

The future of science and technology and pro-poor applications

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Abstract

Purpose – *The purpose of this paper is to highlight the overall lack of focus of existing foresight analysis concerning the future of science and technology on the issue of poverty. The paper looks to re-orient the technology foresight community to adopting an explicit pro-poor perspective when considering future developments in science and technology (S&T).*

Design/methodology/approach – *The paper presents a general overview of existing technology foresight studies from organizations located in North America, Europe, and Asia. By describing the key points made in a selection of foresight studies, the paper emphasizes the conceptual links between forward-looking analysis related to S&T and poverty-related issues.*

Findings – *The paper reaches two main conclusions about the role of S&T foresight and development. The first is that the foresight research community needs to interact more closely with the development community in order to enhance the value of the findings in each field to the other. Second, the pressing matter of poverty alleviation requires that the foresight community should come together and create a sense of urgency in issues that have long-term implications but need immediate action and attention.*

Research limitations/implications – *This paper is limited to an approach that provides an overview of existing work in technology foresight. While no such review could be comprehensive, this paper provides examples of technology foresight analysis from a range of geographies, sectors, and perspectives to help mitigate this gap.*

Practical implications – *The argument suggests that technology foresight practitioners should make issues of poverty an explicit topic or category of analysis in future technology foresight activities. Including poverty issues in future scenario activities would go a long way to closing this gap.*

Originality/value – *This paper synthesizes ideas from a variety of forward-looking studies addressing the future of science and technology and identifies the need to include poverty as a dimension for analysis in future studies. In addition, the paper provides an introduction to technology foresight work being conducted in Asia by the APEC Center for Technology Foresight.*

Keywords *Sciences, Innovation, Forward planning*

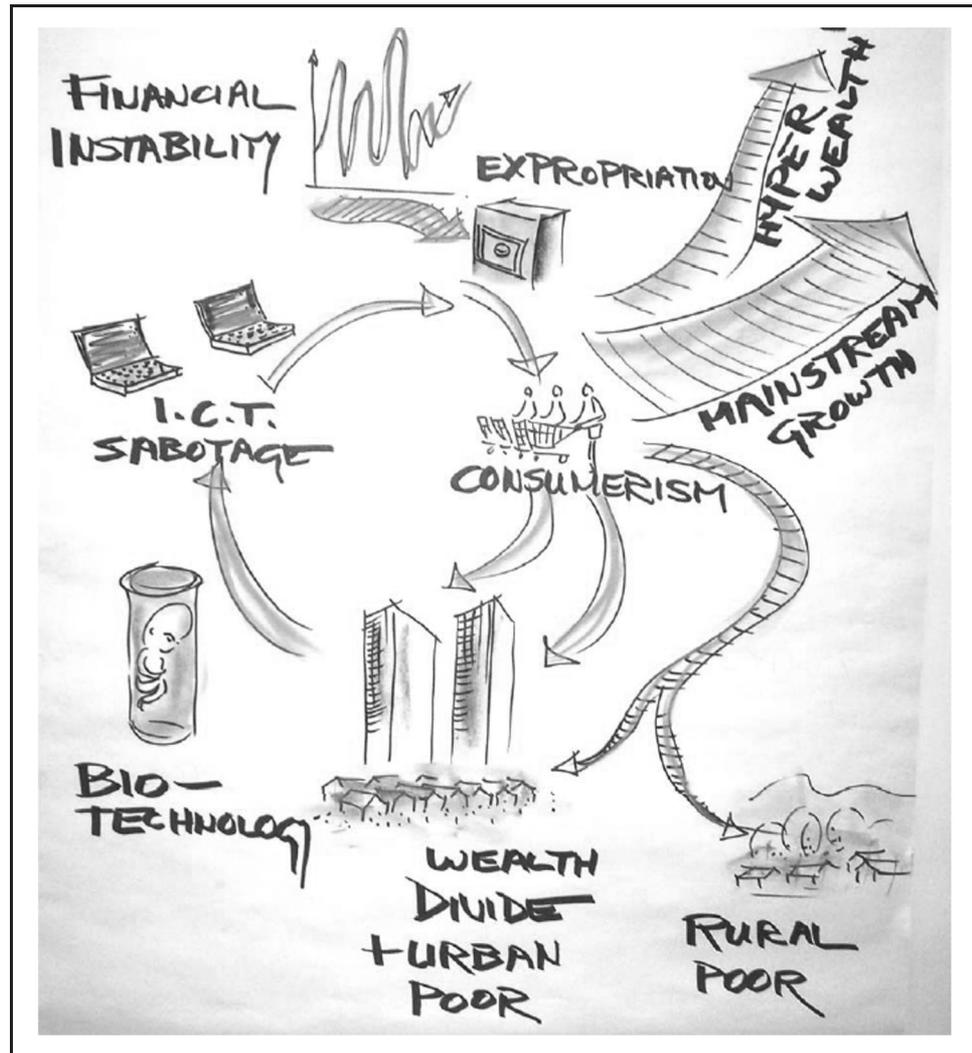
Paper type *General review*

1. Introduction

“Foresight involves systematic attempts to look into the future of science, technology, society and the economy, and their interactions, in order to promote social, economic and environmental benefit” (APEC Center for Technology Foresight, 2009a). The above statement is the definition of foresight as adopted by the APEC Center for Technology Foresight since 1998. As noted in the definition, among the most important elements of the future that need to be assessed with foresight, arguably there must be sufficient attention paid to science and technology (S&T) as the significant driver or accelerator of change, for better or worse.

