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Science, technology and engineering for innovation and capacity-building in education and research

Report of the Secretary-General

Executive summary

This report seeks to identify policies for the effective promotion of science, technology and engineering for innovation and capacity-building in education and research, as part of the wider enabling policy framework to meet the Millennium Development Goals contained in the Millennium Declaration. Though there is wide consensus that technological innovation is a driver and critical source of sustainable economic growth in the new millennium, many developing countries have yet to benefit from the promises of science, technology and innovation (STI).

Harnessing knowledge for development requires putting science, technology and innovation at the centre of national development strategies. In particular, STI policies can provide special working conditions for science and technology talent and institute reward structures to promote research directed at addressing national and regional development challenges. The promotion of research and development can be complemented by the commercialization of scientific and technological research for addressing developmental challenges and creating employment. Venture capital can supplement loans and microfinance as a form of financial and mentorship support needed to catalyse promising enterprises. Developing countries can augment regional STI capacity-building networks with other developing countries that share common development challenges in other regions of the world. Finally, innovation may require that society embrace change, creativity and learning. Without an innovation-friendly culture, STI capacity-building mechanisms may not deliver the returns that innovation promises the developing world.

I. Introduction

1. At the Millennium Summit in 2000, United Nations member States adopted a set of time-bound and measurable goals, targets and indicators to combat poverty, hunger, disease, illiteracy, environmental degradation and gender inequality. Five years later, in September 2005, member States gathered at the World Summit in New York to review the progress made towards fulfilling the commitments contained in the United Nations Millennium Declaration. At this gathering, member States renewed their commitment to achieving internationally agreed development goals, and affirmed the vital role of science and technology to economic and social development.

2. The Commission on Science and Technology for Development (CSTD), in response to the request of the Economic and Social Council in its resolution 2007/240, and recalling the Commission's provisional agenda and documentation for the eleventh session as contained in paragraph 2 of that resolution, decided to explore the substantive theme "Science, technology and engineering for innovation and capacity-building in education and research" as a specific area of concern.

3. To contribute to a further understanding of the issues, and to assist CSTD in its deliberations at its eleventh session, the UNCTAD secretariat convened an inter-sessional panel meeting in Kuala Lumpur, Malaysia, from 28 to 30 November 2007. The present report is based on the findings of the panel, on national reports contributed by members of CSTD, and other relevant literature.

II. Potential of science, technology and innovation capacity-building

4. Science, technology and innovation are powerful tools in the alleviation of poverty through the creation of employment opportunities, growth of indigenous firms and increases in agricultural productivity, as well as the achievement of the Millennium Development Goals. Without STI capacity-building at the centre of the development agenda, developing countries will not be able to meet their socio-economic development goals.

5. Science and technology have played an essential role in achieving industrialization and sustainable development in developing countries, especially as globalization has brought about a more competitive environment. Because innovation played a critical role in the success of today's advanced and emerging economies, developing countries are also encouraged to find ways of building their capacity to innovate. Therefore, developing countries could consider making capacity-building in STI a priority for national socio-economic development, as part of a wider framework of the enabling environment.

6. Though there is wide consensus that technological innovation is a driver and critical source of sustainable economic growth in the new millennium, many developing countries have yet to benefit from the promises of science and technology. More than half the world's population lives on less than $2 a day,[1] and nearly 30,000 people in the developing world die from endemic diseases each day. Many children die of illnesses such as diarrhea that could easily be prevented with access to safe drinking water or treated with some basic medical knowledge.[2] Nearly 1.5 billion people lack access to clean water.

[1] Website of the Millennium Development Goals: http://www.developmentgoals.org/Poverty.htm.
[2] Oxfam International website: http://www.oxfam.org.uk/about_us/thisisoxfam/healthy/.

7. Because STI has been a missing component of the national development agenda of African countries, most of these nations are not yet tapping into the power of innovation to solve their local development challenges. Analysis shows that, although least developed countries (LDCs) are concerned with promoting sustained economic growth as a basis for poverty reduction, the treatment of technological change as a source of economic growth in recent Poverty Reduction Strategy Papers is generally weak.[3]

8. Developing the capacity to address developmental challenges through STI capacity-building involves concerted efforts by the public and private sectors, academia and civil society to infuse innovation as a basis for creatively meeting the needs of the developing world. Developing countries are encouraged to use more innovative approaches in their science and technology-related policies to effectively harness knowledge for development.

