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Science and Technology Promotion, Advice and Application for the Achievement of the Millennium Development Goals*

Report of the UNCTAD Secretariat

Executive summary

Effective harnessing of existing and emerging technologies could serve to reduce the costs of, as well as increase, the likelihood of achieving the MDGs. Applications in ICTs and biotechnologies in particular, hold enormous promise. Innovative strategies are needed to combine the applicable benefits of existing technologies along with the potential growth enabled from new emerging technologies and innovation processes. The sharing of examples on good practice is important in this regard. Access to new and emerging technologies requires technology transfer, technical cooperation and building a scientific and technological capacity to participate in the development, mastery and adaptation of these technologies to local conditions, and to launch into a continuous process of innovation at the government and enterprise level. National innovation policies and strategies are needed to re-align academic institutions to address development challenges and encourage the creation and development of productive enterprises. It also requires a sound governance mechanism that strikes a balance between the global public goods nature of knowledge, the private goods nature of its application, and the need for developing countries to overcome the knowledge divide.

* This document was submitted on the above-mentioned date for technical reasons.

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I. Introduction

1. At the Millennium Summit in 2000, United Nations member States adopted eight Millennium Development Goals (MDGs) to inspire, guide and assess humanity's development efforts. The MDGs constitute a set of time-bound and measurable goals, targets and indicators for combating poverty, hunger, disease, illiteracy, environmental degradation and gender inequality.

2. Application of science and technology is central in facilitating the achievement of most MDGs, especially in such areas as poverty alleviation, health, education and the environment.[1] Science, technology and innovation are crucial inputs to the competitiveness and growth prospects of countries. The long-term driving force of modern economic growth has been science-based technological advance.[2] However, the socio-economic benefits of modern science and technology have not reached across all countries and people. One-fifth of the world's population live on less than US$ 1 a day, suffer from hunger and lack access to water, sanitation and energy. Each year an estimated 11 million children, mostly from developing countries, die from malnutrition or diseases that are easily preventable and treated. It is not the lack of science or technological innovation, but rather the lack of national capacity to acquire and harness its potential, that hinders countries from fully leveraging this vehicle to socio-economic progress and development.

Achieving the MDGs, therefore, requires a clear political commitment to make science and technology top priorities in the national development agenda. In particular, there is need for science advice to ensure that governments make decisions based on sound science, and that science is used as a tool for development by anticipating and minimizing risks and capitalizing on opportunities.

3. In recognition of the significant efforts still required to re-orient science, technology and innovation (STI) policies in support of the MDGs, the Commission on Science and Technology for Development (CSTD) decided, for its 2004-2005 inter-sessional period, to continue its work on the role of science and technology (S&T) in achieving the MDGs, focusing on the following three sub-themes:

- Infrastructure building as a foundation for scientific and technological development;
- The mutual interaction and dependency of S&T education with research and development (R&D); and
- Promoting gainful employment in general and enterprise development, particularly through the use of existing and emerging technologies, especially ICTs and biotechnologies.

4. To contribute to a further understanding of these issues, and to assist the CSTD in its deliberations at its eighth session, the UNCTAD Secretariat convened a panel meeting in Vienna, Austria, from 27 to 29 October 2004. The present report is based on the findings of the Panel, on national reports contributed by members of the CSTD and on relevant literature on the subject. It also benefits from the findings, analyses and recommendations of the United Nations Millennium Project Task Force on Science, Technology and Innovation. Its recommendations are directed towards national Governments, the United Nations system and civil society.

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[1] Report of the Secretary-General on promoting the application of science and technology to meet the Development Goals contained in the Millennium Declaration, 7 April 2004. E/CN.16/2004/2.

[2] UN Millennium Project (2005). Investing in Development: A Practical Plan to Achieve the Millennium Development Goals, http://www.unmillenniumproject.org.

II. Sub-Theme 1: Infrastructure building as a foundation for scientific and technology development

5. Infrastructure serves as the underlying foundation for development activities. Its development plays a critical role in shaping a country's technological capabilities. It also provides opportunities for learning and growth.

