Knowledge partnerships for a sustainable, equitable and stable society

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Abstract

Continued exponential and asymmetrical growth in both population and individual economic productivity would propel world society along a path that is environmentally unsustainable, economically inequitable, and hence socially unstable. Terrorist activity in September 2001 may be vivid evidence of that instability. Revolutionary developments in communications technologies can, however, enable partnerships among scholarly disciplines and among societal institutions to harness rapidly expanding human knowledge (broadly construed) to pursue goals in both population and individual economic productivity that would lead to a sustainable, equitable, and stable world society. Such a knowledge-based strategy could enable us to pursue the vision of a global society in which all of the basic human needs and an equitable share of human wants can be met by successive generations while maintaining a healthy, physically attractive, and biologically productive environment. Several scenarios are presented to illustrate the promise of cooperative efforts to pursue this vision, and to highlight some obstacles to that pursuit.

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Introduction

As the twentieth century drew to a close, scholars reflected on the problems and possible responses in an increasingly interdependent world society as it embarked on the first century of the Third Millennium. Economic historian David Landes, for example, summarized his view of the central problems in *The Wealth and Poverty of Nations*:

> ... the greatest single problem and danger facing the world of the Third Millennium ... is the gap in wealth and health that separates rich and poor. ... The only other worry that comes close is environmental deterioration, and the two are intimately connected, indeed are one (Landes, 1998).

Harvard's Edward O. Wilson succinctly focused on an appropriate response in *Consilience – The Unity of Knowledge*:

> ... unified learning, universally shared, makes accurate foresight and wise choices possible. In the course of it all we are learning the fundamental principle that ethics is everything (Wilson, 1998).

The dimensions of Landes's economic "gap" have been evident for a long time, and they are still the dominant lesson to be drawn from data reported by the United Nations Development Program (UNDP) in *Human Development Report 2001* (UNDP, 2001). Their most recent data show that the value of the average daily consumption of goods and services (adjusted for purchasing power parity) by each of more than 800 million individuals in the 23 high-income countries in the Organization for Economic Co-operation and Development (OECD) in 1999 was about $70. In contrast, the corresponding figure for each of the more than 600 million people in the 40 least-developed countries (LDCs) was about $3 per day. The inequity inherent in these international comparisons is, of course, staggering; but it is equally important to recognize that they mask comparable inequities within rich and poor countries, alike. Indeed, the richest 10 per cent of the people in most countries receive 20-30 per cent of the income while the poorest 10 per cent receive only 2-4 per cent (also see Galbraith (2002) and related articles in that issue of *Daedalus*).

What can be said about the future? That is an impossible question to answer with any precision, but some glimpses of not-implausibility can be drawn from a few simple

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thought experiments. Panel II A of Table I shows the results of the simplest such experiment – projecting decade-long averages for current rates of demographic and economic growth forward to the year 2050 for 23 high-income OECD countries and 40 least developed countries (LDCs). The average production and consumption per day by individuals would climb from $60 in 1999 to $90 in 2050 in the OECD countries, but it would increase by only $2 per day (from $3 to $5) in the LDCs. The inequity would grow from 23-fold to 34-fold. The nearly $40 trillion increase in the economy of the OECD countries would be roughly equivalent to the size of the global economy in 1999. Moreover, the population in the LDCs would increase by nearly 1,500 million people – more than seven times the growth of about 200 million in the OECD countries. The differences of population growth and gains in individual economic productivity between the two groups of nations would jeopardize environmental sustainability and exacerbate economic equability.