The purpose of foresight is usually to identify risks, handle uncertainties, and provide organizations with better preparedness. Figure 1, produced at the Bellagio workshop, illustrates some of these risks and benefits in a visual manner. However, it is rare and unusual

Figure 1 Potential risks and benefits of science and technology



to find any “foresight” that directly addresses the need of the poor, or pro-poor foresight. Particularly when it comes to foresight in science and technology, it is even rarer to find any work aiming at alleviating poverty.

This paper begins by reviewing science and technology foresight work involving scenarios that are relevant to poverty, focusing on general “big picture” global scenarios anticipating the greatest global challenges and opportunities. Then it will examine some sectoral or thematic scenarios that relate science and technology to the global scenarios. Subsequently, the paper will take a closer look into the scenarios for futures associated with, or that directly describe, the prospects of global science and technology, its changing paradigms, and questions that will shape changes in science and technology over the next five to 20 years. Finally, the focus will be given to envisioning the wide-ranging implications for potential intersections and cross-cutting impacts on poverty and development issues.

2. The changing global landscape and alternative scenarios

Some attempts have been made to project and build global scenarios to cast light on the context in which the world, humanity, and organizations operate, to identify emerging challenges, and to foster adaptability to change.

Generally in foresight studies, five main groups of drivers (or driving forces) are identified: Social, Technological, Economical, Environmental, and Political (STEEP). In accordance with the often used STEEP model, this paper will use the STEEP framework to examine some recent global scenarios and identify areas in which science and technology could play a significant role.

For instance, The Millennium Project's work, as reported in the *2008 State of the Future (SOF)*, provides insights that can help decision-makers and educators who fight poverty and address various social concerns, such as fighting against hopeless despair, blind confidence, and ignorant indifference, to improve the prospects for humanity (Glenn *et al.*, 2008). This annual report, published in its twelfth year of the project, presents an optimistic future of the world where advances in science, technology, education, economics, and management seem capable of making the world work far better than it does today.

The *SOF* report sets out to identify 15 Global Challenges and has been updating these challenges through the Delphi process and environmental scanning since 1996. These challenges range from developmental to ethical challenges and can be categorized using the STEEP framework, as shown in Table I. For example, the changing status of women can be categorized as a Social driver, and addressing population growth and resources can be categorized as a Social, Economical, and Environmental driver.

According to Table I, most frequently the challenges fall into the category of Social and then Economical. There are four Challenges with clear implication of science and technology,

Table I The state of the future 15 global challenges

Challenge	Category of driving/pulling force				
	Social	Technological	Economical	Environmental	Political
How can sustainable development be achieved for all while addressing global climate change?	✓	✓	✓	✓	
How can everyone have sufficient clean water without conflict?			✓	✓	
How can population growth and resources be brought into balance?	✓		✓	✓	
How can genuine democracy emerge from authoritarian regimes?					✓
How can policymaking be made more sensitive to global long-term perspectives?					✓
How can the global convergence of information and communications technologies work for everyone?		✓			
How can ethical market economies be encouraged to help reduce the gap between rich and poor?			✓		
How can the threat of new and reemerging diseases and immune micro-organisms be reduced?	✓	✓	✓		
How can the capacity to decide be improved as the nature of work and institutions change?	✓				✓
How can shared values and new security strategies reduce ethnic conflicts, terrorism, and the use of weapons of mass destruction?	✓				✓
How can the changing status of women help improve the human condition?	✓				
How can transnational organized crime networks be stopped from becoming more powerful and sophisticated global enterprises?	✓		✓		✓
How can growing energy demands be met safely and efficiently?	✓		✓	✓	
How can scientific and technological breakthroughs be accelerated to improve the human condition?		✓			
How can ethical considerations become more routinely incorporated into global decisions?	✓				✓

Source: Analyzed using input from *2008 The State of the Future*

including Challenge 1 (“How can sustainable development be achieved for all while addressing global climate change?”), Challenge 6 (“How can the global convergence of information and communications technologies work for everyone?”), Challenge 8 (“How can the threat of new and reemerging diseases and immune micro-organisms be reduced?”), and Challenge 14 (“How can scientific and technological breakthroughs be accelerated to improve the human condition?”).

While science and technology did receive attention, the 2008 *SOF* assessment indicates that the acceleration of S&T innovations, improved communications among scientists, and future synergies among nanotechnology, biotechnology, information technology, and cognitive science will fundamentally change the prospects for civilization. Many of these innovations, however, are likely to be confined to applications directed at improving the lives of individuals in the developed world and could have less of an impact on the developing world. We will come back to examine the details of the future prospects of science and technology as seen in the 2008 *SOF* in the latter part of this paper.

