DPADM/UNDESA Ad Hoc Group of Experts Meeting on Knowledge Systems for Development, September 4-5, 2003 (New York)

Futures of Knowledge for Development Strategies: Moving from Rhetoric to Reality

By: Paul Dufour[1], IDRC
August 2003

"*What matters clearly is culture and institutions. Culture determines preferences and priorities. All societies have to eat, but cultural factors determine whether the best and the brightest in each society will tinker with machines or chemicals, or whether they will perfect their swordplay or study the Talmud. Institutions set the incentive and penalty structure for people who suggest new techniques.*" (Joel Moykr, The Gifts of Athena: Historical Origins of the Knowledge Economy, 2003)

Introduction:
There is much to be said for "la sagesse" or wisdom. Rooted in experience and culture, and , above all, people (the Japanese refer to their true craftspeople as "greatest living treasures"), it is one of those givens of a fully functioning society: though often rarely properly factored in the policies, programmes and statements that have become so common in studying societies or economies. Words like creativity, inventiveness, connectedness, networking, innovation, and entrepreneurship seem to carry more weight as if these too are easily compared and measured. They are not[2].

Knowledge is another such moniker. It usually conveys a non-threatening political message of increasing conformity (repeat after me....) that makes it difficult for anyone to disagree with. How can you be against knowledge per se?..[3]. Progress?.. maybe...development?... perhaps... competitiveness?... at times... but knowledge? And so, the lexicon has happily adopted "knowledge"` as the 21st century harbinger of new things that may be good for you, or that, in the very least, you should think about in a positive sort of way.

---

[1] The author would like to acknowledge the constructive comments and inputs by Pam Golah, Jean Woo and Sonia ter Kuile of IDRC; views expressed herein are the author's and do not necessarily represent those of IDRC

[2] On this see the work of the New Kind project in Europe which has attempted to provide a better set of measures of intangible capital like knowledge. www.researchineurope.org/newkind/index.htm

[3] Luddism might be an exception here, though history is replete with attempts to resist the introduction of new ideas and technology. As the Duke of Wellington once said regarding his resistance to the development of railways: "They would enable the lower orders to go uselessly wandering about the country."

Within this bin called knowledge comes a variety of choices that you can make to qualify the term: tacit, formal, science and technology, imbedded in learning; indigenous or traditional , structured or unstructured, and so on. These too have many connotations that we will not dwell upon in great detail, suffice to say that there is enormous literature on such definitions (*See Box 1: Some KBE-KBS definitions*).

For the purposes of this paper, we will focus on aspects of knowledge that are more structured, formal, networked and conventional, that is, the formulation of knowledge through science and technology for sustainable development.[4] Knowledge in this form has taken on a rather urgent tone, usually accompanied with some sense of objective. In short, knowledge for what and for whom becomes a major consideration. Knowledge for development (or in its sustainable form), therefore, is at the nexus of global questions that surround health, water, environmental, natural resource management, climate change, poverty reduction, economic growth, trade, investment, and so on[5] *(see Box 2: Emerging Global Issues Requiring Effective Use of Knowledge*).

Box 1: Some Knowledge-based economy (KBE)- Knowledge-based society (KBS) definitions

APEC: a KBE is an economy in which the production, distribution and use of knowledge are the main drivers of growth, wealth and employment across all industries.

OECD: where investment in knowledge is defined as public and private spending on higher education, expenditure in R&D and investment in software.

UNESCO: economy in which knowledge is substituted for labour as the main factor of production.

World Bank: a KBE relies primarily on the use of ideas rather than physical abilities and on the application of technology rather than the transformation of raw materials or exploitation of cheap labour; economy that makes effective use of knowledge for its economic and social development including tapping global knowledge.

---

[4] I am conscious of the issues associated with traditional or indigenous knowledge and consider this endemic to the question of knowledge that will be treated in this paper

[5] See for example, the paper in the Proceedings of the National Academies of Science on Knowledge Systems for Sustainable Development by David Cash et al, which outlines several case studies in knowledge systems for sustainability., PNAS, 8 July 2003, Vol 100, no 14, pp 8086-8091

Box 2: Emerging Global Issues Requiring Effective Use of Knowledge

Global Warming
Biodiversity and ecosystem losses
Fisheries Depletion
Deforestation
Water deficits
Maritime Safety and pollution
Fight against poverty
Peacekeeping, conflict prevention, combatting terrorism
Education
Infectious diseases
Digital and knowledge divides
natural disaster preventions
Biotechnology rules and food security
Illegal drugs
Trade, investment and competition rules
Intellectual Property Rights (IPRs)
E-commerce
International labour and migration
Risk management

(*Adapted from Rischard, J.F. High Noon, 2003*)

Policies associated with these challenges have led to some interesting variety of experiments (policy is by definition experimental), as well as attempts to shoe-horn them into some standard bench-marking matrix. Hence, the rise of development reports, leagues tables, indicators for development, etc... Such approaches engender a bit of a herd mentality often bordering on a lemming-like approach leading countries and their geopolitical and economic clubs to which they adhere and other international institutions to adopt frameworks that will allow for better use of knowledge on knowledge.

Nowhere is this more apparent than in the UNDP Human Development Reports. For years (seven to be precise) Canadian politicians made hay with the fact that Canada was ranked 1st on the Human Development Index (HDI). Today, having been chastened by the vagaries of such indices, they are more subdued as Canada has slipped to 8th. Or take the OECD rankings of gross expenditures on R&D to GDP ratios that has become the leitmotif of advanced knowledge economies. Such rankings show up in most global league tables of one sort or other, and they are religiously used to make the political case for moral suasion[6] (see Chart 1 on innovation systems in Appendix).

Knowledge on knowledge begets complexity, which in turn begets confusion and, its consequence, information overload (the new form of an emerging infectious disease in this technologically wired world is something labelled CPA or Continuous Partial Attention). Be that as it may, policy-makers of all stripes are embracing the new word, and using it to justify and launch new programmes, initiatives, ventures and the like. Consultation, coordination and collaboration have quickly become the hand-maidens of knowledge. “Best practice” (if there is such a thing) becomes mantra. Excellence, equity, and sustainability follow quickly from this, and soon, the unsuspecting are pummelled with a blitzkrieg of rhetoric. Some examples are in Box 3.

[6] For instance, Canada’s federal government has suggested that as a target, the country’s expenditures for research and development (R&D) should gradually move from its current 14th place showing among league tables to 5th place by 2010. The dynamic nature of knowledge and the fact that other countries are also investing heavily in R&D is at times forgotten in such statements.

How to move the rhetoric to some form of comprehensible reality is the subject of this paper, but first, we need to look more closely at the cultural phenomenon of knowledge for development.

Box 3: Some recent statements on use of knowledge and science

Progressive Governance Summit:
Both globally and domestically we have discussed a new progressive agenda that is based on preparing our societies and economies fo the challenges of the future, ranging from climate change to science. (London, 13-14 July 2003)

NEPAD: explicitly recognizes that the region's economic recovery and transition to sustainable development will be achieved if science and technology are harnessed and applied to pressing food production, diseases, energy insecurity, communication and environmental problems. (draft, 2003)

G-8: Cooperative scientific research on transformational technologies offers potential to improve public health by cutting pollution and reducing greenhouse emissions to address the challenge of global climate change (Evian, 3 June 2003)

UN: The idea of two worlds of science is anathema to the scientific spirit. It will require the commitment of scientists and scientific institutions throughout the world to change that portrait to bring the benefits of science to all. (Kofi Annan, Science, 2003)

The Notion of National Systems

"Knowledge networks between producers and users cannot be assumed, neither can they be ordained by funders. They need to be carefully constructed.``

(Louk Box,`` Crossing the Divide: the Precious Art of Science and Technology Policy Dialogue", 2003)

The above quotation hints at the need for engineering public policy for sustainable knowledge production. It also argues that a knowledge-based society (or one that is knowledge-thirsty to borrow from a 1990s Canadian report) is linked to the emergence of a more networked economy through the generation, diffusion and use of information. Governments and other decision-making organizations are struggling with how to manage this networked society; both from the point of view of putting in place structures and institutions that will help adjustments to change, but also to increase the flow of this knowledge. Thus, knowledge flows and knowledge regions become important.[7] Chart 2 highlights one such model of these knowledge flows as it represents a global map of science. The illustration here merely points to the grwoing inter-connectivity of knowledge systems.

The use of Information and Communication Technologies (ICTs) becomes a critical investment as witnessed by the enormous sums of funding now going into this transformational technology.

[7] The EU has launched a pilot programme to support regional measures to establish`` Regions of Knowledge`` in the field of technological development. Such regions already exist in the form of the so-called Four Motors of Europe, a loose coalition of sub-national regions designed to enhance competitive advantages through knowledge sharing

But the investment in e-things is a necessary though not sufficient condition for ensuring effective use of knowledge for development.