The respected World Resources Institute (WRI) and several UN agencies have meanwhile analyzed the capacity of global ecosystems to support a continuation of expanding levels of economic activity; and their work has identified "... an almost certain decline in the ability of ecosystems to yield their broad spectrum of benefits" (WRI, 2000). This sobering prospect is the consequence of the 22-fold growth in world population and the 13-fold growth in the economic productivity of individuals that produced a 300-fold expansion in the global economy during the Second Millennium (Maddison, 2001). There was, of course, almost no corresponding growth in the sunlight, air, water, and living organisms in global ecosystems during that millennium. The prospect of adding a four- to five-fold growth in the global economy by 2,050 on top of this historical explosion underscores the gravity of the problem and the urgency of an appropriate response. Homer-Dixon has added more urgency to the mix by warning that "Environmental scarcity ... caused by the degradation and depletion of renewable resources ... has often spurred violence in the past ..." that "will probably increase" in coming decades as the pressure on these resources grows (Homer-Dixon, 1999). At the Nobel Peace Prize Centennial in Oslo in

Table I Scenarios comparing the 23 high-income OECD countries with the 40 least-developed countries (LDCs)

	OECD	LDCs
I. Characteristics of 1999[a]		
Population (10^6)	848	609
GDP/cap (ppp$/day)	71	3.1
GDP (10^9ppp$)	22,026	694
II. Scenarios for 2050		
A. Economies proceeding at current rates of growth		
Population (10^6)	1,040 (+ 0.4%/yr)[b]	2,071 (+ 2.4%/yr)[b]
GDP/cap (ppp$/day)	161 (+1.6%/yr)[c]	4.7 (+0.8%/yr)[c]
GDP (10^9ppp$)	60,949	3,638
B. Economies directed at sustainable, prosperous and equitable development		
Population (10^6)	939 (+0.2%/yr)[d]	1,123 (+1.2%/yr)[d]
GDP/cap (ppp$/day)	119 (+1.0%/yr)[e]	37 (+4.8%/yr)[f]
GDP (10^9ppp$)	40,735	15,196
C. An alternative scenario directed at sustainable, prosperous and equitable development		
Population (10^6)	939	827 (+0.6%/yr)[g]
GDP/cap (ppp$/day)	119	84 (+6.4%/yr)[h]
GDP (10^9ppp$)	40,735	25,306

Notes: [a]Source: UNDP (2001); [b]UNDP estimated growth rate, 1999-2015; [c]Actual growth rate, 1990-1999; [d]One-half the UNDP estimated growth rate, 1999-2015; [e]Two-thirds the actual growth rate, 1990-1999; [f]Three times the actual growth rate in hi-inc OECD, 1990-1999; [g]One-fourth the UNDP estimated growth rate, 1999-2015; [h]Four times the actual growth rate in hi-inc OECD, 1990-1999

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December 2001, 100 Nobel laureates warned that "The most profound danger to world peace in the coming years will stem not from the irrational acts of states or individuals but from the legitimate demands of the world's dispossessed." The tragic and diabolically clever attack on the USA by terrorists on 11 September 2001 was but one manifestation of the threat to the social stability to which the issues of economic equity and environmental sustainability contribute.

Wilson's prescription for addressing these threats challenges us to discover, integrate, disseminate and apply wisely the expanding storehouse of human knowledge in the manner urged by Boyer in his seminal paper *Scholarship Reconsidered* (Boyer, 1990). A knowledge-based society can seek a future path that is equitable, sustainable, and stable. This path points toward the vision of a global society in which all of the basic human needs and an equitable share of human wants can be met by successive generations while maintaining a healthy, physically attractive, and biologically productive environment (Malone, 1995). The strategy for a knowledge-based society calls for new kinds of knowledge partnerships among disciplines as well as among the major sectors of society.

A knowledge-based society

The storehouse of human knowledge about the physical characteristics of the world we inhabit and the universe within which that world is embedded has been steadily expanding. The accumulation of knowledge about the social characteristics of civilization is also accelerating. An explosion of understanding is under way in biology and in health care. Revolutionary communications technologies are becoming available for distributing widely this expanding knowledge. Our message, here, is simple. These are extraordinary tools that can and must be applied to accomplishing a more equitable and sustainable future.

The role of humans in this strategy follows from the dependencies that link human systems to global ecosystems: air, water, land, sunlight, living organisms, nonrenewable resources, and so on. The resulting interactions between human and natural systems are, of course, complicated. They are "site-specific" and "path dependent"; and so they display enormous diversity across the globe that perhaps rivals the diversity of its natural systems. Nonetheless, an aggregate portrait of the fundamental stresses created by these interactions can be expressed in terms of metrics that characterize the evolution of civilization. These metrics include changes in the number of people in the human system and changes in the average capacity of individuals in that system to draw upon the renewable and nonrenewable resources of the natural system to produce goods and services to meet human needs and to satisfy human wants.