III. Beyond science and technology labour shortages: investing in science and technology education

A. Deficit of science and technology talent in the developing world

9. Education, especially science education, is important not only for increasing general science and technology literacy, but also for enabling developing countries to build up a critical mass of scientists, researchers and engineers.

10. However, in many countries, there is a deficit of engineers and scientists. Recent years have witnessed a worrying trend that the percentage of university enrolment in science, mathematics and engineering has been decreasing. Concerted efforts are urgently needed to reverse this trend and encourage science education at all levels.

11. The situation in many developing countries is further exacerbated with the serious problems of "brain-drain." By some estimates,[4] up to one third of research and development professionals from the developing world reside and work in Organization for Economic Cooperation and Development (OECD) countries. Academic and research institutions in many of the developing countries have not expanded sufficiently to absorb graduates in science and technology. The conditions of work are poor in comparison to those in developed nations. Professional opportunities are fewer due to poor physical infrastructure, lack of financial resources and the absence of the critical mass of researchers for active research communities.

12. Even when science and technology professionals remain in their home countries, their attention is often diverted away from research of local relevance. This is because work on scientific problems that are of interest to the international community stands a better chance of receiving academic recognition and opportunities for collaborative research from well-funded institutions. This creates a situation where the scarce resources in developing countries are diverted to benefit developed countries.

[3] UNCTAD (2007). *The Least Developed Countries Report 2007: Knowledge, Technological Learning and Innovation for Development.* (New York and Geneva, United Nations).

[4] UNDP Commission on Private Sector and Development (2004). *Unleashing Entrepreneurship: Making Business Work for the Poor*. http://www.undp.org/cpsd/report/index.html. On the problem of brain drain from LDCs, see UNCTAD (2007): *The Least Developed Countries Report 2007.*

B. Strategies for training and retaining science and technology talent

13. Developing countries could consider providing special working conditions for their best science and technology talent, especially young graduates, as a mechanism to enhance future leadership for science and technology. Developing close ties with expatriates can also help developing countries generate research talent through collaborative projects. These links often provide sources of new technologies through investment in the home countries. Some countries, such as India and Pakistan, have benefited from expatriate scientists or those who have returned from abroad.

14. A review of the academic reward system, particularly within developing countries, could be encouraged. Innovative compensation and reward structures could be created to promote research directed to addressing national and regional development challenges. Educational institutions can provide students with not only an understanding of fundamental principles and technological trends, but also applied skills and industry-specific technological knowledge. Coursework on entrepreneurship and business management could also be introduced, preparing students for the rigors of managing innovative enterprises, as well as facilitating a culture of entrepreneurship.

15. The improvement of higher education will not be fully effective at stimulating innovation unless it is also accompanied by an expansion of opportunities for graduates to apply their skills and talents. By providing employment opportunities and career paths for scientists and technologists, enterprises can encourage more students to enrol in scientific and technological fields. As more students graduate with relevant skills and motivation, this growing pool of human capital can, in turn, attract more enterprises to the region, thus creating a virtuous, self-reinforcing circle of technological capacity development and research and development activity.

IV. Beyond research: turning knowledge into wealth

16. Science and innovation policy analysts face one critical challenge: how to spur innovation in poor countries that do not have the resources to invest in generating new knowledge. At its seventh session, held in May 2004, CSTD suggested that Governments needed to demonstrate their political commitment and appreciation of the role of science and technology in development by increasing research and development expenditure in science and technology to at least 1 per cent of gross domestic product and to encourage research and development, engineering and design including in areas involving the assimilation of existing knowledge that address the needs of national development.[5]

17. While such calls help Governments, and other economic actors focus attention on the role of innovation in development, they are only part of a large portfolio of measures needed to stimulate technological innovation.[6]

A. Moving past STI policies that only promote knowledge creation

18. Building the capacity to acquire and produce additional knowledge will be of little relevance unless national economic actors – such as agricultural, manufacturing and service enterprises – have the capacity to use this knowledge to produce higher value goods and services.

[5] CSTD (2004). Report on the seventh session (24–28 May 2004), Economic and Social Council. Official Records, 2004, Supplement No. 11. (New York, United Nations).

