy with greater innovation, notably for resource-efficient 'environmental' technologies and business practices, alongside some measures for reduction in environmental impacts.[3]

Further development of this strategy must have a strong analytical base in ex-ante evaluation of different policy options. To that end this paper (1) identifies specific policy actions to achieve clearly measurable goals; (2) uses an analysis tool to assess the impact of policy interventions; (3) structures an intervention package that is consistent with both the emerging European strategy and the analysis capabilities of the tool; and (4) examines possible European and global futures, with and without the application of the strategy and its policy interventions.

3. The levers: identifying measurable goals and possible policy options

The re-direction of consumption and production towards more sustainable development requires a combination of measures: (1) to increase feedback to people and companies about the impact of their activities; (2) to adapt fiscal and market frameworks to properly value resources; and (3) to increase investments in social and technological innovations. We have chosen to focus on the second and third of these, especially on the third, and to address sustainable development under the three dimensions of 'human capital', 'social capital' and 'natural capital'. For each of these dimensions, we have sought measurable indicators and policy options open to governments today.

3.1. Sustained growth in human capital

The first dimension is 'human capital'. The OECD [25] defines it as "the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social, and economic well-being."

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[2] GDP grew ten times more than total material use since 1950 in the USA, and increased by 35% from 1970 to 1990 (US EIA). In the last 20 years in the EU, overall material consumption per capita has remained at 16 tons per year, while GDP per capita has increased by 50% [9]. However, this historic rate of increase in 'Material resource productivity'—of about 2% per year is not enough to compensate for a sustained growth of 5% per year in world GDP.

[3] This approach sets us to some degree apart from a number of other scenario analyses of sustainable development. For instance, the Global Scenario Group [27] contrast what they call Policy Reform with the Great Transition. Their approach is more focused on environmental elements and their Policy Reform scenario does not emphasize knowledge/technological development and diffusion nearly as much as ours does.

Our ability to measure it has improved enormously. We have remarkable historic databases on education [1], infant mortality, HIV infection levels, and much more. The UNDP has created the Human Development Index (HDI) that draws upon life expectancy, education levels, and prosperity.

Human capital also depends heavily on the creation of knowledge, for which investment in R&D is essential. Knowledge, once created, must be mastered and applied before it contributes to economic production or sustainability.[4] It must also be diffused widely. One of the keys to this is the networked society.[5]

The policy levers for human capital development we have chosen to investigate are:

- *Greater investment in education*. The key policy lever for enrichment of skills and the quality of people's lives.
- *Greater investment in health care*. Human health is critical to human capital. The report of the Commission on Macroeconomics and Health (2001) [22] maps some of the potential benefits of health expenditures directed at the world's poorest.
- *Increased investment in RTD and innovation*. Knowledge creation obviously precedes its diffusion and use.
- *Measures to support wider electronic networking*, notably to accelerate diffusion of knowledge and its creation.

3.2. Sustained growth in social capital

The second dimension is that of 'social capital'. Putnam [26], Fukuyama [12], and others have warned us about the apparent loss of social capital within societies in recent decades. Sustainable development will require continued growth in it.

The OECD [25] define social capital it as "networks together with shared norms, values and understandings that facilitate co-operation within and among groups." We have looked to norms and values (including interpersonal trust and self-declared happiness) drawing upon World Value Survey data, and at societal stability as manifestations of social capital within and across countries. We have also looked at democratisation, economic freedom, and the level of corruption in societies around the world.[6]

Economic growth and income/wealth equity are arguably even more fundamental measures of social capital. For instance, both value change and democratisation are heavily driven by income levels, and no society with a GDP/capita of more than $7 000 has ever reverted from democracy to autocracy. Family breakdowns, high crime rates, and social tensions can destroy social capital, but are less likely in equitable and growing societies. We have therefore chosen to focus on growth and equity as key ultimate foundations of the development of social capital.

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[4] Interestingly, the UNDP's new Technology Assessment Index (TAI) [31] represents four dimensions: creation of technology, diffusion of recent innovations, diffusion of old innovations, and human skills. In many respects that index therefore corresponds to our operational concept here of human capital.

[5] The concept of a networked society is far broader than an electronically networked society, and refers to social networks of all kinds including those in business, government, and civil society.

[6] Ronald Inglehart [17] has been generous in his permission for use of World Value Survey data.

With respect to economic growth, we have used GDP at purchasing power parity (PPP), rather than GDP at market prices.[7] With respect to equity, we focus on global inequity as measured by the ratio of non-OECD GDP/capita to OECD levels [31] and in Lorenz-curve and GINI distributions [21].

The discussion of policy levers for sustained growth and equity has changed over time [29]. Classical economics focused on increases in capital via higher savings and investment rates, subsequently supplemented by attention to transformations in the labour force, human capital and more. Literature on international dependence patterns variously emphasizes self-help and international transfers. The neoclassical counter-revolution turned attention to efficient markets supported by capable governance. We recognize the importance of contributions and complementarities across these traditions and focus on:

- *Transfers*. Official Development Assistance is the traditional focus, but remittances from migrants and FDI, with its imbedded knowledge- and technology-transfers, are increasingly important. However, we have not looked specifically yet at facilitation of migration from labour 'rich' countries to labour 'poor' ones;
- *Trade liberalisation and participation*. Notably access by developing countries to global markets.
- *Capacity and incentive building*. Easterly [5], de Soto [4] and many others increasingly stress the legal and governance foundations.

3.3. Preserving natural capital

Environmental sustainability requires that both the inputs to human systems from the environment and the output of human systems back to the environment are sustainable in the long run. Measures of specific environmental inputs and outputs are fairly well developed [33]. The TERRA project [20] used an approach in which environmental stress is conceptualised as a 'multiple attribute concept', an approach we adopt.