Changes in the ways by which individuals' actions reflect their valuation of those natural resources and the implications of those valuations must also be reflected. Aggregate indices of economic activity like the gross domestic product per person can, for example, offer some insight into how the future might unfold, but care also needs to be taken to monitor the distribution of income within countries and across the globe and the degree to which long-term sustainability is reflected in human systems. Equity metrics designed to serve the former purpose exist, but metrics for the latter are more difficult to define. Economists offer price indices for natural resources as one option, but stronger standards of sustainability offered by ecologists would focus attention on stocks of "natural capital." Both views need to be accommodated if progress is to be made toward understanding how a vision of an environmentally sustainable, economically equitable, and stable world society is to be achieved.

The power that knowledge vests in individuals to choose demographic and economic paths into the future can be the key to beginning to understand how a new vision of world society compatible with the life-support capabilities of global ecosystems might be pursued. This pursuit will highlight critical questions concerning aggregate metrics. Are the stock and/or price signals of limited sustainability strong enough to spawn sufficient substitution away from scarce natural resources and sufficient conservation of natural systems? Are these signals sufficiently widespread to ensure the future of our environment and the diversity of its natural systems? If not, how much intervention will be required to ensure our long-term future more completely, and to determine when to apply this intervention?

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But will this intervention inhibit our ability to achieve equitably distributed levels of adequate prosperity?

A few landmarks on the path towards a knowledge-based society can already be identified. In his inaugural address on 20 January 1949, President Truman spoke of the distribution of knowledge as an "imponderable resource" more powerful than money in assisting the "peoples of the world" to overcome "hunger, misery, and despair" (McCollough, 1992).

Then, in 1987, the Report of the World Commission on Environment and Development (WCED) urged a commitment to the concept of sustainability that would meet the needs of the present generation without jeopardizing being able to meet the needs of future generations (Brundtland, 1987). The report called for the development of "... a new charter ... setting out the sovereign rights and reciprocal responsibilities of all states on environmental protection and sustainable development ...". In response, a United Nations conference on environment and development was planned as an "Earth Summit" to frame a global agenda that would reconcile economic development and environmental quality in the twenty-first century.

In preparation for that Earth Summit, Sigma Xi, The Scientific Research Society, convened representatives from several disciplines drawn from public and private institutions to reflect on *Global Change and the Human Prospect: Issues in Population, Science, Technology, and Equity* (Sigma Xi, 1992). In summary, participants endorsed Truman's emphasis on knowledge and accepted Ernest Boyers' interpretation of scholarship by observing:

> The overarching need is to bring to bear on these [issues] the expanding storehouse of knowledge about the world in which we live and our role in that world. This requires a balance among the tasks of extending, integrating, disseminating and applying this knowledge. ... The world has not yet addressed the potential of knowledge ... as a vital contributor to enhancement of the human prospect.

In 1994, Polytechnic University Chancellor George Bugliarello (at that time, President of Sigma Xi) argued that knowledge is becoming an organizing principle for society (Bugliarello, 1995). This theme was independently advocated by Sigma Xi's chief scientist in an address to an international conference in Seoul, Korea (Malone, 1998). He proposed a global knowledge strategy to realize the potential of "the storehouse of human knowledge" to address the set of global issues discussed at the 1991 Sigma Xi Forum.

In 1997, the American Geophysical Union organized a subsequent conference to explore initiatives in the twenty-first century that would build on the global collaboration fostered by the International Geophysical Year in the twentieth century (Malone, 1997). The conference concluded that

> An overarching challenge of the next few decades will be to make the transition from an unsustainable, inequitable, and unstable society to one that is sustainable, equitable, and stable. Our expanding knowledge ... offers an opportunity to meet this and other challenges.