To actually “measure” our future landscape, the 2008 *SOF* dedicated substantial effort in the *State of the Future Index (SOFI)*, which describes and updates a measure of the 10-year outlook for the future based on the previous 20 years of historical data. It is constructed with key variables and forecasts that, in the aggregate, depict whether the future promises to be better or worse. A set of 29 variables was identified by an international panel of experts selected by the Millennium Project Nodes around the world during a study conducted in 2006-2007. Participants were asked to rate the variables, give worst- and best-scenario estimates, suggest new variables to be included in the *SOFI*, and suggest sources that could provide at least 20 years of historical data.

As indicated in Table II, the *SOFI* assessment tracks the world’s key indicators over the past 20 years and projecting them for the next 10 gives the basis for a report card for humanity’s future, showing where we are improving or worsening (Table I).

The global *SOFI* indicates that the future over the next 10 years is still getting better, although not as rapidly as it did over the past 20 years. The alternative projections are based on the potential occurrences of events that can alter the future trends.

A trend impact analysis (TIA) was also performed to examine the effect of events that might be important to the outcome of the *SOFI*. As Figure 2 indicates, this analysis had the consequence of improving the forecasted *SOFI* so that the historical trends are extended under different circumstance over the next decade (grey and dotted lines in Figure 2, where the 2007 *SOFI* is the most updated data in the 2008 report).

Although the numbers are somewhat different, the 2007 *SOFI* curve shows the same general shape as the *SOFI* solutions of the past few years: relatively rapid growth since the mid-1980s, then a continued but slower growth into the next ten years.

Beyond the *SOFI*, a report entitled *Science and Technology 2025 Global Scenarios* were included as part of the *SOF* 2008 and will be covered later in this paper. The scenarios provided the readers with some “what if” questions that are both optimistic and desperate, such as:

Table II Areas where the world is improving v. worsening	
<i>Where we are improving</i>	<i>Where we are worsening</i>
Life expectancy	CO ₂ emissions
Infant mortality	Terrorism
Literacy	Corruption
GDP/capita	Global warming
Conflict	Voting population
Internet users	Unemployment

Source: Adapted from 2008 *The State of the Future*

Figure 2 State of the future 2007 with alternative projections by trend impact analysis

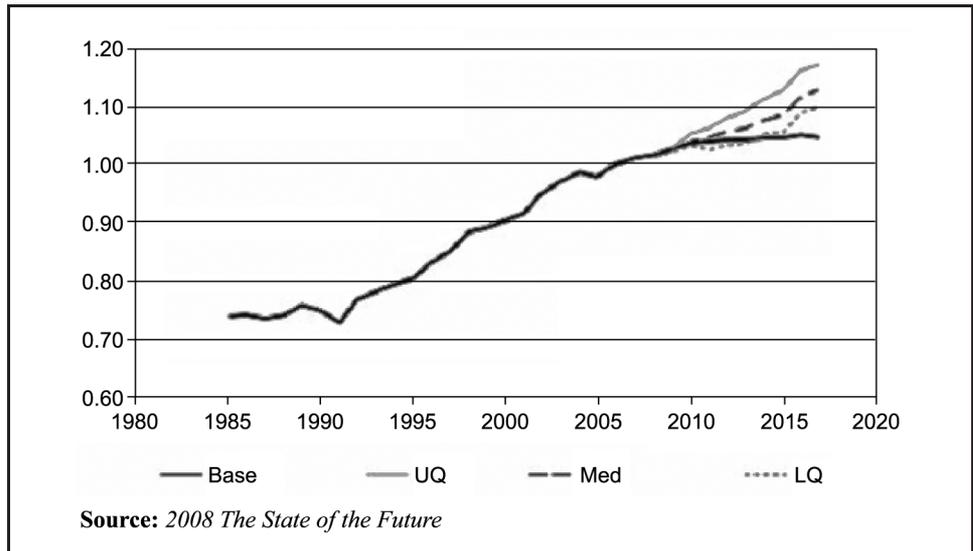
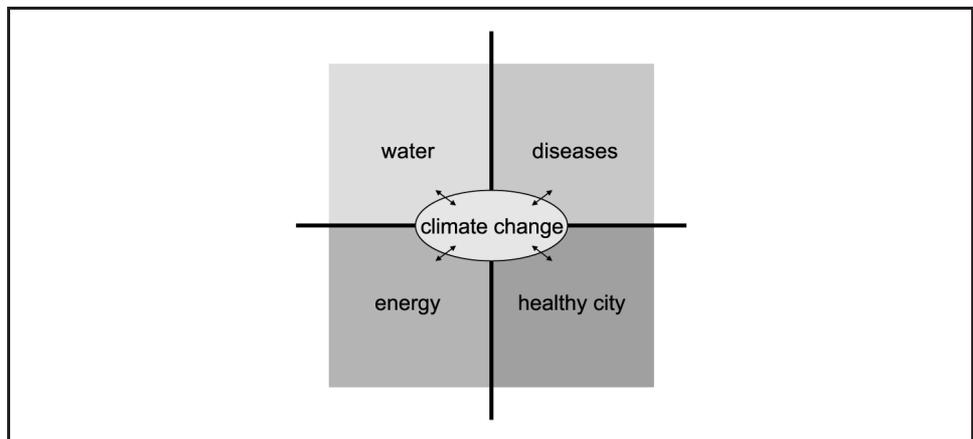


Figure 3 Interactions and integrated impact of four thematic areas on the area of climate change



- What if the world - led by the European Union - pressured the United States and China to create a global energy research and development (R&D) strategy with an Apollo-like goal to turn around greenhouse gas emissions in ten years?
- What if governments declared increasing intelligence as a national educational goal?
- What if politicians campaigned on how to answer the 15 Global Challenges?
- What if we did not waste so much time and talent on trivia?