The Impact = Population × Affluence × Technology (IPAT) identity initially drew attention to the importance of family planning policies. In the 1970–1990s, reducing population growth-dominated debate and has now become part of our base case. In the 1980s and 1990s, some NGOs focused on limiting GDP growth. More recently, attention has shifted to the development of technologies for reduction of inputs and outputs per unit of GDP, and the policy levers by which their development might be accelerated [8].

In this technology focus, policy levers to reduce the energy-intensity of economic activity and promote renewable energy sources are fundamental. These generally include some combination of taxes, subsidies, exhortation, regulation and quantity specification and investment in development of alternative energy resources and energy efficiency [2]. On the output side, the most important emissions are of greenhouse gases [18]. This analysis considers the following policy levers:

[7] Maddison [35] provides benchmarks useful to this analysis.

- *Accelerating development and use of resource-efficient and environmentally friendly production technologies*, such as information- and bio-technologies, renewable energy technologies and those which increase rates of material recycling.
- *Promoting sustainable consumption*, including use of energy-saving technologies and ICT applications that can increase resource-efficiencies per unit of consumption and GDP.
- *Carbon taxation*: notably the imposition of costs on CO_2 emissions, with the costs reflecting abatement costs in 'cap and trade' frameworks.

4. The analysis tool and approach: international futures (IFs)

General understanding of complex human economic and social systems has increased.[8] Ability to represent the operations of individual systems has grown, and even capacity to trace the interconnections across complex interacting systems has expanded. These insights are critical if we are to understand the trajectory on which we find ourselves and the opportunities for leverage that might help attain our goals.

Integrated computer simulation of human systems (starting with [24]) is now a powerful tool for understanding the dynamics of complex processes and thinking through future scenarios. Integrated simulation offers (1) the ability to compare the effect of alternative policy levers within a consistent framework; (2) the potential to explore secondary and tertiary impacts of policy interventions; and (3) the option to investigate interaction effects, both synergies and contradictions, among the policy interventions themselves.

One such integrated simulation system, International Futures (IFs),[9] has evolved for more than 25 years in support of investigation into the emerging global transition to sustainability. It is a global simulation system with an extensive database for 164 countries over as much of the period since 1960 as possible. In 1998–2002, the European Commission supported the TERRA 2000 project[10], within which the International Futures (IFs) model was further developed, and upon which this paper is based [14].

Fig. 1 shows the major conceptual blocks and a small subset of the great many linkages among those blocks.

IFs draws upon techniques found in both econometric and systems dynamics traditions, but also reaches beyond those, especially in its structural representations.

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[8] The TERRA project was sponsored by the Information Society Technologies Directorate of the European Community. The project drew together a substantial number of individuals and project teams from across Europe under the administrative leadership of RAND Europe. This paper is an adaptation and extension of a living document [14] for that project called 'Integrated Sustainability Analysis.'

[9] For introduction to the character and use of the third generation, see [13] and for a description of the current fourth-generation system, see [29].

[10] The EU TERRA2000 project was an important sponsor of recent system development, as have been the European Union Center of the University of Michigan, the RAND Pardee Center, Frederick S. Pardee, and the US National Intelligence Council. Previous support has been from the Strategic Assessments Group (SAG) of the US Central Intelligence Agency; the National Science Foundation, the Cleveland Foundation, the Exxon Education Foundation, the Kettering Family Foundation, the Pacific Cultural Foundation, the United States Institute of Peace, and General Motors. Anwar Hossain, Mohammod Irfan, and José Solórzano have contributed to data-collection, modeling, and programming support for the most recent model generation.

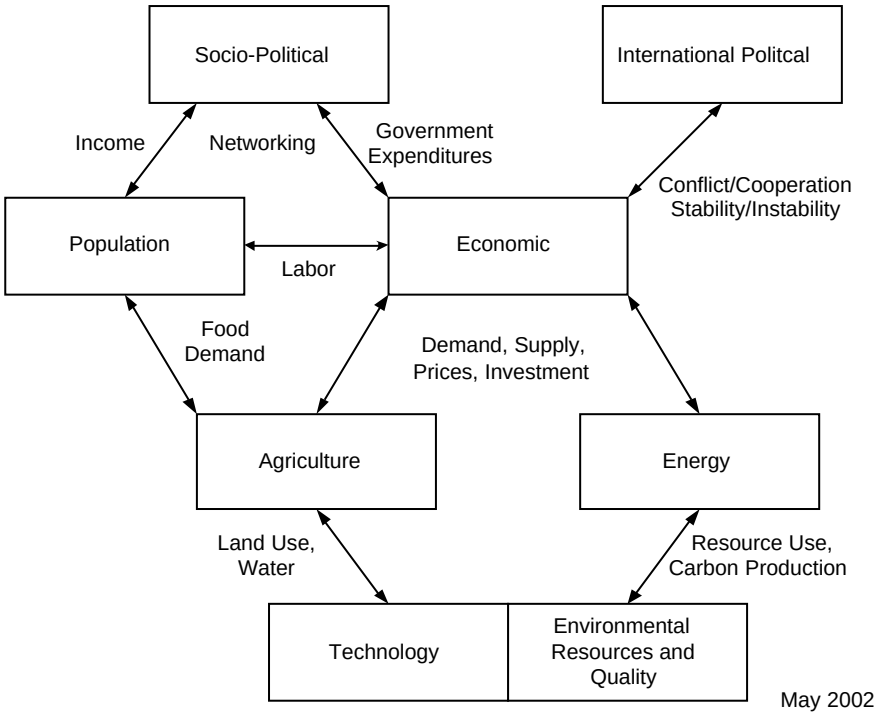

Fig. 1. An overview of international futures (IFs) for TERRA.