[6] Bell Jr. BW and Juma C (2007). Technology prospecting: lessons from the early history of the Chile Foundation. *International Journal of Technology and Globalization*, 3(2/3): 296–314.

19. For example, in several countries, world-class research and development facilities coexist alongside impoverished rural villages and/or uncompetitive local industries.[7] Knowledge per se does not automatically or inevitably create wealth. It is the application and commercialization of knowledge, scientific or otherwise, into useful devices, installations, services and systems that leads to wealth creation.[8]

20. Patent statistics can be a useful proxy for estimating commercial outputs. One of the widest innovation disparities globally is the number of patent applications.[9] Between 1991 and 2004, only 20 United States patents were granted to citizens of LDCs, compared with 14,824 to citizens of other developing countries and 1.8 million to citizens of OECD countries.[10]

21. In spite of this trend, some developing countries are creating new institutional mechanisms to commercialize science, technology and innovation knowledge into products and services. One example is the case of the Chile Foundation (see box 1).

Box 1. Chile Foundation

In the 1970s, Chile Foundation (FCh) wanted to explore transferring fishery-related technologies to increase the degree of processing of maritime resources, making the fishing sector more productive and profitable. Chile seemed ideal for raising salmon on a commercial scale because its southern waters were clean, unpolluted, clear, fresh and oxygen-rich, and its water temperatures and climatic conditions were favourable for salmon breeding as in the Northern Hemisphere.

Cage cultivation technologies were adapted and modified by way of experiments (learning by doing), use of national and international consultants (learning by hiring) and training of permanent staff at ranch farms and fish technology centres abroad. Through experiments, FCh was able to make a feed mixture using exclusively local resources to significantly reduce the overhead. The use of less costly local resources contributed to the international competitiveness of Chile's salmon industry. In January 1982, FCh acquired open-sea ranching Pacific salmon smolt production facilities in order to establish Salmones Antártica, the first fully integrated company in the Chilean salmon farming industry.

While still a foundation subsidiary, Salmones Antártica became the nation's largest salmon enterprise. After 10 years, the salmon industry had become a dynamic export sector. In 1988, profits were generated, the technology transfer cycle was completed and FCh offered Salmones Antártica for sale when it was bought by the Japanese seafood processing firm Nippon Suisan Kaisha for $21 million.

Since the establishment of Salmones Antártica in 1982, FCh's technological assistance projects have helped to form numerous companies in southern Chile. The successful sale of Salmones Antártica at the end of 1988 was FCh's first of many pilot companies that would spin off following technical and commercial development. The growth of the Chilean salmon sector, which was generating $1.4 billion annually by 2005, has resulted in job creation and development of extensive ancillary industry in some of the remote areas of the country.

The Chilean case shows that, contrary to conventional thinking, natural resource-based industries require rather complex technological skills and organizational structure that can be beneficial for the overall competitiveness in the country. The agricultural sector, with the help of a technology development agency such as FCh, might be used to build up the commercialization capabilities of the Government and private sectors.

Source: Bell Jr. BW and Juma C (2007).

[7] Watkins A (2007). Building science, technology and innovation capacity for sustainable growth and poverty reduction. Background Discussion Paper for World Bank STI Global Forum (Washington, D.C., World Bank).

[8] This report does not advocate for the commercialization of STI over and against the production of new knowledge or basic research. However, without mechanisms for translating STI into tangible products, services and interventions that address development challenges, innovation efforts in developing countries will only be a shadow of its true potential. Developing countries are encouraged to strike a balance between the generation of knowledge and the utilization of knowledge (commercialization) for addressing development challenges and improving firm and national competitiveness.

[9] Knell M (2007). Uneven technological accumulation and growth in the least developed countries. Background Paper No. 11 for UNCTAD's *Least Developed Countries Report 2007*.

[10] UNCTAD (2006). *The Least Developed Countries Report 2006: Developing Productive Capacities*. Prepared by the UNCTAD secretariat (New York and Geneva, United Nations).

B. Strategies for stimulating commercialization in developing countries[11]

22. Developing countries could consider strengthening incentives for commercialization of publicly-funded research and development. For example, developing countries can adopt new legislation to promote the emergence of an entrepreneurial spirit on academic campuses and research institutes, by allowing the freedom to negotiate flexible deals with partners in the private sector and allowing rewards to flow back to the labs and individuals who contributed to the revenues.