The 2008 *SOF* report concluded that “after 12 years of the Millennium Project’s global futures research, it is increasingly clear that the world has the resources to address our common challenges. Coherence and direction are lacking.” For example, climate change cannot be turned around without a global strategy. It becomes clear to the world in 2008 more than ever that climate change is going to be one of the biggest challenges, threatening the very future existence of humankind and most other species on Earth (Lovelock, 2009; Griffiths, 2009), and that even the United Nations Development Programme’s (UNDP’s) *Human Development Report 2007/2008* offered an unprecedented dedication to fighting climate change (United Nations Development Programme, 2008).

This examination of the global futures landscape provides an indication how the five areas of driving forces of the STEEP model can be applied, and an overview of what alternative futures and challenges are awaiting the world where science and technology could possibly play significant roles. From this overview, however, we can see the forest and possibly know little about the trees. While it is not possible to cover all the trees, we may examine some thematic scenarios that are relevant to science and technology, especially those themes in the areas of socioeconomic and environmental categories, such as clean water supply and management, food, health, and energy.

3. APEC Center for Technology Foresight thematic foresight studies in high impact areas

When it comes to thematic foresight studies, the research community has never been short of inputs. Over the past 10 years, the APEC Center for Technology Foresight, among others, has been conducting some thematic foresight studies in these high-impact areas, with the prospect of encouraging the Asia-Pacific region in the development and use of potential science and technology to respond to these trends.

- As the Human Development Report 2007/2008 highlights, “approximately 1.8 billion more people could be living in a water scarce environment by 2080”. Foresight studies on the issue of water point out the need for an integrated global water strategy, plan, and management system to focus knowledge, finances, and political will to address this challenge (APEC Center for Technology Foresight, 1998). Countries could apply the lessons learned from producing more food with less water via drip irrigation and precision agriculture, rain water collection and irrigation, and replication of successful community-scale projects around the world. Improvement in water supply and management will also help improving sanitation and health in poorer countries, as about 80% of diseases in the developing world are water-related (Annan, 2003).
- A large number of in-depth studies on the future of energy have been conducted and released by many energy-related companies, governments, and international organizations (Interlaboratory Working Group, 2000; Royal Dutch Shell plc, 2008). Consideration usually focuses around the issue of energy security, along with environmental and social consequences, including safety and cleanliness (greenness) of energy sources and fuels. Renewable and low-carbon technologies are the areas where most R&D investment are placed, with solar energy and biofuels leading the way. APEC Center for Technology Foresight has recently conducted a study on future fuel technology and concluded that the integration of biofuels, unconventional hydrocarbons, and hydrogen will become the key to responding the future demand of fuel in Asia-Pacific (APEC Center for Technology Foresight, 2006).
- About 30 percent of all deaths worldwide are caused by infectious diseases, with emerging and re-emerging infectious diseases increasing at an alarming rate during the recent years, posing a clear global security threat. For sufficient preparedness, all control options, pharmaceutical and non-pharmaceutical, must be considered and fully explored. In most cases these options require capabilities in new technological development and usage, and/or convergence between existing technologies. These technologies include genetic-based vaccines and microbicides, modeling and simulation, ubiquitous computing, cheap diagnostic kits for developing economies, and tracking technologies for effective surveillance (UK Foresight, 2007; APEC Center for Technology Foresight, 2008).
- The concept of the healthy city, including education, transport, and society, has been repeatedly explored in studies conducted by the APEC Center for Technology Foresight. The year 2008 was commemorated as the time when for the first time more than half of the world population is living in cities (United Nations, 2008), and there are many emerging risks and vulnerabilities accompanying this global urbanization. Initiatives like the Rockefeller Foundation’s Asian Cities Climate Change Resilience Network look to address this issue by “creating robust models and methodologies for assessing and addressing

risk through active engagement and analysis of various cities” (The Rockefeller Foundation, 2009).

As Figure 3 indicates, the impacts of risks and vulnerabilities related to water, energy, diseases and cities are the four areas that the APEC Center for Technology Foresight has studied throughout the past decade, with considerable interactions and integrated impacts being addressed in its most recent ongoing foresight project, titled “Futures of Low Carbon Society: Climate Change and Strategies for Economies in APEC Beyond 2050” (APEC Center for Technology Foresight, 2009b). The APEC Center for Technology Foresight is conducting a Real-Time Delphi project on this topic in the Asia-Pacific region and will use the result as an input for a subsequent scenario workshop later in 2009, with final result expected in 2010.

As the demand for specific S&T developments and applications is becoming clearer in these thematic foresight studies conducted by the APEC Center for Technology Foresight, attention will now turn to the future prospects of global science and technology, including its governance, its changing paradigms, and questions that will shape changes in science and technology over the next five to 20 years.

4. Science and technology applications as the building blocks for the future?

Progress in science, technology, and innovation usually happens either in private corporations, academic institutes, or government institutes. However, more attention is needed to ensure that these innovations focus on the poor and address the complexities of globalization, and there have been increasing efforts to link issues in science and technology, such as knowledge acquisition and technology transfer, to these topics (Juma and Lee, 2005).