The methodological approach can be best described as 'Structure-Based and Agent-Class Driven Modeling.' This approach has five key elements: organizing structures, stocks, flows, key aggregate relationships, and key agent–class behaviour relationships. The sub-modules each have strong structural foundations. See the IFs web site for extended information on the system and the option of downloading the student edition [16].

In our analysis policy levers are applied relative to the base-case scenario of IFs, which reflects, insofar as possible, current social and economic trends and policy frameworks. It also, of course, reflects the dynamics of the model as incorporated in its theoretically and empirically based relationships.

With respect to the interventions to be discussed below, the base case [15] assumes:

- No increase in RTD investments as a portion of GDP except those that occur historically as countries become richer;
- Growth in electronic networking at historic and current rates, with saturation over time;
- Stable investment in formal education at current levels, except for changes with economic development;
- Stable investment in health care, except again for changes with economic development;
- Stable savings and investment rates;
- Unchanged official development assistance (ODA) as proportions of GDP;
- No further reduction in trade barriers, and no change in the economic freedom index;

- Rates of technological advance at recent historic levels; for instance, continued increase in crop yields per hectare and reductions of energy use per unit of GDP at about 1.0% per year;
- No new initiatives on energy use such as 'carbon taxes'; and
- No significant new trends in life-styles and consumption.

In addition, there are two important 'framing assumptions' of any long-term global forecast. Firstly, the base case reflects substantial confidence with respect to continued human inventiveness but does not accelerate it. Secondly, it does not include any major environmental tipping phenomena, such as disruption of the North Atlantic thermal conveyer, carrying warmth and moisture to much of Europe. Changes in either of these framing assumptions would substantially alter our analysis. The base case projections from the IFs model are comparable with other scenarios [18,23,28,32,34]. It suggests that significant progress on many aspects of sustainability is likely as a result of historic patterns of global development and current policy interventions. Many of the key indicators show improvement, even in the absence of further policy intervention.[11] Our interest is in accelerating and enhancing those developments.

5. Interventions for more sustainable development: individual policy measures and a combined sustainability scenario

The European strategy for achieving a sustainable future is still evolving, is always under review, and interacts with strategies of actors like the UN. Nonetheless, it has been increasingly elaborated in terms of specific policies and is increasingly quantified in its goals.

The International Futures (IFs) system is, like any simulation system, both incomplete and necessarily inaccurate, but it can represent the effect of most of the policy levers discussed earlier. Thus analysis of the strategy within IFs can provide insight into the possible value of its implementation in terms of achieving a more sustainable world. As much as possible, we have attempted to reflect concrete, existing policy proposals in the illustrative sustainable development scenario:

- *Increased investment in R&D*. An increase for OECD countries of 50% relative to the base-case (an increase from 2 to 3% of GDP in the EU, as agreed at the 'Barcelona Summit' in 2002), phased in over 15 years, and an increase for non-OECD countries of 100%, phased in over 15 years.
- *Increased diffusion of electronic networking*. A 50% increase relative to the base-case for non-OECD countries, phased in over 15 years, and achieved by the pursuit of National 'e-strategies' as envisaged at the WSIS, and modelled on the eEurope Action plan in the EU. EU network access accelerated to 90% coverage by 2015, in a follow-up to the eEurope Action Plans. US rates are at endogenous levels.

[11] The analysis in this paper used version 5.01 of IFs; every version includes enhancements and extensions, so that the base case and alternative forecasts will vary somewhat across them. See the IFs web site for extended discussion of the base case [15].

- *Greater investment in formal education*. A 50% increase in investment relative to the base-case over 15 years for non-OECD countries and 20% increase for OECD countries, both applied to the base percentages (i.e. a 20% increase in a 5% investment rate yields a 6% rate).
- *Greater investment in health care*. A 50% increase relative to the endogenous base-case over 15 years for non-OECD countries and a 20% increase for OECD countries.
- *Increases in official development assistance (ODA)*. Growth over 15 years to 0.45% of GDP for the EU [10] to 0.25% for the USA, and to 0.5% for other OECD countries. These rates are below the 0.7% UN target, but are perhaps more likely.
- *Trade and general economic liberalisation*. A 50% reduction in world-wide tariffs and non-tariff trade barriers over 15 years and further liberalisation of economies realising a 20% increase in the economic freedom index.
- *Support for faster 'environmental technology' development*. We specifically assume this can result in a 20% increase in crop yields per hectare relative to the already increasing yields of the base-case; a 50% faster cost-reduction for renewable energy (from 1.0% per year to 1.5% per year) over 15 years and maintenance at the higher rate thereafter, and faster improvement in energy efficiency (energy use per unit GDP) by 50% over 50 years [9].
- *Carbon taxes*. Phasing in of costs for carbon dioxide emissions of $200 per ton in OECD countries and $50 per ton in non-OECD countries, over 15 year periods, through increasingly tight and inclusive 'cap and trade' frameworks.

In addition and prior to considering these interventions as part of an integrated scenario, it is useful to consider the above list as individual policy interventions. Tables 1 and 2 provide output indicators for simulations of future social and economic evolutions for selected measures from each of the three dimensions of sustainability discussed earlier, across the base case, cases with each of the separate interventions, and with the combined set. Those tables also show the likely impacts if the European Union were to undertake the above initiatives completely on its own, with no complementary activities taking place in other OECD countries or in developing countries. Looking at EU action by itself will help us to understand the degree to which this package of actions has merit for the EU and the broader world even if undertaken without broader support and contribution.