How states organize themselves to strengthen or improve their knowledge-producing, transfer and research capacities is often a bit of hit-and-miss exercise, and there are different methodologies one can engage. The OECD for example, has made an industry of adopting national innovation systems as a technique for assessing the complementarities among research and innovation actors in any given country or region. [8] Fine and good for the developed world. But what of the developing countries? How can they learn? How can they innovate and shape skills? How can they develop effective mechanisms, policies and tools to encourage S&T-conventional and indigenous- and manage the impact of their respective societies? How can they ensure that they are participating in the global pool of knowledge production and taking advantage of knowledge to improve their standard of living, eradicate poverty, and strengthen their capacities for decision-making?

A joint workshop organized by IDRC and UNESCO in April 2003 addressed many of these issues. Both UNESCO and IDRC have had a track record in these national assessments with IDRC having produced reports in partnership with Chile, China, Vietnam, South Africa and Jordan. UNESCO had its history with country reviews dating back to the early 60s, involving over 70 reports, including more recently, Albania, Bahrain and Lebanon. Other institutions such as the World Bank, with its S&T Vision statement,[9] and work on China and Korea; USAID with its report on S&T and capacity development examining cases such as India; SIDA with its programming on universities and research in developing economies; UNCTAD with previous assessments of Jamaica, Colombia, and Ethiopia; and the OECD with reviews of China, Korea and Mexico, have all tackled this trendsetting tool.

And the impacts? Clearly, results vary. Timing for some of these reviews is critical. IDRC's presence and ability to respond to a clearly defined demand in South Africa when the transition to the ANC government took place was a key factor in success of its reviews on S&T. Politics almost always plays a role. How Vietnam has implemented the results of the reviews of its knowledge systems is in part tied to the changing nature of the political regime in that country. Champions are required. It makes no sense to drive recommendations for change by outside experts unless the directions are those that mirror those in charge. So too is funding. Unless states are willing and committed to change by investing in new support for knowledge production or changes to institutions, little will happen. And luck can be important.

But, ultimately, an institutional capacity to absorb the recommendations for change is a must. As many in the Paris workshop recognized, unless there are sound frameworks for decision-making, data collecting, regulatory regimes, communications and governance of innovation and

---

[8] See James Mullin,`` Reflections on the Review Process of national S&T and innovation policies, paper prepared for IDRC-UNESCO workshop on Future Directions for National S&T and Innovation Policies in Developing Countries``, Paris, March 2003.

[9] See David Dickson, "Does the World Bank Really Care about Science?", SciDev.Net, 4 July 2003.

knowledge infrastructure, little will come of recommendations designed to improve research and knowledge capacity. For example, this was spelled out in the Jamaican case study which flagged the need for regulatory and other requirements to put in place sound ICT infrastructure. Training is critical . Not just an educational system that is well developed, but also some need to institutionalize critical thinking on future directions for knowledge and its production. Such is the South African model that has put in place a variety of new training and development organizations for innovation since 1994. Ongoing assessment, benchmarking and evaluation are also crucial, as has been the case of Vietnam where the government has attempted to respond and update its activities related to the 1999 review conducted with IDRC.[10]

Responsibility for such implementation is not a one-sided issue, however. It requires commitment and engagement from all levels of society. Stakeholder activities designed to involve these elements are critical to a successful course of action or policy direction. And donor agencies have a role to play. As the Paris workshop pointed out, learning from good practice is a healthy thing. Enhanced coordination and-or communication among donor groups on their respective approaches to partnerships for knowledge production needs to be re-assessed. As a recent report has argued, the new network age has permitted alternative tools for capacity development and there is an understanding that local knowledge combined with knowledge acquired from other countries and institutions in both the South and North, can contribute to a successful paradigm for growth and social development. “The notion that the only ideas for development that are worth trying are those that derive from the North looks less and less plausible.”[11] For this reason, one must be careful in applying any form of model such as a national systems approach to innovation, without regard to the history, culture or institutional capacity of a country. Indeed, there may be times when such models simply do not apply and other approaches are necessary.

The same premise holds true for knowledge production. As developing states engage in advancement of knowledge and research systems, a learning process is taking place. Soon, such processes lead to a better appreciation of the requirements for a stronger knowledge base and programme initiatives. But one should be wary of what models one examines. It is important to try to look at other models that are similar, rather than vastly different from your own in order to affect change. The fact that India is now looking carefully at the emergence of the Chinese economy and is assessing areas on need to catch up is an indication of this. Collaboration is often another good tactical strategy is the case with certain Latin American countries in support of designing common networks for R&D and S&T data collection. Let us examine the case of four different states that are experimenting with a knowledge transformation: India, Vietnam, South Africa and the Maldives.

---

[10] See Ca, T.N,`` Donor Funded reviews on science, technology and innovation in Vietnam: the impact, the change and some thoughts for the future``, prepared for the IDRC/UNESCO workshop, Paris, April 23-24 2003.

[11] Sakiko Fukuda-Parr et al, Institutional Innovations for Capacity Development, in Capacity for Development: New Solutions to Old Problems, UNDP, 2002.

Four States in Search of Knowledge

***"Sustainable development will not be achieved unless there is a redirection of our efforts to develop the full potential of people through education: an education that must include the mastery of modern technologies*" (Ben Ngubane, 2002)**

In a forthcoming book, the Peruvian scholar Francisco Sagasti makes the argument that the difference in economic disparities and the knowledge divides between the developed and developing world is even more striking when one looks at scientific, technological and production outputs.(See Chart 3). In short, there are huge differences in the capacity to generate and utilize knowledge between rich and poor countries.[12] In fact, there are huge differences of this sort within countries and among regions, which is why one has to be careful when using comparative data to make sweeping generalizations. But the examples of four very different economies will show that there are clear attempts to try to manage and engineer knowledge.

In their recent (August 2002) statement on research and development, the South African Government has made a point of noting that investments in this area will be designed to improving the quality of life with a focus on national poverty reduction and improving national competitiveness in the international environment. Three pillars of the strategy include science, engineering and technology human resources development and transformation focussing on the need to develop human resources on key sectors of S&T: Astronomy[13], human palaeontology, and indigenous knowledge ; innovation centred around various technology sectors; and third, creating an effective government S&T system. Among the areas of technology that the government will develop are those related to S&T for poverty reduction (emphasis on health-diseases, energy and indigenous knowledge), new technology platforms in biotechnology and IT (South Africa has a well developed programme dealing with Public Understanding of Biotechnology or PUB); technology for manufacturing and technology and knowledge for and from the resource-based industries.

In the case of India, its 2003 S&T Policy has a goal of "raising the quality of life of all Indians, particularly of the disadvantaged, in creating wealth for all, in making India globally competitive, in utilising natural resources in a sustainable manner, in protecting the environment, and in ensuring national security." The Indian Department of Science and Technology hopes to ensure

---

[12] Francisco Sagasti, The Sisphysus Challenge: Knowledge, Innovation and the Human Condition in the 21st Century, forthcoming.

[13] The reader may be wondering about the inclusion of astronomy here, but in fact, South Africa is well positioned to be one of the leading global players in this field due to its geography. For an articulate rationale to this, see Khotso Mokhele, ``South African Large Telescope, Model for International Scientific Collaboration between Developed and Developing Countries``, paper presented at MEXT/OECD Global Science Forum Workshop on Best Practices in International Scientific Cooperation, Tokyo, Feb 13-14 2003.

greater integration of R&D activities into the socio-economic sectors; emphasize the basic research strengths and build on them; adapt indigenous resources and knowledge, specifically traditional systems of medicine; collaborate and cooperate with the international community; popularize science and disseminate it to society; and monitor and evaluate the impacts of S&T . And of course, one should remember that with the current effort by India to move away from a donor-assisted country to a donor contributor, the knowledge base through its science, technology and engineering cadre (an enormous one) will be an important contributor to the global knowledge pool.