23. Mobility of personnel between public research and development labs, universities, and industry could be encouraged through competitive awards with generous stipends.

24. Technology parks and business incubators can be expanded with government support and private finance and management, based on international best practice – including the experiences of Israel, Taiwan Province of China, the United Kingdom and the United States.

25. To spur greater international collaboration, developing country Governments can also support advanced research and development and commercialization projects carried out jointly by domestic and foreign enterprises, including other developing countries as well as developed countries.

V. Beyond loans: establishing venture capital mechanisms[12]

26. Since innovation requires investment in research and development, it is a risky endeavour that many firms in developing countries cannot afford to engage in alone. Financial institutions can help foster business development and technological innovation. Unfortunately, in developing countries, domestic financial systems are usually weak and risk-averted, and the availability of venture capital is also limited.[13]

A. Potential of venture capital for business development

27. Venture capital markets have contributed to the success of small and medium-sized enterprises in many developed and some developing countries.[14] Venture capital plays an important role in financing innovation in a number of countries, and can be important for the commercialization of research and development. Venture capital and angel investor financing is usually accompanied by management support, advice and other forms of mentoring critical to business success.

28. Venture capital has also been recognized for advancing the information and communication technology revolution, enabling some more advanced developing and transition economies to catch up with international peers, deepening research and development, and facilitating the transition to knowledge and learning

[11] Strategies in this section are based on recommendations from Dutz MA (ed.) (2007). *Unleashing India's Innovation: Toward Sustainable and Inclusive Growth.* (Washington, D.C. The International Bank for Reconstruction and Development/The World Bank).

[12] This section is based in part on Dhingra IS (2007). Enhancing innovation finance, in: Dutz MA (ed.). *Unleashing India's Innovation: Toward Sustainable and Inclusive Growth:* 163–185 (Washington, D.C. The International Bank for Reconstruction and Development/The World Bank).

[13] UNCTAD (2007).

[14] Branscomb LM and Auerswald PE (2001). *Taking Technical Risks: How Innovators, Executives and Investors Manage High-Tech Risks* (Cambridge, Mass., MIT Press); Bruton G, Ahlstrom D and Yeh KS (2004). Understanding venture capital in East Asia: the impact of institutions on the industry today and tomorrow. *Journal of World Business*. 39(1): 72–88.

economies. The case of Taiwan Province of China shows how venture capital was part of its economic transformation strategy (see box 2).

Box 2. Taiwan Province of China's economic transformation miracle through venture capital

In 1962, Taiwan Province of China was a small, underdeveloped, agricultural island with a per capita gross national product of $170, placing its economy in the range of a number of today's LDCs. Along with the other Asian Tiger economies, Taiwan Province of China designed a macroeconomic set of policies which led to rapid economic growth. One factor which allowed the island to surpass other Asian economies in many of the very high value added technology sectors was its parallel policy of actively promoting a venture capital industry.

Key policies the Government of Taiwan Province of China took to promote venture capital were:

A **20 per cent investment tax credit** incentive for first-time investors in venture funds (rewarded upon actual investment by venture funds in strategic high-tech industries);

Facilitating institutions including funding university science and engineering departments, the Hsinchu Science Park with substantial incentives and ease of registration for strategic firms, and the Industrial Technology and Research Institute (ITRI) which served as an incubator and research and development centre with active linkages to venture capital organizations and forums;

Successive **seed development funds** to stimulate venture capital fundraising;

Creation of a **technology board** and recently an **over-the-counter board** within the stock market, creating a viable exit strategy for venture funds;

Restrictive regulations, preventing venture funds from investing in public securities; and

Diaspora mobilization, creating a bridge for the latest in technical expertise, market knowledge, managerial experience, entrepreneurial skills and capital access. This was exemplified by the Monte Jade association and the STAG advisory group, which worked closely with policymakers during the design and implementation of Taiwan Province of China's new economy.

Starting in the mid 1980s, it took just over a decade for the venture capital market in Taiwan Province of China to make information and communications technology (ICT) exports account for half of the island's total exports, with over $20 billion in output. Venture capital fills a vital financing gap which most developing economies have suffered from, both then and today. Touted as Asia's Silicon Valley success story, Taiwan Province of China's inclusion of venture capital policy in its overall macroeconomic strategy and the successful localization of the venture capital model, have laid the foundation for long-term, sustainable, globally competitive growth.