Understanding of many of the relationships necessary to model the impacts of these interventions is certainly not complete or without controversy. Nonetheless, the simulation results are coherent and indicative. Among the conclusions that one might draw are:

- *Most interventions have a positive impact*. Individual policy interventions advance the European Union (of the 25), non-OECD countries, and the world on the dimension that they target. In particular, each intervention improves the GDP per capita relative to the base case.[12]

[12] The human development index suffers from a structure that builds in saturation; thus the advance in it is not as obvious as is the underlying progress in components such as education levels and GDP per capita. Even the measure of HDI often used in IFs, which is adjusted on the advice of Frederick Pardee to accommodate higher values in the 21st century, saturates inappropriately.

Table 1
Impact of policy interventions on human development and economic conditions

	Human development index (HDI)			GDP per capita at PPP (thousands)			Global GINI	NS ratio of GDP per capita
	EU	Non-OECD	World	EU	Non-OECD	World		
Base case (no special policies)								
2000	0.77	0.55	0.59	21.8	3.7	7.5	0.75	23.38
2050	0.83	0.68	0.7	45.4	14.6	19.3	0.58	7.74
2100	0.87	0.78	0.8	83.8	39	46	0.41	3.89
Individual policy interventions								
R&D								
2050	0.83	0.68	0.7	45.8	15.2	19.8	0.58	7.51
2100	0.87	0.78	0.79	85.9	42.9	49.6	0.39	3.59
Networking								
2050	0.83	0.68	0.7	45.6	15	19.6	0.57	7.52
2100	0.88	0.79	0.8	84.2	40	46.9	0.4	3.76
Education								
2050	0.83	0.68	0.7	46.6	15.5	20.2	0.57	7.35
2100	0.88	0.78	0.8	87.4	42.2	49.3	0.39	3.67
Health								
2050	0.83	0.68	0.7	45.3	14.7	19.3	0.58	7.68
2100	0.88	0.78	0.8	83.8	39	46.1	0.4	3.84
Foreign aid								
2050	0.83	0.68	0.7	45.3	14.8	19.4	0.58	7.64
2100	0.87	0.78	0.8	83.9	39.4	46.4	0.4	3.82
Liberalization								
2050	0.83	0.69	0.71	46.5	15.3	20	0.57	7.51
2100	0.87	0.79	0.8	85.6	40.2	47.3	0.4	3.82
Environmental technology								
2050	0.83	0.69	0.71	46.8	15.6	20.3	0.57	7.41
2100	0.88	0.79	0.8	86.5	40.3	47.6	0.4	3.88
Carbon tax								
2050	0.83	0.68	0.7	45.4	14.7	19.3	0.58	7.71
2100	0.87	0.78	0.8	83.9	39	46.1	0.41	3.9
Combined policies								
2050	0.84	0.71	0.73	51.2	19.5	24.2	0.51	5.95
2100	0.88	0.81	0.82	95.5	52	58.7	0.34	3.04
Europe goes it alone								
2050	0.83	0.68	0.7	47.9	14.9	19.7	0.58	7.73
2100	0.88	0.79	0.8	90.9	39.9	47.3	0.4	3.97

The HDI has been rescaled for the 21st century; the global Gini represents countries as a whole, not subnational populations; the North–South ratio is of GDP at market prices.

- *The combined package of interventions clearly offers more leverage*. The combination of policy measures has a greater effect than any individual measure, and the net effect is positive on all three dimensions of sustainability—a triple-win effect on economic, social and environmental indicators. Therefore, there is no traditional 'trade-off' between economic growth and social or environmental goals, but a synergetic effect on all these goals. The combined effect is greater than the sum of the effect of the separate

Table 2
Impact of policy interventions on global equity, democracy and environmental sustainability

	Democracy (Freedom house)			Carbon emissions (billion tons)			Fossil percent of total energy	Global forest (MHA)	Global Co_2 (PPM)
	EU	Non-OECD	World	EU	Non-OECD	World			
Base case (no special policies)									
2000	2.89	9.06	2.98	0.99	3.33	6.62	90.4	4166	372
2050	2.01	5.93	5.45	0.29	9.29	10.73	63.8	3838	552
2100	2	3.67	3.46	0.01	5.38	5.44	14.3	4110	612
Individual policy interventions									
R&D									
2050	2.01	5.87	5.4	0.28	9.41	10.8	63.6	3826	554
2100	2	3.52	3.34	0.01	5.05	5.11	14.2	4085	614
Networking									
2050	2.01	5.88	5.41	0.28	9.33	10.75	63.5	3831	553
2100	2	3.61	3.41	0.01	5.29	5.35	14.1	4104	613
Education									
2050	2.01	5.8	5.34	0.27	9.44	10.77	63.1	3874	552
2100	2	3.52	3.33	0.01	5.11	5.18	13.9	4178	609
Health									
2050	2.01	5.93	5.44	0.29	9.31	10.76	63.8	3813	554
2100	2	3.66	3.45	0.01	5.39	5.45	14.3	4063	615
Foreign aid									
2050	2.01	5.9	5.42	0.28	9.31	10.74	63.6	3837	552
2100	2	3.64	3.44	0.01	5.34	5.4	14.2	4108	613
Liberalization									
2050	2.01	5.84	5.37	0.27	9.34	10.67	63.3	3803	557
2100	2	3.6	3.4	0.01	5.28	5.34	14.2	4074	617
Environmental technology									
2050	2.01	5.76	5.3	0.2	6.74	7.64	68.2	4066	500
2100	2	3.57	3.37	0.02	4.57	4.63	11.9	4386	529
Carbon tax									
2050	2.01	5.92	5.44	0.28	9.31	10.6	64.2	3842	547
2100	2	3.67	3.46	0.01	5.37	5.42	14.7	4127	603
Combined policies									
2050	2.01	5.24	4.85	0.14	6.86	7.41	63.8	4014	513
2100	2	3.07	2.94	0.03	3.51	3.59	10.3	4334	542
Europe goes it alone									
2050	2.01	5.38	5.4	0.03	9.46	10.67	59.8	3847	548
2100	2	3.6	3.4	0	5.38	5.45	11.3	4109	610

The Freedom House measure runs from 2 to 14 with lower numbers being more democratic.

individual measures for EU and world growth, and for the reductions in in-equities (the GINI coefficient). It is less than the sum of the separate measures in other cases: negative synergy between measures is generally a result of equilibrating processes and contradictory effects between them.