In Vietnam's case, the transformation of the economy from a socialist to a more open economy has gradually been taking place. As a result, the need to assess how knowledge and research will contribute to this process is a critical one. In 1997, the IDRC was asked to undertake a review of its 1996 science and technology strategy which led to several recommendations for the Vietnamese Government to consider. Vietnam has placed a high priority on accessing technology from overseas and then applying and adapting it to the needs of the nation. While there was a focus towards a demand-driven S&T framework with the private sector playing a stronger role, there is still a tendency on behalf of individuals and institutions towards supply-side S&T activities. Vietnam has recently undertaken to assess a key element of its knowledge strategy; that of international S&T cooperation. This review, to take place in the coming year, will examine such issues as human resources; mobilizing and using financial resources; linkages between various actors of the national system of innovation; promoting enterprises to improve their linkages via foreign direct investment and international trade, and examining the question of make or buy.[14]

Finally, in contrast to these emerging players is a small island state, the Maldives. An archipelago of 200 islands, the Maldives economy had grown considerably over the past few years with heavy reliance on tourism and fishery industries. Concern for the long-term sustainability of these industries that are reliant on the natural environment has pushed its Government to consider how S&T can be deployed to address new opportunities. Its Science and Technology Master Plan (drafted in 2001) emphasizes the need to use and adapt external technologies to national needs, rather than on specific areas of national innovation and research . The plan is also designed to put in place a new institution –a National Research Foundation– that can coordinate research funding in selected areas. There is a general emphasis in the Plan to recognize the importance of ICTs (indeed, the responsible Ministry is called Communication, Science and Technology), with a recognition that such technology is useless without information to be conveyed. Other areas of emphasis include energy strategies, health, and research on fisheries and tourism (See Chart 4 for a comparative look at

---

[14] Few countries have actually tried to link their domestic S&T agenda with the international knowledge and trade policies in any systematic way. Some recent examples of going ``intermestic`` include the Swiss attempts at establishing a scientific foreign policy (using foreign policy to link with science issues), and Finland which has recently issued a report on Knowledge, Innovation and Internationalisation (see Science and Technology Policy Council of Finland, 2003) For more on this problematique, see the special issue of Science and Public Policy, Vol 29, no 6, December 2002 on Globalization, Science, Technology and Policy (Josephine Anne Stein, guest editor).

these countries).

One could go on to map the knowledge strategies of the other 204 nations on this planet, but the point is this : good governance, strong economic development and well developed social and environmental practices are all to some extent dependent on a sound knowledge strategy. And a strong, integrated approach to link the objectives of the various functions of governance is critical; otherwise, the right hand will not know what the left hand is doing; or worse, well-intentioned policies will counteract each other.[15] And of course, for it to be effective, knowledge must be connected to the cultural and historical context of the locale of the problems involved. Given this, it should come as no surprise that India's objectives are tied, for example, to national security; that South Africa's and the Maldives emphasize indigenous knowledge; and that Vietnam 's approach seeks to link to the global trade system. It should also come as no surprise given the nature of knowledge transfer that these countries pay particular attention to learning from other places. In South Africa's case, for example, their R&D strategy is premised with a look at the R&D strategies of Australia, South Korea and Malaysia. As an observer to the OECD Committee for Scientific and Technological Policy, and a member of the Commonwealth Science Council, (along with India), South Africa takes advantage of these strategic linkages. For the Maldives, its small size requires international linkages and connections, and for Vietnam, its membership in such clubs as APEC and ASEAN provides it with an entrée into an important club that is examining the use of knowledge through the APEC Industrial S&T Working Group. In short, memberships have their privileges; a subject to which we will return.

Towards a Global Knowledge Contract: Does Advice Really Matter?

"We are calling on society as a whole, and in particular on the State, scientists and the productive sector, to use science and technology in a responsible way, orienting their efforts so that they fulfill the needs of present and future generations, with responsibility and all forms of life."

The above quote could have been drafted by virtually any international body. It could easily have come from the World Conference on Science in Budapest in 1999 or the WSSD in Johannesburg, or could have been the result of a European conference on the science-society interface. Actually, it was written on 21 May 2003 at the University of Antioquia, in Medellin during an international symposium to celebrate that university's 200th birthday and the tenth anniversary of the initiation of the Colombian Presidential Science, Education and Development Mission. The Medellin manifesto aimed at a new social contract in science and technology for fair development and called for a decade of science (2003-2013) within Colombian society. It is the shape of things to come.

---

[15] A good example common to many countries here is the use of immigration policy to attract skilled foreign nationals from developing countries, while the international development or aid policy argues for building capacity and skills in those same developing countries. The UK has recently tried to address this by issuing guidelines to prevent such internal policy clashes.

The use of knowledge for advancing society will need to be imbedded in decision-making structures that are both independent of states, but also linked to some form of accountability. Society will expect nothing else. And with good reason. Turning knowledge into policy and then into outcomes requires a fair measure of integrity and trust, not to mention commitment. Look at any public opinion polls for example that measure civic society's assessment of trust in professional groups, and you will invariably find that politicians are in the bottom rung and health professionals and scientists near the top. (see Chart 5 which looks at how the science community is viewed as a public institution). Dig a little deeper and you will see that public sector scientists rate higher than private sector employed researchers. That is why where a government places its knowledge assets is just as important as with whom.

For example, the Zambian government has just unveiled a $40M National Biosafety and Biotechnology Strategy Plan that will be used to support human resource and infrastructure resource development. This comes after Zambia had spent some considerable political capital rejecting modified foods. The Nigerian Government, in a flashy insert in the NY Times on July 14 labelled its new approach "Towards a Knowledge-Based Society,"` as being dependent in large part on plans to make Nigeria a key player in IT by 2005. Mozambique has been working to introduce a new plan for innovation, and science as a key element of its economic development. Argentina has just announced the notion of a ``debt for knowledge`` scheme whereby one percent of the interest that it pays to foreign creditors should be reinvested in the country's S&T. These examples imply a new, and creative engagement with society, and of course, with global partners.

Public demand has dramatically altered the knowledge landscape. Specialized institutions and elites no longer have a monopoly on wisdom. The spread of knowledge (not just Western science) has led to an opening of a more global and national debates on issues surrounding risk, choice, culture, environment and quality of life. This demand, manifested through new groups, advocacy organizations and NGOs (all of whom have ironically mastered the new technology) is a driver for change—sometimes for positive effect, but not always for the better or to the good of the society. [16] There are signs that research or knowledge producers are also changing their ways. No longer as insular , protective or arrogant about the implications of the implementation of new knowledge, they have gradually come to adopt new strategies to work with the public at large, and eventually have become more adept civic players in communicating and consulting on the results of research and the implications for the future human condition.

ETC and Greenpeace have both engaged in the latest debate surrounding the introduction of nanotechnology, and have argued that lessons need to be learned from the public controversies that affected biotechnology and its social and environmental impacts.[17] South Africa's public

---

[16] See for example, some warning by Jesse Ausubel, in ``Reasons to Worry about the Human Environment, `Technology in Society, 21 (1999) 217-231 where he argues that the greatest threat to future well-being is the rejection of science. There's an interesting story in this paper about Galileo who contrived to have his two daughters placed in a convent. One of them was not able to pursue her own scientific interests as a result.

[17] See ETC Group: The Big Down: Atom tech: Technologies Converging at the Nano-scale, 2003. And Future Technologies, Today's Choices: Nanotechnology, Artificial Intelligence and Robotics: A

understanding of biotechnology approach argues for the public to inform itself with the best knowledge available and then decide for itself (``Biotechnology and you: read about it, talk about it, think about it... and decide for yourself``).[18] Taking a page from this, the IDRC has begun an exercise in assessing the landscape for changing receptivity to GMOs and biotechnology issues in the South and it is looking carefully at how to engage a multistakeholder dialogue in this controversial field. The World Bank has been the leader in issuing a Budapest Declaration urging a global assessment of agricultural science, knowledge and technology that can improve rural livelihoods and address poverty reduction in low income countries. Similarly, the UK Government has prepared an elaborate public engagement process for the future development of both the research and the policy associated with biotechnology and nanotechnology [19]

But it will take more than a change of strategy from knowledge producers to have an impact on policy outcomes. After all, as Yankelovich has argued, "Most public policy decisions must rely on ways of knowing–including judgement, insight, experience, history, scholarship, and analogies-– that do not meet the gold standard of scientific verification."[20]

Decision-makers will have to be more creative at integrating and learning from various sources of advice. Multiple networks of knowledge are growing in complexity (not just those associated with government, and not just traditional science), making it difficult to isolate the cause and effect of policy outcomes. Governance and risk management here take on a much more meaningful public policy function. One of the key forms that this advice takes place is through science advice. Increasingly, attention is being paid to this dimension of knowledge production within most states. The reason: decision-making operates in a social and public value milieu , rather than a strictly economic investment framework. Indeed, the debate in most societies today has shifted from the hey-day of competitiveness and prosperity to its more complex, yet socially inclusive assessments of innovation and knowledge trends.[21]

Technical , political and institutional map of emerging technologies, A report for the Greenpeace Environmental Trust by Alexander Huw Arnall

[18] There are signs that these knowledge producers are learning hard lessons from the GMO public scientific debacle in the next new emerging technology arena, nanotechnology. See Rebecca Willis and James Wilsdon, ``Technology, Risk and Environment``, working paper seven for the Progressive Governance Summit, London, July 13-14 2003.