For instance, *Towards 2020 Science*, published in 2006 from Microsoft Research in Cambridge, UK, contained the initial findings and conclusions of a group of internationally distinguished scientists who met over an intense three days in July 2005 to debate and consider the role and future of science over the next 14 years, towards 2020 (The Science Group, 2006). In particular, the report discusses the importance and impact of computing and computer science on science towards 2020. A number of findings from this project present a proposed vision for science, including “a leap from the application of computing to support scientists to ‘do’ science (i.e. ‘computational science’) to the integration of computer science concepts, tools and theorems into the very fabric of science”; combining computer science tools with other areas of science to “accelerate key breakthroughs in science and benefits to society by helping to protect the life-support systems of Earth on which we all depend for our survival”; and link “fundamental new developments in biology, biotechnology and medicine, and potentially profound developments in the future of computing”.

Although this report is heavily and narrowly computer/computational science-oriented, and seems to be mismatched with the global and thematic future scenarios discussed so far, the findings suggests a number of *social* and economical implications. According to this report:

Scientists will need to be completely computationally and mathematically literate, and by 2020, it will simply not be possible to do science without such literacy. These developments will also fundamentally affect how science needs to be funded, what science is funded, and questions many current assumptions underpinning existing science policies. This assessment also has economic implications, as governments are starting to give birth to ‘new kinds’ of science and possibly a new economic era of “science-based innovation” that could create new kinds of high-tech sectors that can barely be imagined today, just as today’s rapidly growing “genomics” sector could barely be imaged two decades ago (The Science Group, 2006).

A wider-range examination of future science and technology and its impact was presented in a report by the RAND Corporation in 2006, entitled *The Global Technology Revolution 2020, In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications* (Silbergliitt *et al.*, 2006). The report not only looks at the applications, implementation, and impact of a number of key future issues in science and technology, but

it also offers an international comparison of the different capacity to acquire technologies and illuminates problems and issues in applying technologies to societal challenges.

The RAND report analyzed technology trends and applications in the areas of biotechnology, nanotechnology, materials, and information. It argued that it is the integration of developments that “can have the most profound impact on society by providing multifunctional technologies to meet specific application needs”. To evaluate the potential impact of technology applications on society, the RAND report used a rough net assessment index composed of the sum of the number of societal sectors - such as water, food, land, population, governance, social structure, energy, health, economic development, education, defense/conflict, and environment/pollution - that the technology applications could affect over the coming years. The report notes that this evaluation “was conducted using measures of technical feasibility, implementation feasibility, and global diffusion.” While this rough net assessment index did not measure the magnitude of impact on specific sectors, it did highlight feasible applications with multi-sectoral impact and global reach (Silberglitt *et al.*, 2006, p. 16).

The report notes that of the 56 technology applications that emerged, a “top 16” emerged based on this net assessment index, which formed a representative group that “allowed further evaluation of worldwide variation in technology implementation and its relevance to significant societal problems and issues” (Silberglitt *et al.*, 2006, p. xviii). These “top 16” technologies include: Cheap solar energy; Rural wireless communications; Communication devices for ubiquitous information access anywhere, anytime; Genetically modified (GM) crops; Rapid bioassays; Filters and catalysts for water purification and contamination; Targeted drug delivery; Cheap autonomous housing; Green manufacturing; Ubiquitous RFID tagging of commercial products and individuals; Hybrid vehicles; Pervasive sensors; Tissue engineering; Improved diagnostic and surgical methods; Wearable computers; and Quantum cryptography. The report uses a series of criteria to evaluate the societal implications of these new technologies, as well as considering technology “might contribute to problems and issues that have less-obvious linkages”. It notes that, “for example, filters and catalysts will benefit rural economic development and homeland security, respectively, by providing clean water to rural populations that lack access to reliable and safe water supply, as well as to communities after terrorist attacks or hazardous materials spills that damage their regular drinking water source” (Silberglitt *et al.*, 2006, p. 55). In conclusion, the RAND report recognized that “continuing development of these technology applications, changes in laws and policies, new business models to dissemination innovation, and other factors may make a technology application more or less relevant to a particular problem or issue” (Silberglitt *et al.*, 2006, p. 61).

The question of whether and how science and technology applications can actually become the building blocks for the future is also assessed in one of the most prominent works on this topic, the *2025 Science and Technology Management Scenarios* (also referred to as *Science and Technology 2025 Global Scenarios*) (Glenn *et al.*, 2008, chapters 3 and 5). This work was conducted as part of the Millennium Project, a global participatory futures research network of futurists, scholars, business planners, and policy makers who work for international organizations, governments, corporations, NGOs, and universities.

During 2001-2003 the Millennium Project and its representatives Nodes around the world conducted a Delphi survey - a two-round questionnaire aiming at a limited number of selected participants - to assess future science and technology, policy, and management issues. The results of the survey were then used to produce long-range alternative scenarios on global science and technology. The project explored S&T issues over 25 years from the year 2000, the implications of these issues for S&T management, and finally the policy and management alternatives explicit via the scenarios. It was a worldwide effort to collect and synthesize judgments about emerging global challenges that may affect the human condition.