Source: Hsu M (2007). Taiwan Province of China Venture Capital Case Study, personal communication. Master's candidate, Harvard U. JFK School of Government.

B. Strategies for stimulating venture capital

29. Governments could play an important role in setting up an enabling framework for private parties to launch venture capital institutions. Policy measures to provide a positive enabling environment could address basic aspects of the legal and regulatory environment, such as (a) providing for the legal status of ownership, minority shareholders rights and a system for the rapid and transparent handling of conflicts between various owners and creditors; (b) an appropriate tax system; and (c) an adequate accounting standard. The legal and regulatory environment could support the establishment of sound, organized markets. The idea is for the public sector to be responsive to the needs of the productive enterprise sector.

30. Certain measures could make it more attractive for wealthy individuals to invest in venture capital funds. This can be done through tax incentives and other

legislative changes that allow tax pass-through benefits for "accredited" angel investors. The investment guidelines of pension and insurance funds could also be relaxed to increase their investments in early-stage ventures.

31. Another possible mechanism is the creation of a special venture capital fund (VCF), involving partnerships between private investors and the public sector, as well as local partners. The VCF could foster a mutually beneficial synergy between the international investment community, multilateral and bilateral aid agencies, Governments and entrepreneurs, by pooling investment projects in many developing countries, thus overcoming the obstacle of small individual markets and providing a diversified portfolio of investment.

VI. Beyond regions: developing needs-based partnerships

32. Many countries are organizing themselves into regional economic blocs. As a result, many scientific and technical opportunities are also being pursued in the context of regional associations of neighbouring countries. Regional partnerships have been promoted as a possible solution for developing countries to harness the collective human resources, expertise and infrastructure of multiple countries and research hubs to address similar development challenges.

A. Common development challenges across regions

33. However, there are many developing countries that share common development challenges but are not located in the same geographical region. Issues related to food security, sustainable and alternative energy sources, availability of water resources and sanitation services, and neglected diseases are cross-cutting themes that are not necessarily relegated to particular regions but are shared by many developing countries from varying regions.

34. Collaboration in science, technology and innovation can go beyond the regional approach to an international approach, where countries not necessarily in the same region collaborate on research and development to address similar concerns related to water, energy and other issues.

35. These countries can perhaps develop common solutions to their common problems outside of the conventional regional approach. One example is that of the International Aids Vaccine Initiative (IAVI), which brings scientists from all over the world to collaborate on the AIDS pandemic (see box 3).[15]

Box 3. International AIDS Vaccine Initiative

IAVI is a global not-for-profit, public–private partnership working to accelerate the development of a vaccine to prevent HIV infection and AIDS. IAVI's scientific team, drawn largely from the vaccine industry, researches and develops HIV vaccine candidates and conducts HIV clinical trials and clinical research through partnerships with more than 40 academic, biotechnology, pharmaceutical and government institutions. Scientists at Oxford University and the University of Nairobi, and manufacturers in Germany and the United Kingdom, have moved the leading vaccine from concept to clinical trials in record time. IAVI has encouraged the buildup of local capacity by working with developing country researchers and using local doctors to conduct trials.

IAVI implements a major part of its research, policy and advocacy programmes in developing countries, where 95 per cent of new HIV infections are occurring. IAVI's HIV vaccine trials, conducted in collaboration with local scientists, are located primarily in Africa and India, where different subtypes of the virus are circulating. Local partner institutions include the Kenya AIDS Vaccine Initiative, Rwanda's Project San Francisco, the Uganda Virus Research Institute, the Indian Council of Medical Research and the

[15] This proposal is not to debunk the regional approach to development, but rather to complement it. Developing countries need better and more effective ways of organizing themselves to address their challenges.

Zambia Emory HIV Research Project. In other areas of the world where IAVI is not currently sponsoring HIV vaccine trials – Brazil and China, for example – the organization works with on-the-ground partners to support national efforts in HIV vaccine research and mobilization.

As part of the organization's advocacy in developing countries, IAVI is supporting the India–Brazil–South Africa trilateral agreement as a vehicle for spurring cooperation in vaccine development among countries with growing biomedical research and manufacturing capabilities. Science ministers from Brazil, India and South Africa have been working together to identify areas for trilateral cooperation in nanotechnology and efforts to prevent and treat HIV/AIDS. The partnership was inspired by the low level of investment in research on tropical challenges. This is the first major effort to promote cooperation with a focus on emerging technologies. It is likely that the collaboration will inspire other countries to want to join the group or seek to benefit from the results of the alliance.