[19] See www.ost.gov.uk

[20] Daniel Yankelovich, "Winning Greater Influence for Science", Issues in Science and Technology, Summer 2003.

[21] See Barry Bozeman and Dan Sarewitz, "Public Failures in U.S. Science Policy, Centre for Science Policy and Outcomes," Washington , D.C., 18 October 2002.

Hence, as a result of the growing nexus between science, citizen and state, many countries and organizations are re-shaping their formal (and informal) science advisory mechanisms while keeping an eye on how others do it. This latter point is critical since much of what is being discussed as involving changes in knowledge and its impact on society is not limited to domestic sources, but has become globalized.[22] SARS epidemics, mad cow disease, HIV/AIDS, disaster mitigation, food safety are but some examples of issues requiring transboundary advisory structures and channels. But science advice must go hand in hand with other forms of governance. It needs to be imbedded into the full machinery of government. As Tony Blair has bluntly put it: "Bad science didn't cause the spread of BSE; it was bad agriculture and poor government.[23]" The attempt by the UN to re-examine its own structures of science advice is a good case of recent recognition of the importance of this issue, In the National Academy of Sciences (NAS) report, Knowledge and Diplomacy released last year, the report argues for a series of changes. Among them:

- That governing bodies of the UN that have substantial responsibilities for implementing sustainable development programs should each create an Office of the Science Adviser or equivalent facility[24];
- That each such facility should adopt an appropriate set of general procedures based on best practice procedures of science advice;
- That the UN should help member states to strengthen their own scientific advisory capabilities[25]; and
- That assemblies and other deliberative bodies should make greater use of scientific assessment mechanisms that have transparency and credibility.

One should be circumspect about science advice of course... it is after all, only advice. It can be acted on or ignored. And it is only one part of the policy equation. And if science advisers are not used (or studies requested), the relevance of such bodies quickly becomes an issue. In Canada, for example, the Advisory Council on Science and Technology which (on paper only) advises the Prime Minister on issues of national importance affecting S&T, was largely ignored by the former Minister responsible for its work. Today, it is undergoing a transformation and has developed a new remit to better address urgent questions related to priority -setting . In a similar vein, the Council for Science and Technology in the UK has just undergone a quinquennial review with the Government responding that it will ask the CST to organise its work on five broad

---

[22] See Francis Fukuyama and Caroline Wagner,`` Governance Challenges of Technological Revolutions``, in Science, Technology and Governance, (John de la Mothe, editor), London, Continuum, 188-209.

[23] Tony Blair,`` Science Matters``, speech to the Royal Society of London, 10 April 2002.

[24] As a similar example, the UK Government through its Office of Science and Technology, has recently argued that each ministry or science-based department of Government should have its own chief scientific adviser, The Forward Look 2003, UK Department of Trade and Industry, 2003.

[25] On a related note, the National Academies have been working separately with both the African Academy of Sciences and the Arab states to introduce effective science academies that could in part serve as advisors on significant science-based issues of public policy for those regions.

themes: sustaining and developing science, engineering and technology (SET) in the UK and promoting international cooperation; SET and society; SET education: SET in Government, and SET and innovation. The Government will even advertise publicly to get new members, a significant departure from traditional methods of recruiting advisers you can control.

Given its very nature, science advice needs to address global as well as domestic issues. For this reason, science advice is increasingly seen as an integral part of foreign policy, international finance, trade, global ethics and sustainable development issues. A more global science advisory capacity is required. While there are clubs that meet periodically to discuss such questions in the European context and the G-8[26] , quite often the developing world has little say in such structures nor does it have a major presence. Groups like the InterAcademy Panel established by the NAS on international issues have established a creative structure—the InterAcademy Council (IAC)-- to help provide these links. The IAC brings together the collective advisory expertise and experience of a worldwide group of national academies, including those in Brazil, China, Mexico, South Africa, and the Third World Academy of Sciences (TWAS). The IAC is just completing a major report on promoting worldwide science and technology capacities for the 21st Century. And the UN Commission on Science and Technology for Development has concluded an e-chat group on measures for strengthening support institutions and science advisory mechanisms.

Thus, science advice has taken on a much needed renaissance, one that will look to using the knowledge assets and expertise of many states to resolve issues affecting sustainable development. But such advice is only part of the picture.

What we have here is a failure to communicate

***"Science is just knowledge. And knowledge can be used by evil people for evil ends. Science doesn't replace moral judgement. It just extends the context of knowledge within which moral judgements are made. It allows us to do more, but it doesn't tell us whether doing more is right or wrong."* (Tony Blair, Science Matters, 10 April 2002)**

Knowledge networks of the future–especially those affecting the South-- will be challenged by at least three key issues. The first is the question raised by the Blair quote above. For the advisory apparatus to be effective and politically attuned, it will need to pay attention to issues at the margins (not marginal to) of knowledge development. A key concern surrounds ethical and legal issues affecting the introduction of new and emerging technologies to both developed and developing state alike. Unless you are a card-carrying member of the Raelian Movement[27],

---

[26] The Carnegie Group of Science Ministers for the G-8 meets twice a year in different locales to discuss (off the record and informally) issues of mutual concern amongst the G-8 memberships. See : D. Allan Bromley, Science Advisers to Presidents and Prime Ministers: A Brief History of the Carnegie Group's First Three Years, 1990-1992, April 1996, NY: Carnegie Commission on Science, Technology and Government.

[27] The Raelians showed up to demonstrate the G-8 Carnegie meeting of science ministers in Quebec in June 2001 to protest the discussions by Ministers of the ethics of new cloning technologies. Friends of the Earth and other activists were also in the crowd arguing against cloning; the Raelians were

most organizations are taking this challenge up from the UN system through to Greenpeace. The biggest debate facing the Bush Administration before September 11 was in fact the ethical issues surrounding use of stem cells for reproductive purposes. Other countries have followed suit and are now debating the questions of human cloning, xenotransplantation and other medical issues associated with the spread of revolutionary health sciences. A similar debate will emerge on nanotechnologies as countries like India, China, Korea, Philippines, South Africa and Vietnam adopt strategies for these newer technologies.. These are issues not just ripe for ethicists, religious leaders, philosophers and lawyers, but concerned citizens as well. The mere mention of the need for biotechnology and genetically-modified crops is enough today to generate a raft of spins on the good, the bad and the ugly of this issue.

The media will need to be engaged in such future debates. They play a strong role in shaping the debates, and can influence public policy in significant ways. (See Chart 6 for an understanding of how the public attitudes differ from country to country re GMFs) The adage that politicians are scientifically illiterate and scientists politically clueless is not far off the mark. Add to this the oft made observation that scientific communities tend to be insular or even arrogant, and combine this with the notion that governments are prone to spinning information to suit respective needs and you have a deadly fuel that can ignite quickly. Linking science journalists, communicators and practitioners of research and knowledge is a key element of a successful knowledge strategy. In the UK and Canada, efforts have been developed to strengthen the communication of science to the general public and guidelines have been produced to assist this process. In Canada, for example, these guidelines help shape communications as an integral part of the government's S&T policy. A recent report argues that federal science departments should embrace the concept of participatory communications, whereby audiences engage in dialogue, deliberation and decision-making; adopt communications by integrating this element in the early planning phases of S&T programming; develop comprehensive communications strategies to complement and support the conduct of S&T; and invest in S&T communications planning; training and delivery.[28] Governments everywhere are realizing that in order for the public to both understand, become active in, and be informed of decisions that will affect public policy, they need to be part of the process, not separate from it, or worse, separated from it.

At the global level, similar challenges are being addressed. A new web-site on science and technology for development (SciDev.Net) has been established whose objective is to provide reliable information on issues related to science and science-based technology that impact on social and economic development. The service, funded in part by donor agencies and supported by the prestigious journals, Science and Nature, is a valuable tool in assisting decision-makers from the developing world and other professionals interested in the interaction between science and development. The site offers news and various briefs called dossiers on such issues as the brain drain, GMOs, biodiversity, climate change and ethics in science and technology. It has also improved its geographic spread from its HQ in London to include regional networks in Sub-Saharan Africa, Latin America and has initiated capacity-building workshops to train science

---

for it, making for a nice symmetrical debate.

[28] Council of Science and Technology Advisers; Science Communications and Opportunities for Public Engagement, Ottawa, 2003.

journalists on emerging issues in those regions. One, on the use of ICTs to report on the science of AIDS, took place in Kampala last year, and this may likely be repeated in India later this year. A public meeting on science and technology communication is being organized for Nairobi in 2004. At last count, just under half of all registrants to the web-site (which is free) came from developing countries, with the top five coming from India, Brazil, Mexico, South Africa and Argentina. SciDev is looking to its next five year plan (2004-2008) with a view to increasing its presence in the South and increasing coverage of various dossiers and regional nodes.