- *Some interventions are more important than others*. For carbon emissions, faster environmental technology development is the most effective for the

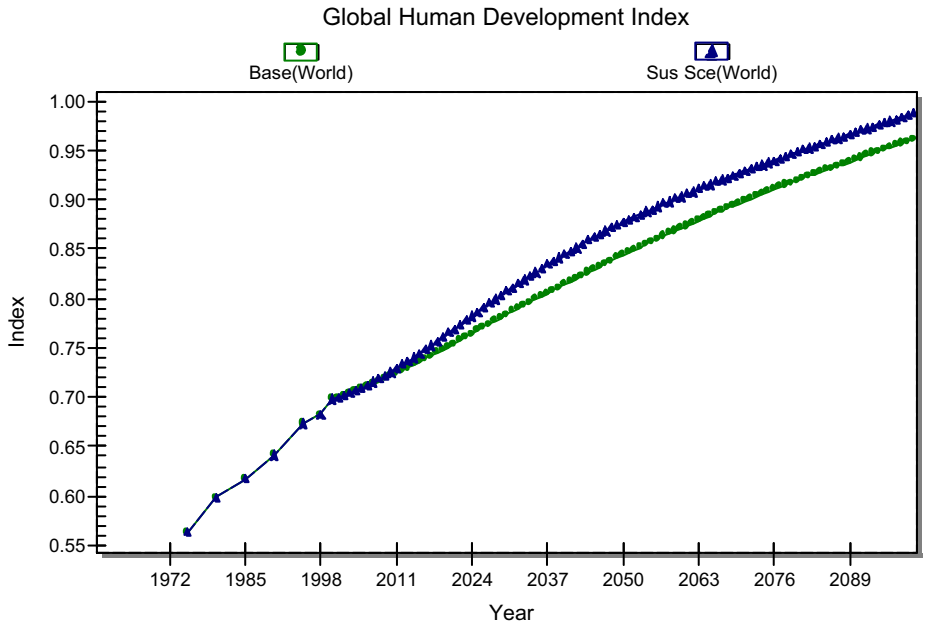

Fig. 2. Global human development index (Current UN Development Program Index Construction). The EU-only scenario does not differ significantly from the base case.

European Union and at the world level, and carbon taxes are a much less effective measure.

- *There can be complex temporal and cross-issue dynamics*. For instance, improvements in environmental technologies can raise economic performance and lower fossil fuel requirements in the short- and mid-run, but lead to some rebound in fossil fuel demand in the longer run.
- *Initiatives in developed and developing countries are complementary and mutually reinforcing*.[13] Benefits in one part of the world are not accompanied by negative affects in another. There are many non-zero sum elements of the package.
- *Policy measures in the EU, or OECD countries, need to be complemented by coherent measures in developing countries for effectiveness at the world level*. Implementation of the strategy in only the European Union has benefits nearly everywhere, but the magnitude of the gains is small compared to implementation world-wide.

Figs. 2–10 directly compare the combined sustainability scenario with the base case over time, and in some instances with the EU-only scenario. The comparison shows that the combined sustainability scenario:

[13] On the urging of Frederick Pardee, the IFs project has added two alternative HDI measures with somewhat less saturation and values that remain below '1' throughout the century. But the inputs to these HDI measures also tend to saturate perhaps more than does the underlying concept of advance in human capabilities.

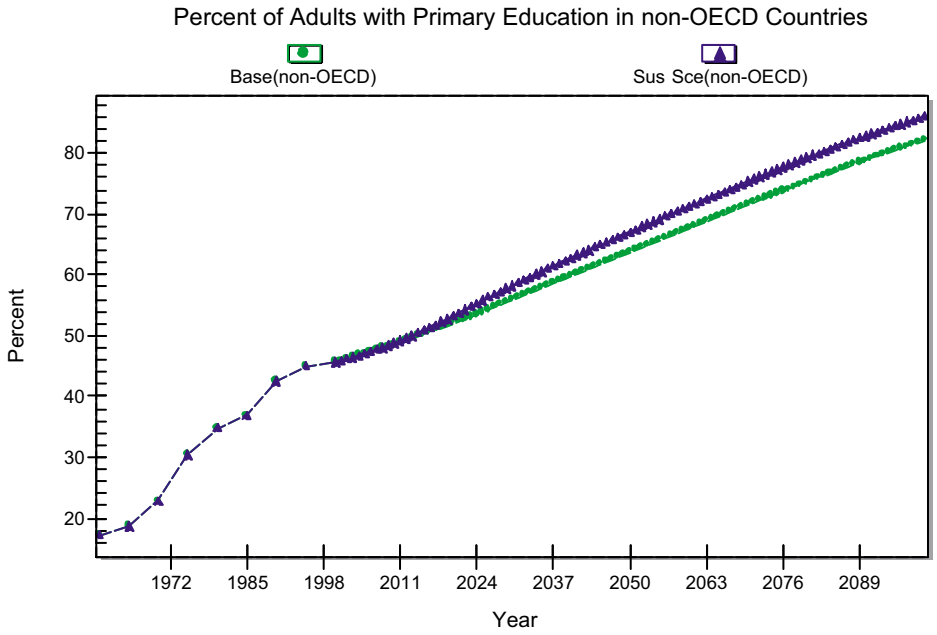

Fig. 3. Percent of adults with primary education in non-OECD countries. Note: Pattern reflects the persistence of low education levels for the entire population even after achieving near universal literacy for young people.