Still later that year, the World Bank convened a conference in Toronto on "Knowledge for Development in the Information Age" that called for "a partnership of public and private organizations ... to mobilize knowledge capital ... to achieve sustainable and equitable growth" (World Bank, 1998). This conference stimulated the organization of a series of meetings and led to plans for an ambitious worldwide information network. Innovations that flow from mobilization of knowledge capital are gaining momentum (Amidon, 2001; Ruttan, 2001).

The early formulation of the charter urged by the WCED in 1987 did not gain the endorsement of governments at the 1992 Earth Summit in Rio, but it did rise Phoenix-like in subsequent discussions among nongovernmental organizations. The Charter that finally emerged in March 2000 was the culmination of more than a decade of extensive discussions at the grass roots among thousands of individuals from 78 countries, students from 300 universities, and dozens of nongovernmental institutions (see www.earthcharter.org). In brief, it noted:

> We stand at a critical moment in Earth's history, a time when humanity must choose its future. ... The choice is ours: form a global partnership to care for Earth and one another or risk the destruction of ourselves and the diversity of life. Fundamental changes are needed in our values, institutions, and ways of living. We must realize that when basic needs have been met, human development is primarily about being more, not having more. We have the knowledge and technology to provide for all and to reduce our impacts on the environment. ... This requires a change of mind and heart. ...

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The Earth Charter enunciated 16 principles that would underlie a just, sustainable and peaceful world. These principles suggest that ethical values are an integral part of the knowledge base that brings within reach an attractive vision for society. The Charter calls on "... the arts, sciences, religions, educational institutions, media, businesses, nongovernmental organizations, and governments to offer creative leadership – locally, nationally, regionally, and globally." It is to be presented as a "peoples' treaty" to the UN World Summit on Sustainable Development in Johannesburg, South Africa in 2002.

The message in the Earth Charter was supported in a completely independent statement, "Transition to Sustainability in the Twenty-first Century", adopted in Tokyo on May 2000 by more than 50 national and international academies of science (www.sustainabilityscience.org). Their interpretation offered society a challenge for the next century:

> During the twenty-first century, human society faces the daunting yet inspiring task of forging a new relationship with the natural world. This new relationship is captured by "sustainability," a concept that ... implies meeting current human needs while preserving the environment and natural resources needed by future generations. A successful transition to sustainability requires more effective use of existing scientific knowledge and technology, generation of further scientific knowledge, greater integration of science into society as a whole, and the wisdom to avoid the destructive uses of technological advances. ... if current trends in population growth, consumption of energy and materials, and environmental degradation persist, many human needs will not be met and the numbers of hungry and poor will increase.

This statement took, as its foundation, the seminal report *Our Common Journey: A Transition Toward Sustainability* published by the National Research Council (NRC) of the United States that urged "Integrating knowledge and action" (NRC, 1999a). A formal structure that includes an Inter-Academy Council, an Inter-Academy Medical Panel, and an Inter-Academy Panel on International Issues was established at Tokyo to bring together scientists, engineers, and medical experts to provide advice to governments on critical international issues.

Finally, a session on intergenerational equity at the Sigma Xi Forum on New Ethical Challenges in Science and Technology, on 9-10 November 2000 in Albuquerque, NM was a venue for the proposal to create Western Hemisphere Knowledge Partnerships (Gibbons and Malone, 2001). Dubbed WHKP, these partnerships are intended to test the hypothesis that knowledge, broadly construed, could be a critical factor in the pursuit of a society that is environmentally sustainable, economically prosperous and equitable, and therefore likely to be socially and politically stable. WHKP could become a model for other regional initiatives.

Some scenarios that illustrate the problems and the opportunities

Data on population and individual economic productivity, and their trends, are prepared and published annually in the series *Human Development Report* by the United Nations Development Programme. These data provide the basis for illustrative scenarios that starkly display the contrast between futures that would be simple continuations of current trends and alternatives that would pursue the vision of an equitable and sustainable future. Table I compares 23 high-income countries in the Organization for Economic Co-operation and Development (OECD) with the world's 40 least-developed countries (LDCs). Panel II A of Table I portrays the future that would emerge if current rates of growth were sustained over the next 50 years. As noted above, the "gap" in the average daily production and consumption of goods and services by individuals between the two groups of countries would increase from 23-fold to 34-fold even as the increase in the economy of the high-income OECD countries between 1999 and 2050 began to approach the size of the global economy in 1999 (~$40 trillion).