If the research and knowledge communities are to build more powerful alliances with states and other sectors they will need to consider building on the changing dynamics of the science-society interface and develop newer tools (such as SciDev) that are more representative of the issues involving global civic society itself. Hubris and humility, not the new 21st century post modern affliction of Acquired Situational Narcissism (as the NYTimes puts it) will be required. Educating people is not the answer as this implies a one-way view of knowledge (or the information deficit approach) : from the expert to the layperson. Rather, the issue is about involving the key stakeholders in all societies in the decision-making process, not just meting out information (which almost always has some spin to it). [29]

As a second consideration, the new technologies that are shaping innovation and change will require not just attention to new knowledge, but to social and institutional innovation as well. Anticipating change will be one of the most important dimensions of this. As Willis and Wilsdon aptly point out, "New technologies will never achieve their full potential unless they are accompanied by social and political innovation that alters the framework within which economic choices are made."

So how to anticipate change and scan the horizon? How to put into place new mechanisms to do this? This will be a major challenge for societies bent on using reliable knowledge to make choices. Here, the issue is how to engage in a dialogue that will potentially alter visions of the future. Private sector firms engage in this type of exercise, Shell International being probably the most well- known. But increasingly, governments are now experimenting with different forms of foresight exercises. UNIDO has recently produced a summary of some of these national exercises to highlight some of the common themes that are emerging with respect to economic and social change.[30] Among them:

- That technological development will be the key agent of change and change will be faster;
- The life cycles of products will be shorter and shorter and new knowledge networks will emerge;

---

[29] For an interesting comparison of how the private sector and NGOs address communications of complex S&T issues, see the analysis of Edna Einsiedel,``A Snapshot of Private Sector and Non-Government Organizations' Science and Technology Communications Tactics and Related Best Practices``, A report commissioned by the Science and Technology Communications Sub-Committee of the Council of Science and Technology Advisers, Ottawa, 2003.

[30] UNIDO : ``Technology Foresight Initiative for Latin America: An Overview of the Programme``, 2003.

- The demands on education will increase especially with respect to technology and natural sciences;
- In developing countries, information technology is expected to dramatically influence the possibilities of growth, as will biotechnology;
- Globalization will get even more accentuated than it is today and there will be a free flow of information investment capital, ideas, products and services between countries; and
- The proportion of women in the work force will increase and a series of new systems and models for childcare and housing services will emerge.

Of course, this all sounds well and good, but as the adage goes, if you can't forecast well, forecast often...The UK, Germany and Japan have years of experience in this type of methodology, producing biennial versions, but gradually, the list has expanded. ICSU , for example, has recently published an examination of these reports and suggested areas that have an international or global scope for further assessment.[31] (See Chart 7 for some examples of national approaches) The APEC Centre for Technology Foresight launched in 1998 is one of the more unique since it covers multi-country assessments. Consultations on megacities, urban and water issues, genomics and nanotechnology had been produced with the expert inputs of many countries from that region. Foresight activities also require sound data collection and analysis. The data issue is problematic in many respects as several counties do not have the institutional capacity to collect necessary data and analyze in a way that can be helpful for decision-makers. The need to train people in this area will be important. The UNESCO Institute for Statistics has been working on a strategy that will elaborate such requirements for S&T data and indicators in developing countries. Creating demand for such information and linking data needs will be a challenge in this area. But this is one of a complex of questions that needs to be addressed if communication of knowledge processes is to be adequately addressed. There are some bigger issues though, and this is the third area that will need to be addressed.

The 500 pound Gorilla

"I feel myself fully competent to render this dear cheek as faultless as its fellow, and then, most beloved, what will be my triumph when I shall have corrected what Nature left imperfect in her fairest work." **(Nathaniel Hawthorne, The Birthmark, 1846)**

Are there brakes to local innovation and global knowledge production? Yes is the short answer. As the public debate becomes more heated and engaged in the coming years over the development of knowledge, there will be more calls for ensuring a sound social function to this knowledge. To borrow from Auguste Comte's dictum: "Savoir pour prévoir, prévoir pour agir." Those societies that have invested heavily in knowledge over the past forty years are beginning to understand the hidden costs of such investments. True, knowledge has given us many gifts, but there are limits : limits in terms of costs, limits regarding choices and priorities, limits with respect to technical tolerance and risk, limits to capacity, limits to ethical standards, etc... Above all, there are society's transactions costs. The bar has been raised. More will be expected of investments in this knowledge. More accounting, more transparency, more translation of the

[31] ICSU, Identification of Key Issues in Science and Society: an International Perspective on National Foresight Studies, 2002

benefits AND costs of this. Some of this will fall on the shoulders of the research communities; some on the public; and much on the commitment from decision-making systems.

Ironically, at the very time the West has called on a greater need for investment in knowledge (10 countries are responsible for over 80% of the world's total expenditures on S&T) in the developing world, and at the very moment that technologies have increasingly become more "open-sourced" and freely available, geo-political and security issues threaten to stall the potential for a new knowledge renaissance. Continued and fair access to knowledge will be a strong playing card. Trade issues are blocking the ability of the South to develop intellectual property regimes that are relevant to their respective economies; including concerns over bioprospecting and the need to respect traditional knowledge, and access to generic drugs for health care. Subsidy regimes for agriculture in the West are hampering the development of export markets for the South, not to mention strengthening of their research infrastructure for agriculture. The development of global research organizations to address social and economic gaps have been short-circuited as funds are slow in coming. National policies designed to address a strengthened innovation and research effort are poorly integrated into national policies designed to assist developing countries; quite often , these are conflicting policies. And the knowledge community will be challenged to address its responsibilities as the landscape shifts with many more players than before. As noted earlier, media will play an increasing role in this; the public will become a more diverse stakeholder in these debates. Calls for moratoria on certain technologies will likely become de rigueur, however misplaced such arguments may be.

The geo-politics of security, and the moral compunction of aid will have counteracting roles on the potential for a truly open knowledge system. The debate over the research community restraining from certain publications because of national security or international spread of "dangerous" technology, will grow (though there are now calls for a global Public Library of Science to allow for free, on-line access to scientific and medical information). The restrictions on movement of skilled personnel in certain fields and from certain states, will clearly impact on creativity and entrepreneurship. Paradoxically, the knowledge community will be drawn into the security and defence fields as demand for these areas grow, and the higher education community will feel the impact of this on enrolments and faculty. Visas will limit movement. Foreign students are being watched. Wraps will be put around certain key technologies in IT, biotechnology and nanotechnology because of security concerns. At the very time that the university community is becoming internationalized– with more and more players having a role in knowledge production – there is a public pressure for them to be more responsive to a risk environment. New structures for knowledge production will emerge that respond to such limits[32]

So what is to be done?

---

[32] The Department of Homeland Defence has an entire budget and sub-structure devoted to technology that subsumes the research activities of several existing agencies. As a consequence, along with the bioterrorism and health budgets, it has become the one of the biggest single recipients of funding for research in the US Government. In Canada, a new programme for research and technology production in counter-terrorism and defence related areas is now the biggest single recipient of new funding for a government laboratory.

Constructing knowledge societies around such impediments will be delicate and complex challenges. But a key will be continuous learning and investment in training and education. Paying attention to grey matter, (not just grey goo) will be a major issue for developing societies. Not for nothing that a key Millennium Development Goal is universal primary education or that the World Bank has focussed on tertiary education systems. or that the G-8 Research Councils have developed a strategy for math and science education as key inputs for development. The talent pool is rich in all countries. Entrepreneurs, skilled craftspersons and knowledge producers exist in all societies. Providing the right incentives and institutional capacity to attract such development is what often distinguishes the richer societies from the poorer ones. In developing countries. A healthy mix of investing in national educational policies for growth, and a strong linkage with the diaspora abroad will be critical investments to consider.[33] Development of national or regional centres of excellence will help keep talent at home, along of course with strong professional recognition of the knowledge producers and adequate support through wages and infrastructure.[34]. Investing in teachers and rewarding them is also essential. Some countries have tried to develop Teachers' Awards to provide incentives in this direction. Development of diplomatic corps to use their networks for increased linkages to the diaspora and to new opportunities for investment in ideas and innovation from their respective host countries is another strategy in the knowledge toolkit. Countries like China, Eritrea, South Africa, Colombia and Argentina have introduced strong incentives and mechanisms to tap into their talent pool living abroad.