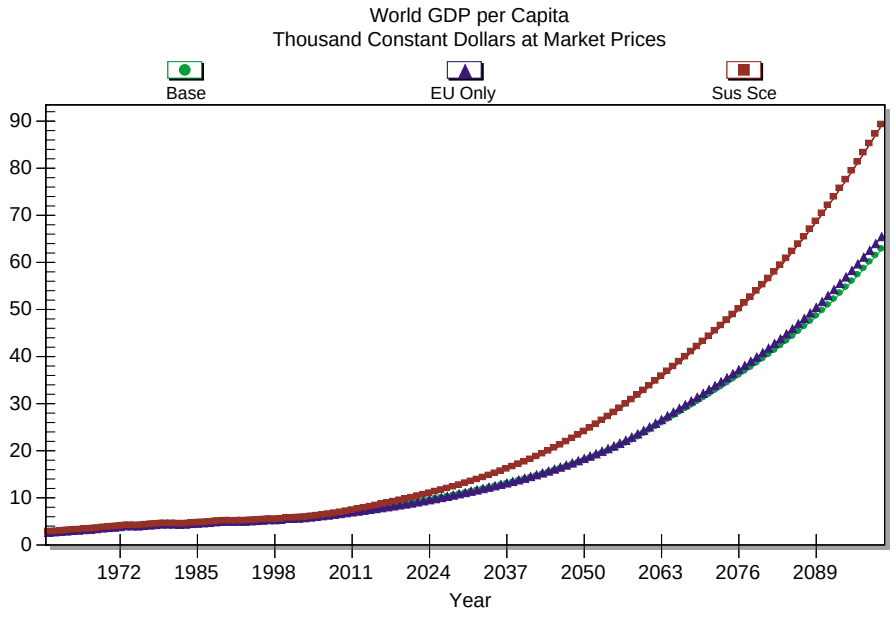

Fig. 4. World GDP per capita in the IFs base case and the sustainability scenario. Note: EU-only implementation differs very little from base.

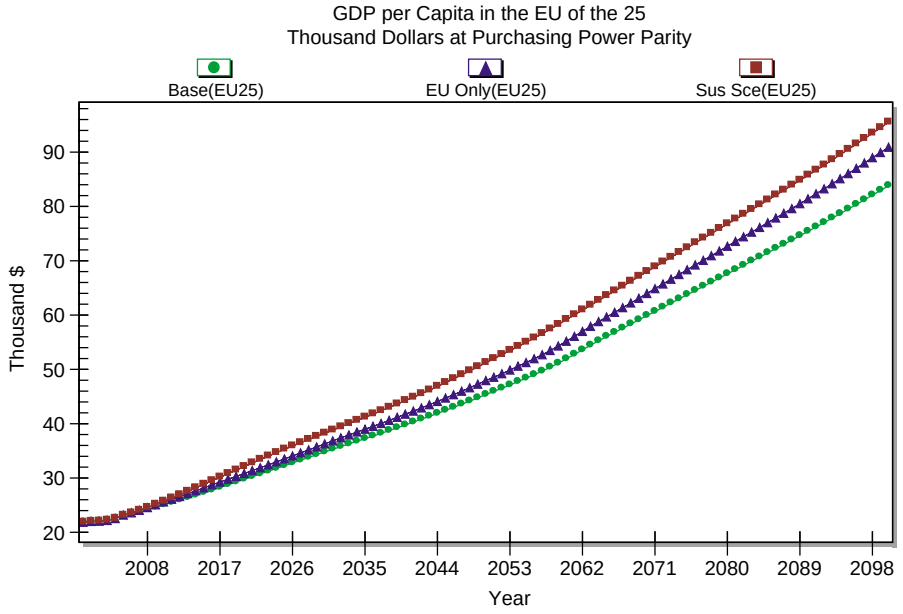

Fig. 5. EU GDP per capita (PPP) in the IFs base case, EU-only scenario, and the sustainability scenario.

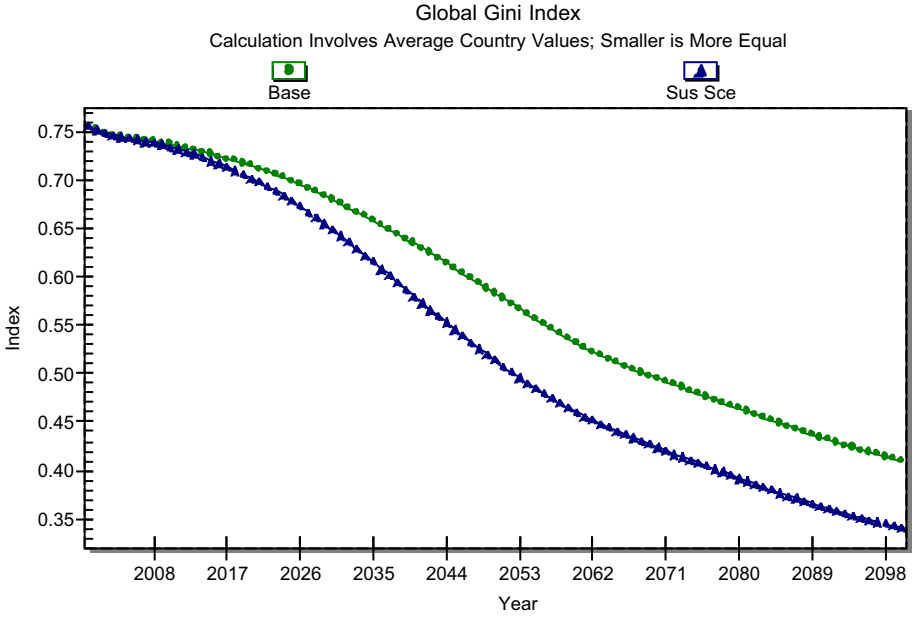

Fig. 6. World GINI index in the IFs base case and the sustainability scenario. Note: EU-only implementation differs very little from base.