Panel II B of Table I portrays the results of a different, hypothetical, and "not-implausible" scenario designed to reflect a vision of equitable and sustainable development. It stipulates a 50 per cent reduction in the rate of population growth in both groups of countries accompanied by:

- an increase in the annual rate of growth in LDC productivity to levels that are three times larger than the current rate in OECD countries; and

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- a contraction in future productivity gains in the OECD countries to two-thirds of the current levels.

In this illustrative scenario, the gap in average individual production and consumption between the OECD and the LDCs in 2050 would be reduced to a three-fold difference from the 34-fold difference in Panel II A, while the growth in the combined economies of both regions would be significantly less. Panel II C illustrates how that gap could be reduced to less than two-fold, by annual gains of 6.4 per cent, but at the expense of an increase in the combined economies. Is a gain of 6.4 per cent really "not-implausible"? Perhaps not, but it is modest in comparison with the record of long-term annual gains of more than 8 per cent in China over the past several decades.

Scenarios presented in Table II compare China and India in like manner. China has maintained an annual increase in individual economic productivity of more than 8 per cent for the past quarter of a century while annual increases in population averaged only 1.3 per cent. If current growth rates were to continue to 2050, the economy of China would then be 20 times larger than the global economy in 1999. The average Chinese would be producing and consuming goods and services valued in local currency at the astronomical figure of more than 1,000 dollars per day! Other combinations of population growth and gains in economic productivity could reduce this multiple by a factor of ten. India, on the other hand, appears to be poised to move along a more sustainable path, with an eight-fold gain in the economic productivity of individuals by 2050 if current growth rates can be maintained. However, an associated near doubling in population would generate a 16-fold increase in India's economy. The associated demands on the life-supporting capacity of ecosystems could be diminished to 11-fold by reducing the rate of population growth by one-half. Alternatively, a scenario with smaller gains in productivity (e.g. 3.2 per cent per year) would reduce this 11-fold increase to seven-fold, but at a reduction in the living standards of individuals from one supported by individual economic productivity of $50 per day to one supported by only $31 per day.

Still another comparison of scenarios is presented in Table III where the declining

Table II Scenarios comparing China with India

	China	India
I. Characteristics of 1999[a]		
Population (10^6)	1,265	993
GDP/cap (ppp$/day)	10	6
GDP ($10^9$$)	4,535	2,242
II. Scenarios for 2050		
A. Economies proceeding at current rates of growth		
Population (10^6)	1,808 (+0.7%/yr)[b]	1,927 (+1.3%/yr)[b]
GDP/cap (ppp$/day)	1,260 (+9.5%/yr)[c]	50 (+4.1%/yr)[c]
GDP ($10^9$$)	831,208	35,058
B. Economies directed at sustainable, prosperous and equitable development		
Population (10^6)	1,512 (+0.35%/yr)[d]	1,383 (+0.65%/yr)[d]
GDP/cap (ppp$/day)	112 (+4.75%/yr)[e]	50 (+4.1%/yr)[f]
GDP ($10^9$$)	61,658	25,161
C. An alternative scenario directed at sustainable, prosperous and equitable development		
Population (10^6)	1,512 (+0.35%/yr)[d]	1,383 (+0.65%/yr)[d]
GDP/cap (ppp$/day)	51 (+3.2%/yr)[g]	31 (+3.2%/yr)[g]
GDP (10^9ppp$)	28,224	15,489

Notes: [a]Source: UNDP (2001); [b]UNDP estimated growth rate, 1999-2015; [c]Actual growth rate, 1990-1999; [d]One-half the UNDP estimated growth rate, 1999-2015; [e]One-half the actual growth rate, 1990-1999; [f]Actual growth rate, 1990-1999; [g]An example: twice the actual growth rate of 1.6 per cent in the high-income OECD, 1990-1999