In the end, specific attention must be devoted to a suite of measures that will maintain a healthy national knowledge system linked to the global environment. The rhetoric of investing in knowledge has to be followed by the reality of long-term (not on and off again) support for skills and people. Institutions and integrated policies that complement , not contradict, each other need to be viewed as assets, along with an attention to the specific cultural, economic and social fabric of the society one is trying to improve. Capacity to learn has to be introduced: not just in copying other models blindly, but in studying and analysing carefully the good practice that can be gleaned from such exercises (including examining the right countries for comparison). And, an advisory and communications capability that is able to interact with various stakeholders in the society to ensure adequate and effective decision-making on futures for knowledge strategies. Finally, the careful monitoring and analysis of global developments will be a sine qua non for positioning the society and economy in a well-rounded approach to development .

In this last context, more attention needs to be paid to the strategic use of and learning fromthe activities of regional and global clubs. All countries belong to clubs of one form or another (some belong to too many making it difficult to provide proper funding or substantial inputs)[35].

---

[33] See the arguments of Jacques Gaillard, "Overcoming the scientific generation gap in Africa: An urgent priority", Interdisciplinary Science Reviews, Vol. 28, No.1 15-25.

[34] Of course, such investments do not limit themselves to the South. In Canada, one of the principal reasons for the creation of 2000 well-paid Canada Research Chairs in research centres and universities, was the need to address a brain drain of talent to the US.

[35] It stands to reason that as more countries are created, more clubs will emerge. It also stands to reason that as knowledge becomes more specialized, the fora that discuss these issues will equally

The use of such fora , be it through the UN system, or APEC, the Commonwealth, the African Union, or OAS, or la Francophonie, or NATO, etc..., offers countries rare opportunities to leverage funding, talent, and political cachet. Unfortunately, it is rare that states pay much attention to evaluating the benefits or impacts of memberships in these clubs.

In fact, most states often join clubs because they see a political advantage to such adherence, not necessarily because the membership offers substantial intellectual rewards. Canada, for example, as a member of the G-8, takes it as a given that it will have to continue to belong to many clubs simply because of the geo-political cachet such a membership brings.(See Box 4) Nevertheless, because of limited resources, developing countries in particular should be paying more attention to how they can benefit from selected knowledge fora.

Box 4: Selected international S&T clubs that have Canada as a member:

OAS Common Market for Scientific and Technological Knowledge
APEC Industrial S&T Working Group
OECD CSTP
NATO Science Committee
World Health Organization
International Arctic Science Committee
International Space Station
International Panel on Climate Change Convention

An assessment of existing and potentially new memberships should be developed in such instances. In addition, regular, careful examinations of bilateral and multilateral S&T, education and related agreements should be introduced in the decision-making systems in order to ensure that national and international objectives can be met.

But there is more to this equation. International organizations must themselves become more attuned to their clientele. It is axiomatic that international organizations are experimental and learning institutions. Nevertheless, they must be attuned to changes in the landscape. The NGO ETC (based in Winnipeg) has transformed itself radically over the past several years to focus its efforts on emerging technologies that may have significant impacts on society. As part of its new long-range plan, the International Foundation for Science (based in Stockholm) has substantially increased its work in support of young scholars from low income and lower middle income countries by 2004. USAID is exploring a new approach to supporting science and technology in specific regions of the world. A new Global Research Alliance of technology organizations for the South has been established to create a network designed to build on opportunities for technology exchange and joint ventures: in short to fill a perceived gap. NEPAD has a newly minted African Forum on Science and Technology for Development. And the UNDP Human Development Report of this year has argued for a series of international fora to help establish research priorities required to meet the technological needs of the developing world. The list goes on.

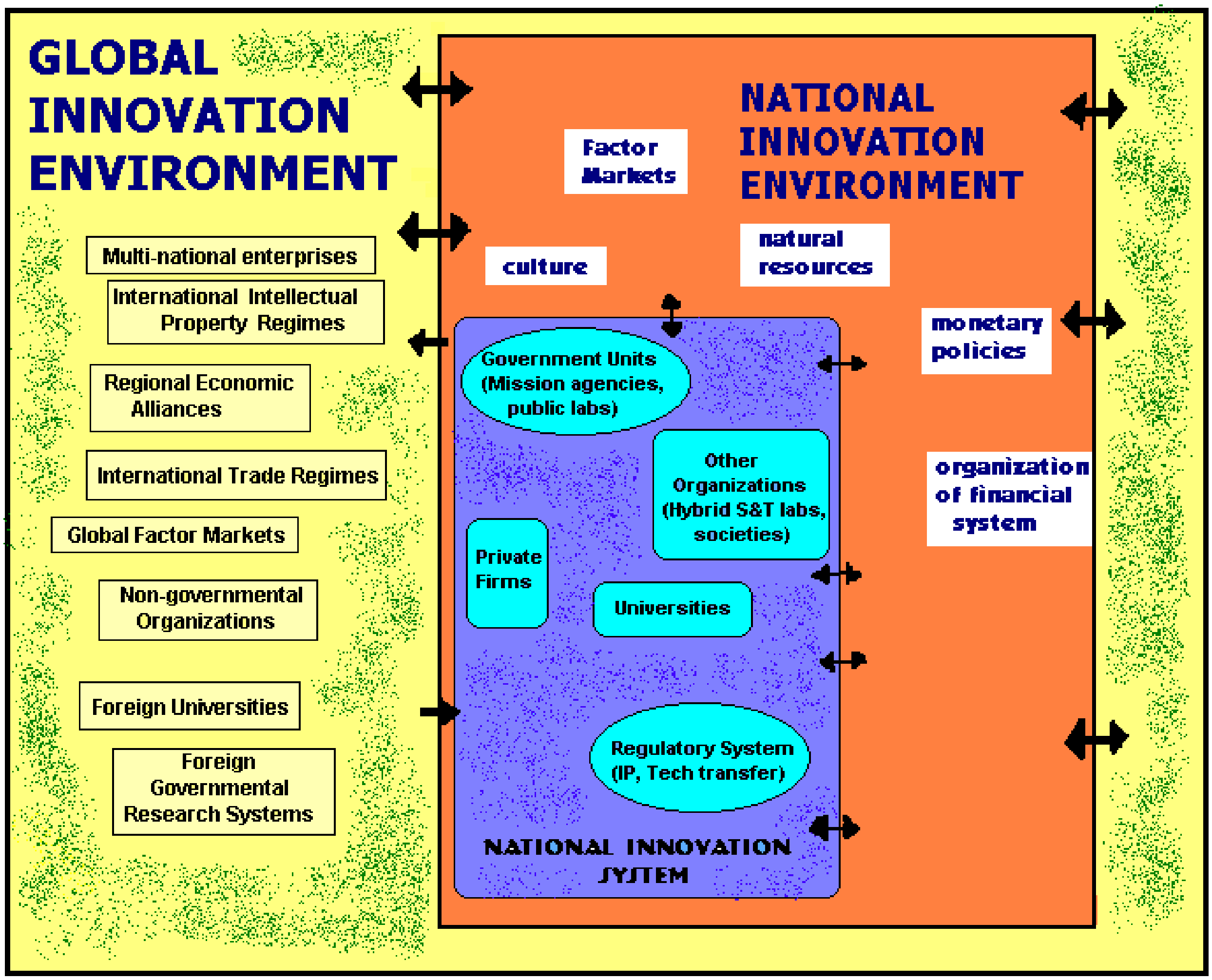
It is not rocket surgery to say that knowledge will continue to expand. Institutions designed to advance and diffuse this knowledge will also increase. The developing countries have an opportunity to position themselves well in this new arena if they pay attention to the lessons of

increase.

the past, and help shape and dictate the direction of this new and complex frontier of knowledge.