From the point of view of developing countries, the four global scenarios resulting from this research, though slightly outdated now, were of interest and value to the national

governments, scientific communities and the institutions that fund such research, providing the context for setting long-term goals and strategies for technology applications. The four scenarios were termed “S&T develops a mind of its own”, “The world wakes up”, “Please turn off the spigot”, and “Backlash” (Glenn *et al.*, 2008, chapter 3.5). From each scenario emerge a number of questions that are relevant to the course of science and technology policy options for the future. These questions include:

- Are dramatic increases in collective human-machine intelligence plausible?
- Is it likely that organizations designed to regulate the course of S&T will generally fail to keep pace with accelerated advances of S&T?
- Is it plausible that weapons of mass destruction will be available to single individuals?
- Is it plausible that advances in cognitive science, information technology, and new educational systems and/or changes in older ones will be able to significantly improve tolerance for diversity?
- Is it plausible that international S&T treaties and regulations will have provisions for enforcement police enforcement or military intervention?
- Can S&T regulators and commissions be virtually free from corruption?
- Is it plausible that an anti-science movement will be as or more powerful than the environmental movement?
- Is it plausible that international systems (like the International Atomic Energy Agency – IAEA) will be established to monitor and regulate biotechnology, nanotechnology, and other areas of scientific research and development with enforcement powers?
- When extreme unintended consequences are involved, can a cost-benefit trade-off be logically made?
- Might scientists in the future unite into a global labor organization? Can science disciplines effectively self-regulate?

The scenarios and the above questions reveal the prospects of global science and technology and its changing paradigms. They demonstrate that science and technology is recognized not only as positive but also possibly negative driver to the future, sometimes dangerous, depending on how it is managed and the setting where it is applied, as seen in the questions. How we answer these questions will shape changes not only in science and technology but the societies we live in over the next five to 20 years. The next and final part of this paper will focus on the wide-range implications, potential intersections and cross-cutting impacts on poverty and development issues.

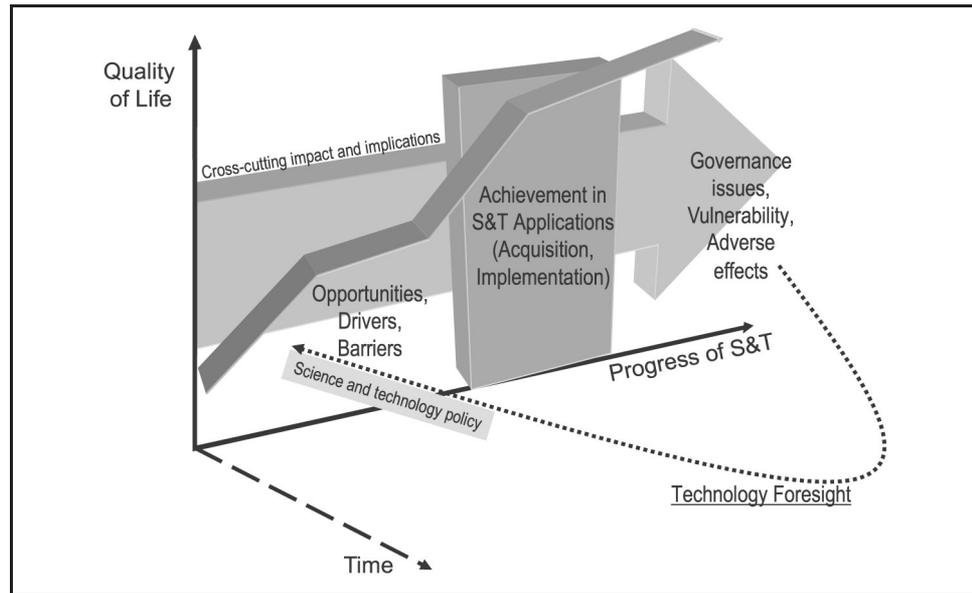
5. Cross-cutting impact and implications on poverty and human development issues

As reviewed so far, it is evident that there are few literatures on foresight, and particularly technology foresight, which directly address the issue of poverty. Therefore, we may have to also consider the indirect implications of future technology applications that might have less obvious linkages to poverty reduction and addressing inequalities.

Figure 4 maps the progress of science and technology with the improvement of quality of life, such as improved health, welfare, and security, amongst other factors. Our general assumption is that the quality of life improves with the progress of science and technology, although this may not necessarily be the case in certain contexts where poverty and vulnerability remain rampant. The cross-cutting impact and implications (the solid arrow) lies in the background and includes opportunities, drivers, and barriers that play crucial roles *before* the achievement of transformative S&T applications (acquisition and implementation of technologies). However, it is also important that the cross-cutting impacts needs to be considered after the achievement in S&T applications, such as the adverse effects of science and technology to society, and the governance issues.

Therefore, from the foresight literature, the two folds of cross-cutting impact and implications on poverty and pro-poor development are (in reverse order from the main arrow in Figure 4):

Figure 4 Cross-cutting impact and implication of science and technology and the role of technology foresight



vulnerability and risks to the poor due to the (seemingly) successful development of S&T including its adverse effect; and opportunities, drivers and barriers in using S&T for pro-poor development.