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Table III Scenarios comparing the Russian Federation with Ireland

	Russian Federation	Ireland
I. Characteristics of 1998[a]		
Population (10^6)	146	<4
GDP/cap (ppp$/day)	20	71
GDP (10^9ppp$)	1,093	97
II. Scenarios for 2050		
A. Economies proceeding at current rates of growth		
Population (10^6)	108 (+0.6%/yr)[b]	>6 (+1.0%/yr)[b]
GDP/cap (ppp$/day)	1 (–5.9%/yr)[c]	1,593 (+6.1%/yr)[c]
GDP (10^9ppp$)	40	3664
B. Economies directed at sustainable, prosperous and equitable development		
Population (10^6).	146 (+0.0%/yr)[d]	4.9 (+0.5%/yr)[e]
GDP/cap (ppp$/day)	55 (+2.0%/yr)[d]	336 (+3.05%/yr)[e]
GDP ($10^9$$)	2,931	602
C. An alternative scenario directed at sustainable, prosperous and equitable development		
Population (10^6)	146 (+0.0%/yr)[d]	4.9 (+0.5%/yr)[e]
GDP/cap (ppp$/day)	92 (+3.0%/yr)[f]	336
GDP ($10^9$$)	4,926	602

Notes: [a]Source: UNDP (2001); [b]UNDP estimated growth rate, 1999-2015; [c]Actual growth rate, 1990-1999; [d]For example; [e]One-half the UNDP estimated growth rate, 1999-2015; [f]Another example

population and individual economic productivity in the Russian Federation is compared with the exuberant expansion of both in Ireland. A reversal in the trend of productivity in the Russian Federation while holding population constant would have the potential of creating a path into the future that would be consistent with global trends. The stage is set for substantial gains in productivity in the Federation. Clearly, a moderation in productivity increases in Ireland is in order.

A final set of scenarios for the Western hemisphere is presented in Table IV. Canada and the USA represent industrial countries. The 34 nations in Latin America and the Caribbean portray countries in various stages of development. Under current rates of demographic and economic growth, the "gap" in the daily production of goods and services between these two groups would increase from $67 to $193 while economic activity in the Western hemisphere would increase by more than four-fold to support 50 per cent more people living in Canada and the USA and nearly 100 per cent more people living in Latin America and the Caribbean. Cutting the rate of population growth in both groups by 50 per cent, increasing individual economic productivity rates two and a half times in Latin America, and curtailing productivity growth by one-fourth in Canada and the USA, would reduce the economic gap in the daily production and consumption of goods and services to $19 per day from the $193 per day in the business-as-usual scenario. Living standards in Canada and the USA would still increase by more than 100 per cent. They would improve more than eight-fold in the other countries. Equity of this kind would be the goal that could be achieved in the Western hemisphere, but steps would be required to reduce the impact of concomitant economic expansion on the carrying capacity of life-supporting ecosystems. In Panel II B of Table IV, the population of the Americas would increase by one-third and economic activity would have expanded nearly five-fold. Economic equity would be pursued, but formidable challenges in sustainability remain to be resolved.

These scenarios are representative of many that might be constructed to pursue the vision of a sustainable, equitable, and stable society. Growth rates of population and individual economic productivity that would simultaneously pursue environmental sustainability would have to be compatible

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Table IV Scenarios for the Americas

	Canada and USA	34 nations in Latin America and Caribbean
I. Characteristics of 1999[a]		
Population (10^6)	311	494
GDP/cap (ppp$/day)	86	19
GDP (10^9ppp$)	9,668	3,391
II. Scenarios for 2050		
A. Economies proceeding at current rates of growth		
Population (10^6)	468 (+0.8%/yr)[b]	959 (+1.3%/yr)[b]
GDP/cap (ppp$/day)	238 (+2.0%/yr)[c]	45 (+1.7%/yr)[c]
GDP (10^9ppp$)	40,622	15,702
B. Economies directed at sustainable, prosperous and equitable development		
Population (10^6)	381 (+0.4%/yr)[d]	688 (+0.65%/yr)[d]
GDP/cap (ppp$/day)	185 (+1.5%/yr)[e]	166 (+4.25%/yr)[f]
GDP (10^9ppp$)	23,142	41,253