Sources: IAVI website (www.iavi.org); United Nations Millennium Project (2005). *Innovation: Applying Knowledge in Development* (London; Sterling, Va., Earthscan); United Nations Development Programme (2001). *Human Development Report 2001: Making New Technologies Work for Human Development* (New York, Oxford University Press).

B. Strategies for developing needs-based partnerships

36. International agencies can develop a clearinghouse of common development challenges of developing countries that can be addressed through STI and convene representatives of those countries to explore concrete ways of engaging and partnering in solutions.

37. The International STI Centre for South–South Cooperation under the Auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO) is being launched in Malaysia in May 2008. In particular, it aims to create a problem-solving network of centres of excellence in developing countries as well as a supporting exchange of students, researchers, scientists and technologists among developing countries. This problem-solving network could possibly serve as a forum for developing countries to set up global partnerships to address common development challenges through science and technology.

VII. Beyond a stigma of failure: creating a culture of innovation

A. Lack of support for innovation

38. In many developing countries, there is a lack of support for research and development and innovation. Without changing this mindset, there is no potential for innovation in the developing world. Novel ideas are critical for supporting entrepreneurship and innovation.

39. The fear of social dislocation can ultimately deter innovation or economic progress. For example, the first waves of industrial innovation in Spain led to social unrest and the destruction of textile machinery by Luddites, as workers, bereft of voting rights, violently expressed their anxiety over technological changes.

B. What innovation requires socially and culturally

40. More than any technical, financial, institutional or policy mechanism, stimulating innovation in any economy requires broad and far-reaching shifts in how people and society view and embrace change, creativity and learning. The

utilitarian value of technological innovation is not only concentrated in products and processes, but also the transformation of society and its value systems.[16]

41. Innovation involves a shift in traditional relationships where society is laden with a science culture that encourages transparency, openness, criticism and exploration.[17] This emerging science culture endows a society with the capacity to move beyond the constraints of maintenance learning and adapt and reflectively manage complex, dynamic challenges.[18]

42. Research has shown that a region's openness to new ideas, creativity, diversity and inclusiveness is a critical factor in its ability to attract talented people, incubate new firms and catalyze economic growth and prosperity.[19] Malaysia is recognizing the cultural barriers to technological innovation and is developing broad-based campaigns to reinvent the culture of the youth towards science and technology.

C. Strategies for facilitating innovation-friendly culture[20]

43. Countries can launch campaigns to raise awareness of the importance of research and development for competitiveness and of commercialization of ideas for wealth creation and national welfare. Mass media (including television, movies and radio), role models, celebrities and mentors could be used for these efforts.

44. Success stories can be disseminated about techno-entrepreneurs and other innovators through publicity, prizes and public recognition for cases that exemplify how knowledge has been turned into wealth or used to improve welfare.

45. High-profile awards can be established for creative teachers to encourage them to inspire creativity in their students, from primary and secondary school through vocational training and university education.

46. New approaches can be contemplated to encourage risk-taking and the associated inevitability of failures. Reforming exit policy through more efficient bankruptcy rules and initiating reforms to improve the legal and regulatory framework for insolvency would help remove the stigma of failure and contribute to increased risk-taking and experimentation.

47. International agencies can perhaps work with high-level political officials and policymakers to identify cultural and societal issues that challenge a culture of innovation, particularly as a part of their policy review and consultation processes. The international development community can also assume responsibility in promoting innovation on a broader global level to complement the work of individual countries and regions. CSTD could serve as a torch bearer in innovation through the application of science, engineering and technology for development in general and for the Millennium Development Goals in particular.

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[16] Sagasti FR (2004). *Knowledge and Innovation for Development: The Sisyphus Challenge of the 21st Century.* (Cheltenham, United Kingdom; Northhampton, MA, E. Elgar).

[17] United Nations Millennium Project (2005).

[18] Brown LD (1999). Social learning in South–North coalitions: Constructing knowledge systems across social chasms, in: Lewis D (ed.) *International Perspectives on Voluntary Action: Reshaping the Third Sector:* 39–59 (London, Earthscan); Juma C and Timmer V (2003). Social learning and entrepreneurship: a framework for analyzing the Equator Initiative and the 2002 Equator Prize finalists, Working Paper (Science, Environment and Development Group, Kennedy School of Government, Harvard University).