The role of technology foresight is to take a leap through time, envision the future where science and technology applications are put to work, identify potential new technologies, including their cross-cutting impact and implications in advance, and bring suggestions back to the science and technology policy community to better anticipate long-term developments.

Vulnerability and risks

The Millennium Project scenarios covered in the previous section depict some nightmarish futures where S&T caused serious adverse effects, intentionally or not, with substantial impact on the poor. For example in Scenario 3, “Please turn off the spigot”, the scenario includes an important point:

Particularly worrisome was accidentally or intentionally released genetically modified organisms and the potential for weapons of mass destruction. The poor were ignored (Glenn *et al.*, 2008, chapter 3.5).

Another example is a scenario from an analysis entitled *Nanotechnology Foresight* by the APEC Center for Technology Foresight, where nanotechnology had to retreat to the backstage due to fear of its adverse effect. This assessment indicated that:

Repeated bio-food and GMO scares, coupled with scandals on genetic profiling and DNA chips, led to a poor public image for nanotechnology products. Nevertheless R&D in APEC economies increased and products based on nanotechnology continued to be introduced, although increasingly little mention was made of nanotechnology. By 2015, products based on nanotechnology had achieved clear technical success in many areas but widespread adoption and acceptance of the full potential has been clouded by uncertainty and nanotechnology is scarcely visible. It had to be re-branded and integrated with other technology labels to be accepted (APEC Center for Technology Foresight, 2002).

Other analysts, such as Jerome C. Glenn and Theodore J. Gordon of the Millennium Project, have argued that the risks from acceleration and globalization of S&T are enormous and give rise to future ethical issues. The world’s “increasing dependence creates new vulnerabilities

such as, fraud, cyber terrorism, information warfare, cultural threats, widening knowledge gaps, making financial markets vulnerable to fast manipulations (\$2 trillion/day moves around the world which increases the likelihood of speculation and money laundering widening the rich-poor gap)” (Glenn and Gordon, 2000).

It will take good governance and transparency in the development and application of S&T in order to ensure that the poor will *not* be ignored.

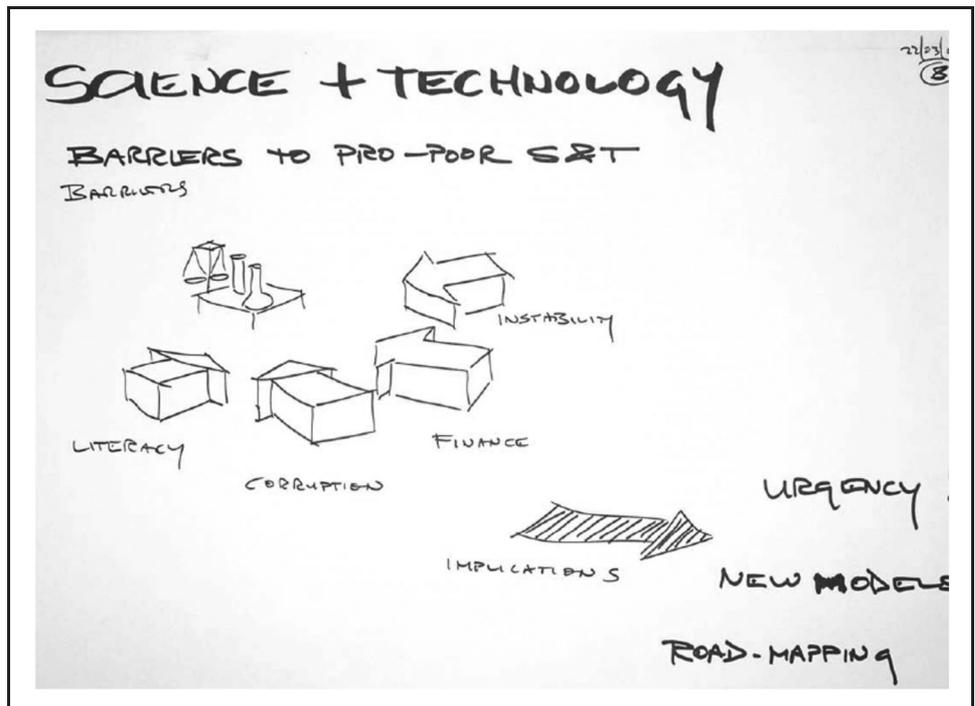
Opportunities and barriers

Even if we disregard the nightmarish or worst case scenarios where science and technology do go wrong and hope that the advanced nations will be obliged to take care of and control these issues, the ideas from the scenarios reviewed above still suggest that continued effort needs to be made proactively on the part of poor countries to seek opportunities from science and technology applications. In short, the poor cannot afford to be left behind in S&T knowledge and capacity, and as Figure 5 indicates, there are a number of barriers to advancing pro-poor science and technology.

Moreover, as the research agenda for the APEC Center for Technology Foresight has indicated, poorer country’s risk and vulnerability in areas such as water supply, mega-cities and climate change can be improved if S&T is implemented properly. Besides, as noted above, there are a number of technology applications already mentioned in the RAND report that can help in promoting poor rural economic development such as cheap solar energy, rural wireless communications, genetically modified (GM) crops, filters and catalysts for water purification and decontamination, and cheap autonomous housing.