Notes: [a]Source: UNDP (2001); [b]UNDP estimated growth rate, 1999-2015; [c]Actual growth rate, 1990-1999; [d]One-half the UNDP estimated growth rate, 1999-2015; [e]Three-quarters of the actual growth rate, 1990-1999; [f]Two and a half times the actual growth rate, 1990-1999

with emerging knowledge on the carrying capacity of global ecosystems (Goldemberg, 2001). Do they teach us anything new? Again, perhaps not. The fundamental lesson of these scenarios was revealed centuries ago in Sir Thomas More's *Utopia*: "pursuit of an ideal society requires that restraint be exercised in accumulating material luxuries" (More, 1516). And it was reconfirmed at the end of the twentieth century by Kates (2000).

But how can that restraint be distributed without doing harm to goals of improved equity? Yohe and Van Engel (2001) have conducted a visioning exercise calibrated to the storylines underlying the scenarios that have been described in *Special Report on Emissions Scenarios* of the Intergovernmental Panel on Climate Change (IPCC) to explore just that question (IPCC, 2000a). Their economic visioning exercise targets equity and sustainability goals explicitly, but in a very aggregate context; their results must therefore be interpreted with extraordinary care. Nonetheless, the results show that the economic paradigm can offer insight into how and when certain visioning targets might be relatively more or less difficult to achieve (Yohe and Van Engel, 2001).

Specifically, Yohe and Van Engel show that it might be possible to achieve ambitious combinations of equity and sustainability over the next 50 years, but it will not be easy. They suggest that bringing per capita income in low-income countries above 33 per cent of levels observed in high-income countries could be infeasible if those efforts were coupled with modest sustainability targets under even the most optimistic of scenarios. That point notwithstanding, the severity of the trade-off between sustainability and equity could be overstated even if specific sustainability targets turned out to be quite expensive to achieve. Transfers of international capital and the knowledge that it embodies on the production side of the economy would improve relative equity between low-income and high-income countries. And the same transfers would also spread the incidence of achieving any sustainability target more evenly across international boundaries.

Casting these insights into the present context, we can claim with some confidence that:

- transferring technology and knowledge from high-income countries to low-income countries through direct investment could significantly reduce global inequality measured in terms of per capita income over the next 50 years; and that
- effecting these transfers before the middle of this century could ultimately lead to a situation where the cost of reflecting sustainability targets in the prices of scarce and depleting resources could be shared in equal proportion.

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Recognition that it will take time for this situation to materialize was, of course, the reason why the United Nations Framework Convention on Climate Change divided the world into Annex I and non-Annex I countries, but the failure of the Kyoto Protocol shows that global leaders have not yet committed themselves to the requisite first steps in confronting the equity issue. The international institutions and mechanisms that will be required to initiate and sustain effective technology and knowledge transfers simply do not exist, and they will not be created without a concerted and persistent global commitment to do so. The more than 100 regimes of Multilateral Environmental Agreements need to be reviewed and strengthened.

Elements of a strategy

Armed with visions like these, the next step is to fashion a strategy to pursue that vision, we propose a strategy that is human-centered and knowledge-based: a partnership among

- disciplines that embrace the physical, biological, health, and social sciences, technology, the humanities, and the learned professions;
- societal sectors that include academia, business, industry, labor, government, and nongovernmental institutions; and
- industrial and developing nations.

The partnership would be along eight topical areas ranked by importance and urgency in the following order:

(1) Education – development of human capital is the *sine qua non* of a knowledge- and ethical values-based economy (there are 880 million illiterate adults in the world and 113 million youngsters without access to primary education (UNDP, 2001)). But education should be interpreted in terms of life-long learning. Potentially powerful new communications technologies are opening the way to act on this interpretation (Hanna and Latchem, 2001). More than deployment of a new technology will be required. Integration across disciplines and an understanding of the role of knowledge in social and economic development will be necessary (Dorf, 2001; Rhodes, 2001; Carrillo, 2001).