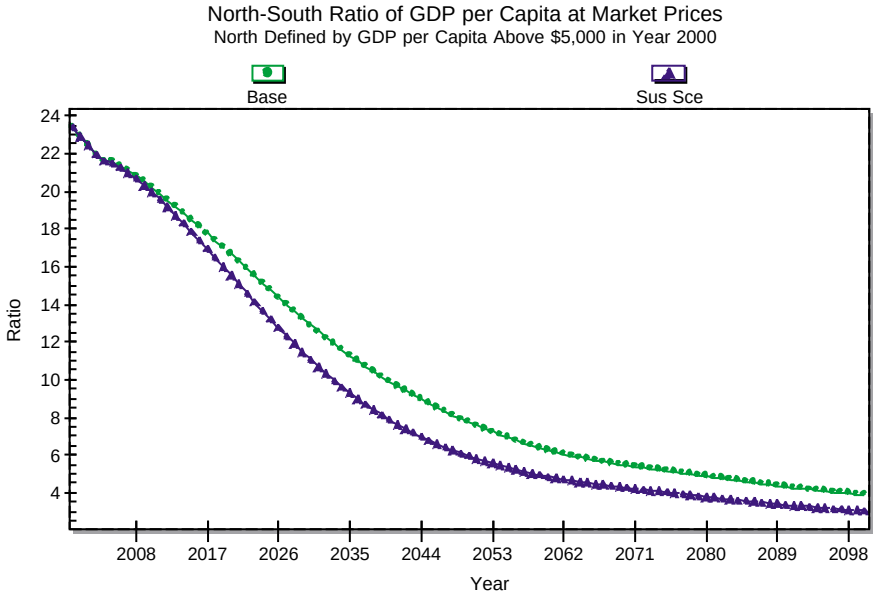

Fig. 7. Ratio of GDP per capita in richer and poorer countries.

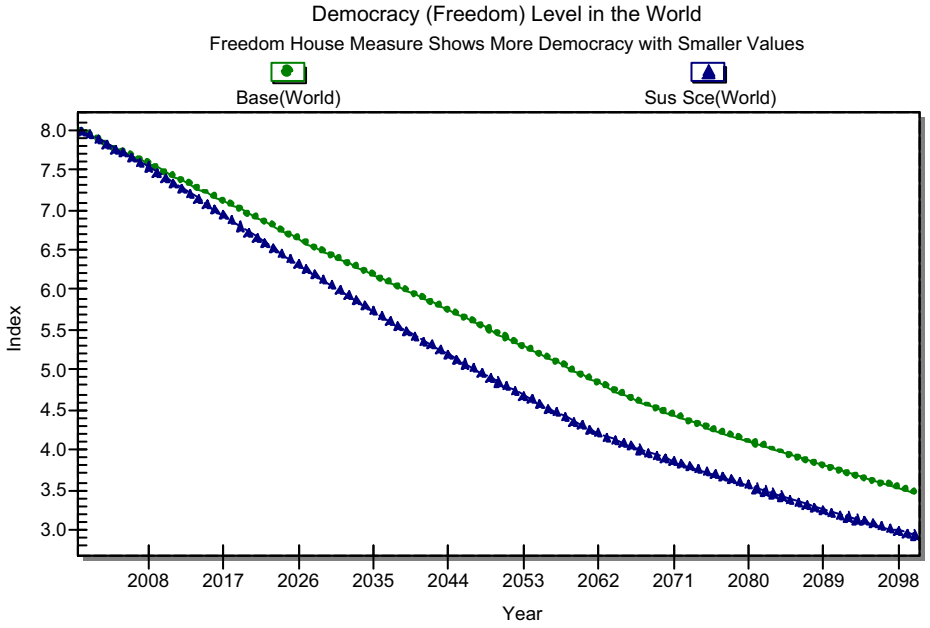

Fig. 8. Democracy level.

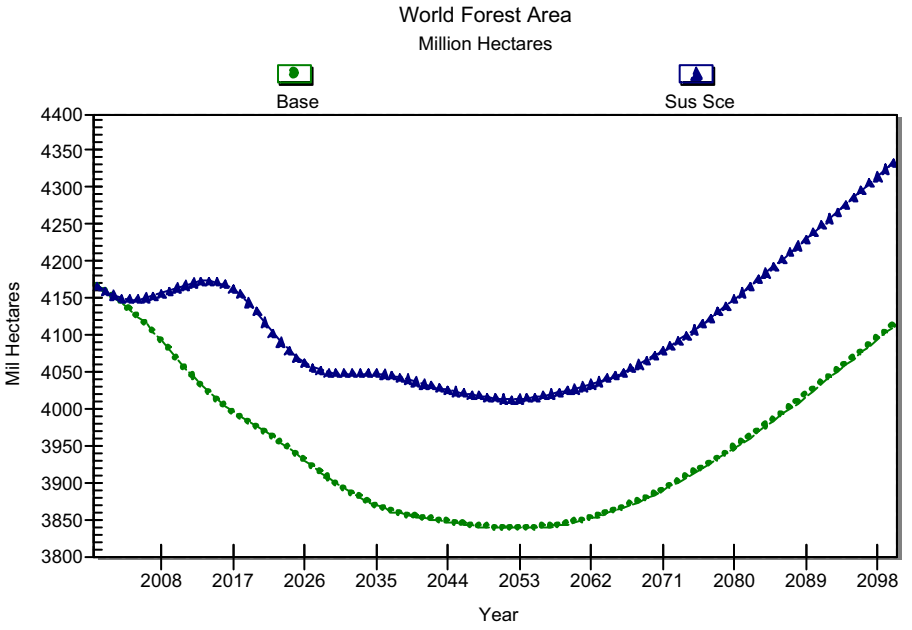

Fig. 9. World forest area.