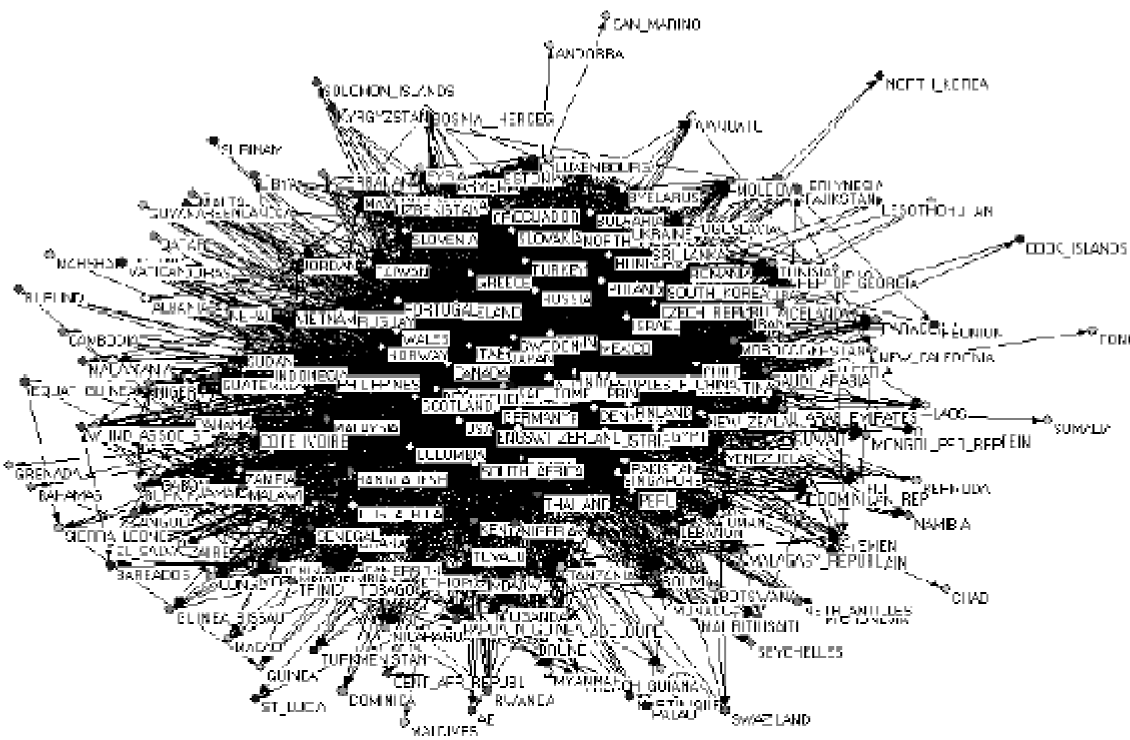
Appendix: Charts 1-

Chart 1: Innovation Systems [36]



[36] Adapted from *Knowledge Flows, Innovation, and Learning in Developing Countries.* CSPO, 2003. www.cspo.org

Chart 2: Models of Knowledge Flows: The Global Map of Science [37]



[37] Caroline Wagner and Loet Leydesdorff, "Mapping Global Science Using International Co-authorships: A Comparison of 1990 and 2000". University of Amsterdam. January 2003

Chart 3: Economic Disparities and the Knowledge Divide [38]

	Values and Ratios				
Indicator	**OECD countries (A)**	**Low income countries (B)**	**Ratio (A)/(B)**	**Low income countries (excluding India) (C)**	**Ratio (A)/(C)**
Gross capital product per capita (constant 1995 US$)	29,578.0	461.0	64.2	465.8	63.5
Gross capital formation per capita (constant 1995 US$)	6,730.3	101.7	66.2	95.2	70.7
Trade per capita (imports + exports of goods and services) (constant 1995 US$)	13,030.9	190.6	68.4	246.4	52.9
Scientific Output : Scientific publications per 100,000 inhabitants (1995)	72.9	0.8	88.8	0.2	331.4
Technological Output: Patent applications by resident per 100,000 inhabitants	75.4	0.4	197.2	0.3	260.0
Production Output: High-technology exports per capita	831.6	1.3	645.5	1.1	729.5

[38] Francisco Sagasti, The Sisphysus Challenge: Knowledge, Innovation and the Human Condition in the 21st Century. Forthcoming.

Chart 4: Comparative Charts on S&T Policy and Directions: South Africa, India, Vietnam, and Maldives.

Table 4.1: S&T Policy and Performance Indicators[39]

				Education Indicators			Science and Technology Indicators			
	UNDP 2001 Technology Achievement Index Ranking[40]	Total R&D Expenditure (% of GDP, 1996-00)	Planned Increases in R&D Expenditure (Policy date), (% GNP)	Public expenditure on Education (% GDP, 1998-00)	Youth literacy rate (% age 15-24, 2001)	Tertiary Students in science, math and engineering (as % of all tertiary students, 1994-97)	Tech. Diffusion: Telephone mainland and cellular users (per 100 people, 2001)	Tech. Creation: Receipts of royalties, licence fees (US$ per person, 2001)	High-tech exports (as % of manu-factured exports, 2001)	Scientists and engineers in R&D (per million people, 1996-00)
Finland	1	3.4	N.A.	6.1	100	37	135.1	112.5	23	5059
South Africa	39	0.7	1(2002)	5.5	91.5	18	35.3	1.2	5	992
India	63	1.2	2 (2003)	4.1	73.3	25	4.4	0.1	6	157
Viet Nam	-	1	2 (1981)	N.A.	95.4	N.A.	5.3	N.A.	N.A.	274
Maldives	-	N.A.	N.A.	3.9	99.1	N.A.	16.8	12.8	0	N.A.

39 Sstatistics originate from UNDP. 2003. *Human Development Report 2003.* New York: Oxford University Press; Government of the Republic of South Africa. 2002.; Ngoc Ca, Tran and Bo Goransson. 1999; Department of Science and Technology of the Government of India. 2003.

40 UNDP. 2001. *Human Development Report 2001.* New York: Oxford University Press. UNDP Technology Achievement Index ranks countries based on various indicators of technological achievement, including technology creation (patents, royalties), diffusion of innovations, and human skills. Viet Nam and Maldives are not ranked because not enough information was available at the time of publication.

Table 4.2 : S&T Policy and Directions [41]

	S&T Policy Objectives	Salient Research Areas	Key Strategy Focal Points	Current Areas of Difficulty
South Africa (History of Apartheid)	Improving the quality of life of all Poverty reduction National competitiveness	S&T Innovation Missions: Poverty reduction New technology (Biotech and IT) Manufacturing Resource-based Industries Defining IPRs	Basic research and innovation Developing key sectors of strength (niches) Equity in human resources (women, black community)	Lack of clear strategy Human resources- aging white/male researchers Declining R&D in private sector Fragmentation of government S&T leadership
India	Raising quality of life of all National competitiveness Sustainable use of resources National security	Popularization of science Protection of traditional knowledge systems S&T for National security programs Defining IPRs	Basic research and innovation Developing key sectors of strength (niches) Bridging R&D and industry Empowerment of women Emphasis on monitoring and evaluation	Not available.
Viet Nam (History of socialist/ communist system)	S&T "as a means for development"	Social S&T (AIDS, water, poverty reduction) Economic/technical S&T (IT, Biotech, New Materials, Automation)	Application and adaptation of technology from overseas to national needs Shift towards privatization and liberalized trade Diversification and decentralization of S&T	Weak horizontal links between institutions Tendency towards supply-driven S&T activities Immense number of regulations and unclear

[41] Information on **South Africa** comes from Government of the Republic of South Africa. 2002. *South Africa's National Research and Development Strategy.* Pretoria: August 2002; **India**: Department of Science and Technology of the Government of India. 2003. *Science and Technology Policy 2003*. New Delhi: January 2003. http://dst.gov.in/doc/STP2003.doc ; **Vietnam:** Ngoc Ca, Tran and Bo Goransson. "Reforming the Science, Technology, Education and Training System in a Transitional Economy: The Case of Vietnam" *Reconstruction or Deconstruction? Science and Technology at Stake in Transition Economies.* Ed. Claes Brundenius et al. Hyderabad : Univerities Press, 1999.; **Maldives**: Ministry of Communication, Science and Technology, *Republic of Maldives, Science and Technology Master Plan.* Government of Maldives, 21 April 2001. http://www.mcst.gov.mv/Documents/mplan.htm

			Strong political commitment to integration of S&T with national socio-economic objectives	overall strategy Aging researchers
Maldives (small island state, economically dependent on tourism and fisheries)	S&T towards country's goals "to raise the standards of living, improve social equity, modernize the economy, and participate effectively in an increasingly integrated world"	Overall focus on IT and communications devt Other research areas: energy (alternative sources) health research fisheries/tourism	Application and adaptation of technology from overseas to national needs Gov't coordination and encouragement of private sector R&D Fostering research in regional/atoll centres outside capital Explicit criteria for selection and monitoring	Economic and human resources insufficient to foster S&T Weak IT awareness and usage Older telecommunications infrastructure Weak education system, particularly in S&T/research

Chart 5: Public Opinion of Professionals and Technologies[42]