6. Adequate infrastructure is a critical requirement for the application and promotion of S&T for development. The application of information and communication technologies (ICTs) depends on telecommunications systems, including hardware such as telephones, cable, satellites, and broadband networks. Human capital development cannot take place without proper schools and healthcare provisions; agricultural productivity depends on, among other things, irrigation systems and land management. Enterprises, particularly those in high-tech industries, cannot function and produce without stable electric grid systems, and institutional infrastructure such as adequate legal protections for their property. Commercial activities requiring logistics and physical supply and distribution chains, require roads and transport mechanisms.

A. Infrastructure as critical prerequisite for the development of a nation's S&T System

7. Infrastructure consists of facilities and processes necessary for the functioning and growth of a society. As such, it can include academic instructions, laboratories and research facilities, housing, hospitals, irrigation systems, electric power stations, telecommunications, water supply, sanitation, sewerage, waste disposal, roads, railways, ports, waterways and airports.

8. A broad and affordable communications network can facilitate technology applications such as e-commerce, information access and remote education. In knowledge-based economies and cross-border collaboration, a reliable information and communications infrastructure is essential for the conduct of research, and facilitating linkage between universities, industry and the Government. Goal 8 of the MDG includes specific indicators regarding ICTs infrastructure and connectivity.

9. Strategies to improve access to ICTs and the Internet include liberalizing local telecommunication markets to foster competition and creating a supportive legal and institutional environment to encourage investment in ICTs. Where possible, broadband access should be emphasized as it allows several users to share an Internet connection, reducing the cost of individual connections. In each instance, the objective is to encourage an expansion of the telecommunications network, decrease the cost of Internet access for businesses and households and ensure proper quality, efficiency and service.

10. Significant work and investment are required in developing countries, particularly those in Africa where the average Internet user still has about 20 times less bandwidth capacity than the average user in Europe.

BOX 1. A 'hole in the wall' in India and a 'digital doorway' of South Africa: Sharing good practice examples on innovative ways to bring infrastructure to the poor.

Dr. Sugata Mitra, head of the Centre for Cognitive Sciences in India, initiated an experiment in 1999 by installing a computer with free and unlimited access to the Internet outside of his office in New Delhi. Within days, street children taught themselves functional computer skills. Today, the Indian Government, with support from the World Bank, has expanded the initiative throughout India with more than 75 computer kiosks. Several thousands of children in rural and urban India have benefited from this initiative. Local teachers and researchers have noted improvements in some of the school examinations, particularly in subjects that deal with computing skills, improved English vocabulary and usage, improved concentration, attention span and problem solving, as well as working together and self-regulation.[3]

Inspired by the initiative, the South African Council for Scientific and Industrial Research (CSIR) and the Department of Science and Technology financed a similar project in South Africa. A “digital doorway kiosk” was installed in November 2002 in Cwili, a rural township in the Eastern Cape where small numbers of people were considered to be computer literate.

The "Digital Doorway" computer terminals provide children and adults with regular word-processing software for typing letters or messages, mathematics, science, music and language applications, HIV/AIDS presentations, Internet and e-mail access. Observations from South Africa show that the Doorway project is used from as early as 5 a.m. to as late as 1 a.m. The users included primary school children to middle-aged adults. There were approximately 8,300 visits over a 3-month period. Within a month of installation, about 60 per cent of the village's children took the opportunity to teach each other basic computer functions, including the ability to drag icons, re-arrange windows and open applications. Users also reported that they had accessed useful information on HIV/AIDS, and job information. Based on the Cwili experience, the CSIR has planned additional digital doorway research sites, with growing interest and support from the private sector.

11. The advent of new information and communication technology infrastructure in the course of the past two decades has created additional opportunities and challenges for developing countries. Whereas the previous communications paradigm relied on common-carrier communications infrastructure, new systems can involve a gradually evolving web of inter-connected private networks. In addition, developments in wireless technology, along with the falling price of optically-based technologies, enable developing countries to leapfrog past implementation stages of traditional copper wire line networks. With strong competition for the sale and provision of such equipment, Governments have the opportunity to choose among a wide array of innovative forms of financing and partnership in communications infrastructure, implementation and servicing.

12. Increasing globalization in production and consumption has placed greater demand on transportation infrastructures. Transportation infrastructure is especially critical for the commercialization of technology. Both intra-national and international commercial logistics require viable and stable means to transport goods and people. As production value chains disaggregate into discrete components, efficient, reliable and rapid transportation of supplies and finished products has become ever more critical.