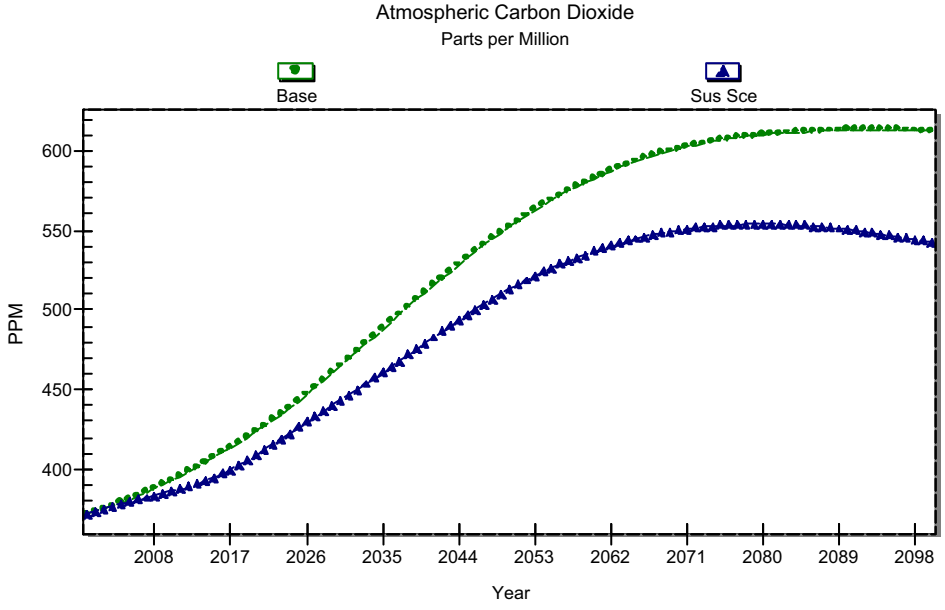

Fig. 10. Atmospheric carbon dioxide.

- *Clearly helps broader human development, especially in non-OECD countries*. However, the Millennium Development Goal of universal primary education by 2015 would not be met even in the sustainability scenario (not shown).
- *Substantially increases global GDP growth and GDP per capita*. The increase most benefits developing countries (see again Table 1). The EU-only scenario does not substantially affect world GDP per capita, but does enhance that of the EU relative to the base case.
- *Significantly reduces global inequity*. Fig. 6 shows the evolution of the GINI coefficient globally. A global GINI coefficient of about 0.4 could be achieved by about 2100 for GDP at market prices, similar to that in the United States today. Fig. 7 shows the ratio of GDP per capita in richer and poorer countries in the world, which converge substantially in the base case but more rapidly in the sustainability scenario.
- *Substantially accelerates the development of democracy and economic freedom around the world*, with a value of 5 in the Freedom house measure being achieved by about 2050—a decade before it is reached in the base case.
- *Assists recovery of world forest cover to above current levels* by century end. In addition, forest levels do not fall as far in the period from 2020 to 2080.
- *Significantly accelerates the reduction in carbon emissions and allows atmospheric carbon dioxide levels to peak* at a lower level of about 550 parts per million by about 2080 and actually begin to decline.

6. Conclusions

The central question that motivated this analysis was whether a combination of policy initiatives, including investment in research, environmental technology development, and human capital development, could point towards 'win–win–win' opportunities for sustainable development—simultaneously benefiting growth and human development, social capital and socio-economic equity, and resource-efficiency. More specifically, our desire was to explore some of the initiatives already proposed within the European Union and elsewhere.

The base-case simulation itself indicates that we are on a trajectory for dramatic economic and social change in the next 100 years:

- World GDP per capita will increase 11-fold at market prices and 6-fold at PPP;
- World population will peak at about 9 billion by 2070;
- Global social and economic equity will dramatically increase—the global GINI coefficient will fall to about 0.4—comparable to that within the US in 2000 as the North/South GDP ratio falls from 23 to 4; and
- There will be a major shift from use of fossil fuels with high carbon emissions to renewable energy.

However, the base-case scenario policies may not achieve a sufficiently rapid evolution in social equity and energy use to avoid major risks of social disruption or climate change.

We have therefore looked at the individual and combined effects of the policy measures that constitute the emerging sustainability strategy for the EU, and for wider world development strategies emerging from the WSSD, WSIS, Monterey and WTO negotiations. Two primary conclusions emerge.

First, it is clear from the analysis that most individual policy initiatives could, if fully implemented, have substantial benefit. Moreover, a wider and integrated approach to sustainability, combining many challenging but by no means impossible initiatives, will have a greater effect than any individual measure, and the net effect is positive on all three dimensions of sustainability. Implementing such a package would involve determined and sustained government, business and social action. Yet measures already agreed at European and global levels constitute valuable first steps, if fully implemented.

Second, policy initiatives in Europe and elsewhere in the developed and developing worlds will be necessary. Policy initiatives in the EU need to be complemented at the world level. Although EU action alone benefits some global measures, as well as EU conditions, in most instances the EU alone does not have sufficient leverage to make substantial change relative to the base case. Movement towards sustainability cannot be pursued in isolated pockets of the world. At the same time, coherent initiatives in the EU and in the developing world can be complementary and mutually reinforcing. Globally sustainable development requires not only leaders, but also demands partnership.

The unfolding of the 'sustainability century' is a challenging period in human history. Because stakes are high and costs of action (not just of inaction) are significant in economic and social terms, analysis of the possible impact of alternative policies is critical. This analysis shows that there is a credible and effective way forward.

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