Table 5.1: Public confidence in Professional Institutions

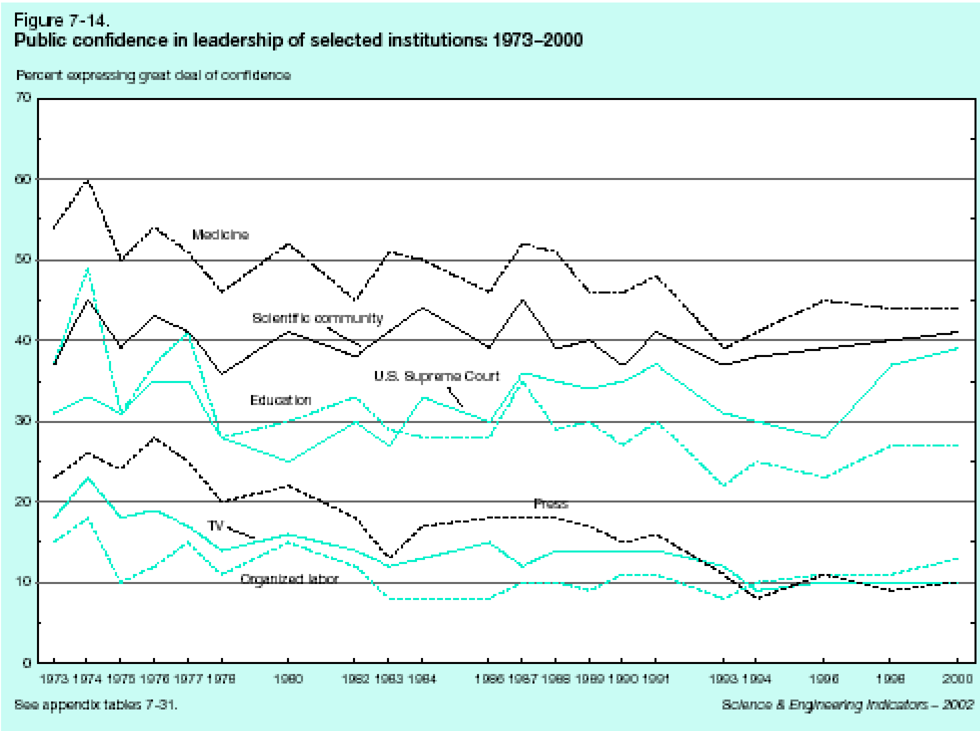
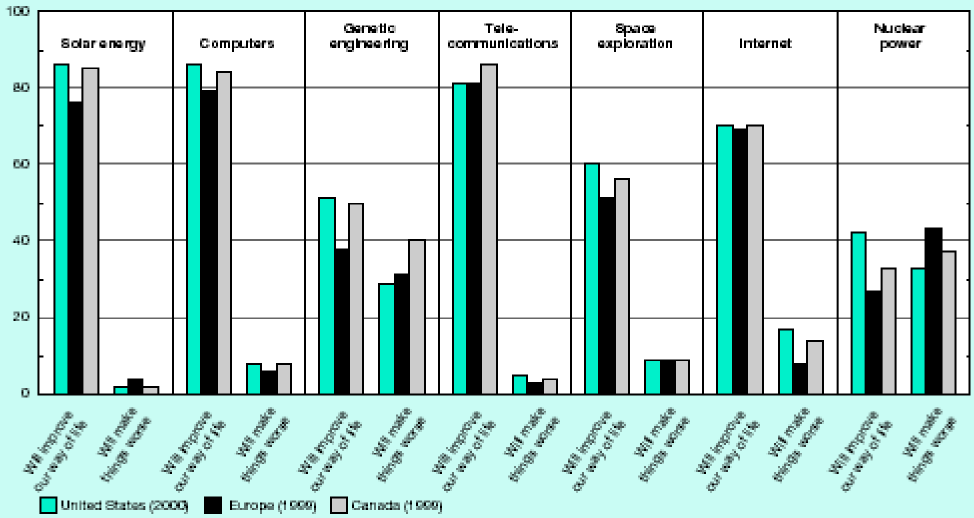


Table 5.2 : Public Attitudes towards Selected Technologies

[42] *Science and Engineering Indicators 2002.* National Science Foundation, Division of Science Resources Statistics. Arlington VA: January 2002.

Figure 7-11.
Public attitudes toward selected technologies in the United States, Europe, and Canada

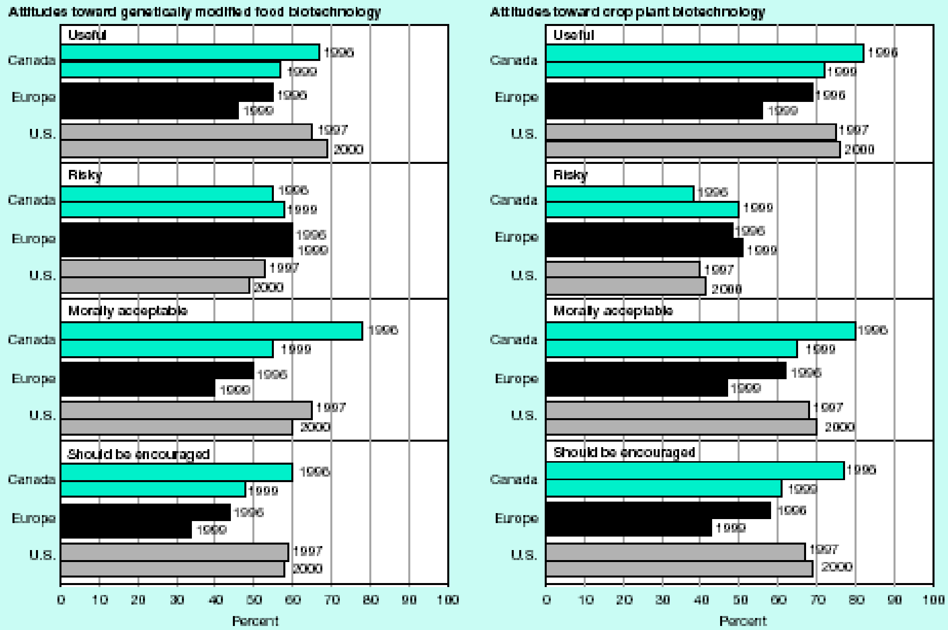


SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996-2000*, National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Alum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary.

Science & Engineering Indicators – 2002

Chart 6 : Public Attitudes of GM Foods [43]

Figure 7-9.
Attitudes toward genetically modified food and crop biotechnologies in Canada, Europe, and the United States



SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996–2000*, National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Alum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary. The 1997 U.S. survey was conducted by Jon D. Miller, Chicago Academy of Sciences.

Science & Engineering Indicators – 2002

[43] *Science and Engineering Indicators 2002.* National Science Foundation, Division of Science Resources Statistics. Arlington VA: January 2002.

Chart 7: Priorities Identifies in Foresight Exercises and Relevance to Selection Criteria [44]

		Criteria					
Country	**Scientific Development**	**Scientific Potential**		**Collaboration Potential**		**Potential Impact**	
		Major scientific advances in 5-10 years	Impact on other sciences	International collaboration opportunities	Multi/ inter-disciplinary opportunities	Major societal benefit	Ethical issues
LIFE SCIENCES & BIOTECHNOLOGY							
Australia, Brazil, Canada, France, Hungary, Ireland, Japan, S Africa, Spain, UK, US, APEC	**Human Genetics, functional genomics-** identify disease-related genes/proteins, bio-informatics, gene therapy	YES	YES	YES	YES	YES (for some people/ countries)	YES
Australia, Brazil, Canada, Finland, France, India, Ireland, Japan, Peru, S Africa, UK, US, Uruguay, APEC	**Genetic modification of food/ crops-** eg using crops using less water, saline/disease/ pest resistant, etc.	YES	YES ?	YES	SOME	YES	YES
Australia, Hungary, APEC	**Intellectual property** and knowledge regulation, control	YES	YES	YES	YES	YES	YES
HUMAN HEALTH							
Austria, Brazil, France, Japan, UK, US	**Medical and supportive technologies** for the elderly and disabled	YES	MAYBE	YES	YES	YES	SOME?
ENVIRONMENT, SUSTAINABLE USE OF NATURAL RESOURCES							
Brazil, France, NZ, Peru, S Africa, Spain, US	**Biodiversity-** bio-mapping, inventory/ databases, conservation/ maintenance of biodiversity	YES	SOME	V LARGE	YES	YES	YES
Brazil, France, India, Japan, Peru, S Africa, UK, APEC	**Water recycling-** treatment and re-use of waste water from sewage	MAYBE	NO	YES	SOME	YES	NO

[44] Adapted from International Council for Science. 2002. *Identification of Key Emerging Issues in Science and Society: an International Perspective on National Foresight Studies.* pp18-19.

ENERGY							
Brazil, Germany, Ireland, India, Japan, Peru, S Africa, UK, US, Uruguay	**New/ renewable clean energy** sources (biomass, wind, hybrid systems)	YES	MAYBE	YES?	YES	YES	NO
INFORMATION AND COMMUNICATION TECHNOLOGIES							
Australia, Canada, India, Ireland, Hungary, Spain, UK, US	**Sensors-** biosensors, artificial senses + sensors directly stimulating nerves, integrated intelligence sensors, environmental sensors	YES	YES	YES	YES	YES	SOME?
MATERIALS SCIENCE							
Brazil, Canada, France, Hungary, S Africa, UK, US, APEC	**Nanotechnology-** including nanofabrication	YES	YES?	YES	YES	YES	NO