[19] Florida R and Gates G (2003). Technology and tolerance: the importance of diversity to high-technology growth. *Research in Urban Policy*, 9: 199–219. The City as an Entertainment Machine.

[20] These strategies build on recommendations cited in Dutz MA and Dahlman C (2007). The Indian context and enabling environment, in: Dutz MA (ed.). *Unleashing India's Innovation: Toward Sustainable and Inclusive Growth:* 23–48 (Washington, D.C., The International Bank for Reconstruction and Development/The World Bank).

VIII. Findings and recommendations

A. Main findings

48. Science, technology and innovation are powerful tools in the alleviation of poverty through the creation of employment opportunities, growth of indigenous firms and increases in agricultural productivity, as well as the achievement of the Millennium Development Goals.

49. Though there is wide consensus that technological innovation is a driver and critical source of sustainable economic growth in the new millennium, many developing countries have yet to benefit from the promises of science and technology.

50. Education, especially science education, is important not only for increasing general science and technology literacy, but also for enabling developing countries to build up a critical mass of scientists, researchers and engineers. However, in many countries, there is a deficit of engineers and scientists. Even when science and technology professionals remain in their home countries, their attention is often diverted away from research of local relevance.

51. Knowledge per se does not automatically or inevitably create wealth. It is the application and commercialization of knowledge, scientific or otherwise, that leads to wealth creation.

52. Although it is difficult to establish venture capital markets, this financing mechanism has played an essential role in financing innovation in a number of countries and can be important for the commercialization of research and development.

53. Many developing countries share common development challenges but are not located in the same geographical region. Issues related to food security, sustainable and alternative energy sources, availability of water resources and sanitation services, and neglected diseases are cross-cutting themes that are not necessarily relegated to particular regions in the world, but are shared by many developing countries from varying regions.

54. In many developing countries, there is a lack of support for research and development and innovation. Without changing this mindset, there is limited potential for innovation in the developing world.

B. Recommendations

55. The CSTD panel has put forward the recommendations set out below for consideration by the Commission at its eleventh session:

- Developing the capacity to address developmental challenges through STI capacity-building will require concerted efforts by the public and private sectors, academia and civil society to infuse innovation as a basis for creatively meeting the needs of the developing world.
- Developing countries could consider providing special working conditions for their best science and technology talent, especially young graduates, as a mechanism to enhance future leadership for science and technology.
- In academic and research institutions, innovative compensation and reward structures could be created to promote research directed to addressing national and regional development challenges.
- Developing countries could consider strengthening incentives for commercialization of publicly-funded research and development:

  - New legislation can promote the emergence of an entrepreneurial spirit on academic campuses and research institutes, specifically by allowing the freedom to negotiate flexible deals with partners in the private sector and allowing rewards to flow back to the labs and individuals who contributed to the revenues.
  - Technology parks and business incubators can be expanded based on international best practice.
  - Greater international collaboration can support advanced research and development and commercialization projects carried out jointly by domestic enterprises.
- Developing countries can adopt measures to make it more attractive for wealthy individuals to invest in venture capital funds.
- A special VCF can be created for developing countries, involving an effective partnership between private investors and the public sector, as well as local partners. The VCF could foster a mutually beneficial synergy between the international investment community, the multilateral and bilateral aid agencies, Governments and entrepreneurs, by pooling investment projects in many developing countries, thus overcoming the obstacle of small individual markets and providing a diversified portfolio of investment.
- Collaboration in science, technology and innovation at the regional level can be complemented by other needs-based partnerships, where countries not necessarily in the same region collaborate on research and development to address similar concerns related to water, energy and other issues.
- International agencies can develop a clearinghouse of common development challenges of developing countries that can be addressed through STI and convene representatives of those countries to explore concrete ways of engaging and partnering in solutions.
- Countries can launch campaigns to raise awareness on the importance of innovation for wealth creation and national welfare:
  - Mass media (including television, movies and radio), role models, celebrities and mentors could be used for these efforts.
  - Success stories can be disseminated about techno-entrepreneurs and other innovators.
  - High-profile awards can be established for creative teachers to encourage them to inspire creativity in their students.

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