These pro-poor applications can be realized only if poor countries can overcome the many barriers and find the right drivers and opportunities. In the RAND study, ten major types of drivers and barriers to technology implementation were identified, including: cost and financing; laws and policies; social values, public opinion, and politics; infrastructure; privacy concerns; resource use and environmental health; R&D investment; education and literacy; population and demographics; governance and political stability. This is not a simple task, since there are complex dynamics between a country’s capacity to acquire

Figure 5 Barriers to pro-poor science and technology



technologies and the specific drivers and barriers that affect its capacity to implement technologies.

As the RAND report notes, “capacity to acquire does not necessarily equal capacity to implement, because the latter requires a threshold level of physical, human, and institutional capacity; financial resources; and the social, political, and sometimes even cultural environment necessary to maintain and sustain widespread use of technology applications” (Silberglitt *et al.*, 2006, p. xx). The report also highlights that drivers and barriers often can be present simultaneously, “reflecting progress in some aspects and problems in other aspects” (Silberglitt *et al.*, 2006, p. 42). The RAND report further analyzed selected countries’ capacity to implement new technologies and found, for instance, that “promoting economic growth in rural areas continues to challenge national governments, nongovernmental organizations, and multilateral development banks. This is particularly true for those areas in poor countries because reducing rural poverty is a top priority in many of these societies. The lack of infrastructure, weak institutions of governance, low level of knowledge and technical capacity, shortage of financial resources, and other difficulties have hindered efforts to spur economic growth in these communities” (Silberglitt *et al.*, 2006, p. 99).

The RAND report notes that countries that are most in need of rural economic development have little capacity to implement the relevant technology applications. In short, “these countries command few drivers and are saddled with numerous barriers. They lack financial resources and are short on institutional, human, and physical capacity. Poor governance and stability presents another significant barrier. In these countries corruption and abuses at lower level of government frequently go all the way up to the national leadership” (Silberglitt *et al.*, 2006, p. 102).

6. Recommendations, potential responses, and conclusions

The 2008 *SOF* suggested the need for a global collective intelligence system to track S&T advances, forecast consequences, and document a range of views so that politicians and the public can understand the potential consequences of new S&T. The science and technology community will have to invest sufficient effort in bringing together S&T knowledge in a more user-friendly fashion to help illustrate and make government’s understand the risks and opportunities inherent in emerging innovations. The community also needs to facilitate transparent international scientific assessments of controversial areas, such as the intersection of biotechnology and nanotechnology, and to make clear how these innovations would improve the human condition, particularly those living in poor countries.

In terms of bridging the gap between science and technology, on one hand, and poverty alleviation, on the other, the UN Task Force on Science, Technology, and Innovation “emphasizes the need to create space for policy experimentation and learning in developing countries. Development is largely an expression of local initiative and international partnership; it cannot be sustained without local ownership and champions” (Juma and Lee, 2005, p. xiii). It continues by noting that “countries and economies could and should help other developing countries by sharing their best practices and experiences in the spirit of South-South cooperation” (Juma and Lee, 2005, p. xiv).

This brings our agenda, examining the future of science and technology for pro-poor applications, closer to the arena of science, technology and innovation for development. On this topic, the UN Task Force report notes clearly that “the achievement will require a substantial reorientation toward development policies that focus on key sources of economic growth, including those associated with new and established scientific and technological knowledge and related institutional adjustments. To promote the use of science, technology and innovation for development, countries need to adopt strategies for technological learning at the local, national, regional, and international levels. These strategies will involve continuous interactions between government, industry, academia, and civil society” (Juma and Lee, 2006, p. 177).

One key strategy for developing countries will be to ensure that their linkages with the international science and technology community remain strong. An OECD report analyzing international science and technology policies notes that OECD countries could help “to identify good practices in international science and technology co-operation” and to develop “the fuller integration of science and technology dimensions in sustainable development policies” (Organisation for Economic Co-Operation and Development, 2007).

In working for pro-poor applications, the foresight community should interact closely with the development community and encourage the use of anticipatory intelligence and governance in this area. More specifically, countries with higher levels of industrial development (such as middle income developing countries) could use some practical foresight tools such as technology roadmapping, as practiced in industrialized countries, to help in identifying new market opportunities and to anticipate the links between products and the global marketplace before setting out to develop new technologies. In this spirit, the APEC Center for Technology Foresight has involved developing countries in all of its international foresight projects to ensure interaction and mutual learning in the process. The roadmaps are usually focused on a number of technologies or converging technologies, with specific and implementable recommendations as to their outputs. Usually the recommendations will include not only new knowledge but the identification of platform technologies with wide applicability, while also suggesting a direction for building a foundation for long-term R&D activities.

Second, the foresight community should come together and create a sense of urgency in issues that have long term implications but need immediate action and attention. In this regard, the influence and interaction between the foresight community and governments, international organizations, and the business community is vital. Unfortunately, evidence so far shows that the foresight community has not been very successful in this endeavor, as we have seen in the recent global financial crisis. However, evidence-based foresight could potentially provide good recommendations to governments on how they should spend money on reviving the economy (Institute of Development Studies, 2008).

The author of this paper hopes and expects that there will be more effort within the foresight community to collaborate and focus on the future of science and technology for poverty alleviation and development as the field progresses.

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