(2) Exploration of environmentally benign sources of energy to power economic growth (Goldemberg, 2001). The accumulation of greenhouse gases in the atmosphere is emerging as a regional and global issue (IPCC, 2000b).

(3) Eco-efficiency in the production and consumption of goods and services in order to alleviate the impact of further economic growth on US ecosystems. The literature is extensive (NRC, 1999b and www.innovaworld.net).

(4) Health and resilience of natural ecosystems – described as "enormously challenging", this topic will require developments of indicators of the pressures, extent, and output of agricultural, coastal, forest, freshwater, and grassland ecosystems and the analysis of natural disasters (NRC, 1999c) and www.milleniumassessment.org).

(5) Extension of national income accounts to include environmental impacts and to be consistent with other measures of social health (NRC, 1999c as well as Miringoff and Miringoff, 1999).

(6) Local community networks need to be fostered to ensure a societal response in rural and rapidly growing urban areas (www.vcn.bc.ca and www.globalideasbank.org/BOV/BV-612.HTML).

(7) Intellectual property rights demand attention in a knowledge-based economy (NRC, 2000).

(8) Delivery of health care is entering an era of profound change in which integration with the sciences and sharing of new knowledge and practices are increasingly important (NRC, 2001 and www.intrah.org).

In each topical area, interaction will be cultivated intensively and extensively with organizations and programs through networks and communications technologies (distance learning for education (Hanna and Latchem, 2001) and collaboratories for research (NRC, 1993)).

Conclusions

Visions of knowledge-based societies have dotted the landscape for nearly a decade. We have offered a few simple quantitative

exercises that were designed to make it clear that distributing expanding knowledge and shared ethical values through emerging communications technologies could be the key to unlocking the sort of environmentally sustainable, economically prosperous and equitable future that is likely to be socially and politically stable. The formidable challenge of the next few decades is to marshal that knowledge and those values with the aid of the new communications technologies and pursue the societal vision now within reach. To respond to that challenge, the empowerment that expanding knowledge and new communications technologies vested in individuals to create their future must be embedded in partnerships of disciplines and institutions. These new communications technologies open new vistas for knowledge management. As noted in a major assessment released in 2002, "... information and communication technologies (ICTs) remain a powerful and important force for positive change in the world. ... (this) report addresses the major opportunities and obstacles that global leaders face as they try to more fully participate in the Networked World" (Harvard Center for International Development and World Economic Forum, 2002). The diverse leadership identified in the Earth Charter must be closely linked with individuals for knowledge management to be effective.

Our discussion of scenarios for human development underscored three overarching conclusions. First of all, a comprehensive agenda must be addressed with vigor and a keen sense of urgency by an array of knowledge partnerships involving all disciplines and all sectors of society in both industrialized and developing nations. Wilson's (1998) prescriptions of "unified learning, universally shared" and "the fundamental principle that ethics is everything" are central to the activities of those partnerships. Coordinated regional programs, such as the proposed Western Hemisphere Knowledge Partnerships and similar initiatives in other parts of the world, offer attractive opportunities for creating pilot projects in an endeavor that ultimately must be global in scope. To accomplish a global scale, however, imaginative innovations and institutional restructuring will be essential.

Second, a new paradigm that frames the interactions between human and natural systems on planet Earth and within human systems is equally imperative. The principles included in the Earth Charter provide the bases for this paradigm by making it clear that a sustainable, prosperous and equitable future will not be the product of business as usual. A fractious world is poised on the brink of an era of terrorism, so we have no time to lose. The Charter closes with a challenge:

> Let ours be a time remembered for the awakening of a new reverence for life, the firm resolve to achieve sustainability, the quickening of the struggle for justice and peace, and the joyful celebration of life.

We urge early adoption of these principles by the United Nations as the basis for developing legally binding instruments by all nations.

Finally, further development of the conceptual framework for knowledge management and its application to social innovation will be required. New instruments based simply on legal constructions will not effect change if social innovations do not promote "win-win" opportunities and thereby convince decision-makers around the world that we are not confined to the payoff matrix of the conventional zero-sum game.

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