[3] For further details of the initiative, see http://www.niitholeinthewall.com/

B. Infrastructure projects and technological learning

13. Infrastructure projects require extensive planning and significant upfront investment. During much of the previous century, governments provided the vast majority of infrastructure. Through the 1990s, foreign participation for infrastructure projects increased. During this period, the World Bank and related institutions pursued a strategy that encouraged private sector investment and participation in infrastructure projects, thus providing developing countries with opportunities for technological learning through infrastructure development.

14. Every stage of an infrastructure endeavour, from planning through maintenance, involves assessing and applying a wide range of technologies and associated management techniques. For example, the development of the international airport and mass rapid transit system in Singapore provided local enterprises and public agencies with opportunities to develop civil, aeronautic and transportation engineering skills, as well as capabilities in large-scale project management and communication.

15. In addition, the presence of reliable infrastructure is a key factor in attracting FDI and multinational enterprises, which, in turn, creates an upward spiral effect. The successful completion of one infrastructure project could lead to foreign investment in another, with the learning from such activities contributing to the development of the overall national innovation system.

16. Owing to the importance of infrastructure development to developing countries, the planning and selection of infrastructure projects should form a cornerstone of national strategic planning. It should be conducted in conjunction with other components of the national science, technology and innovation (STI) system, including education and human resource development, technology forecasting and R&D strategies. As such, infrastructure planning should be considered as a multi-level, systematic and highly integrative process, which impacts other aspects of social and economic development planning.

BOX 2. Technological learning through infrastructure projects: Building the railway network in Indonesia.[4]

Driven by the aim to transform the local industry into a full-scale rolling stock industry, the Indonesian government decided in the mid-1970s to revitalize the national railway network. Following the establishment of a new rolling stock manufacturing business (PT.INKA), a number of technology transfer processes – based on technology sources from abroad – were undertaken to prepare for the work. However, as the revitalization of the railway relied heavily on the use of modern technology and because of limited human capital available in only one company, the government decided that the project could not be implemented without close collaboration with other local industries and institutions. A number of public and private players including the Ministry of Communication, a governmental technology agency (BPPT), local industries and a state-owned company (PT.KAI) succeeded in accumulating the various technology capabilities required. They jointly rebuilt the railway network.

The involvement of different local institutions (governmental bodies, industries and service company) yielded positive effects in acquiring technological capabilities.

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[4] Putranto, K., Stewart, D. and Moore, G. (2003). "International technology transfer and distribution of technology capabilities: the case of railway development in Indonesia," *Technology in Society*, 25(1): 43-53.

The project provided local industries with both capabilities and opportunities for specialization within transportation and motoring and as a result, some companies decided to expand the range of services based on the experience they had acquired with this project.

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17. The rise of private involvement in the establishment and servicing of infrastructure has additional implications for strategic planning. Whereas the establishment of certain forms of infrastructure was previously the sole purview of government, new technologies have lowered certain barriers to entry, attracting private sector involvement. For example, in Bangladesh, a partnership between Grameen Telecom and Grameen Bank facilitated women borrowers in remote villages to obtain GSM phones for use in their villages. As of April 2004, there were more than 58,000 subscribers to the network, providing telecommunication access to more than 60 million people living in rural areas of Bangladesh.[5] This resulted in a large network of mobile public call offices throughout the region, providing communications access in areas where there had been no connections before. Although such a network is not a complete substitute for a comprehensive communications network – access is still limited and high-bandwidth data traffic is not enabled – it, nonetheless, demonstrates the capability for the private sector to address certain infrastructure needs. This is but one example among many. Given the vast infrastructural needs of developing countries, private sector involvement in many sectors is often essential. However, to help ensure that liberalization and privatization measures would enhance the quality and operational efficiency of infrastructure at reasonable cost, such measures should be accompanied by appropriate competition policies, sectoral regulations and/or contractual requirements aimed at preserving and promoting competition, competitiveness and development. Since what would be appropriate would vary among different countries, sectors and technologies, developing countries would need both the necessary policy space to allow them work out what best suits their needs and well-focused technical assistance to assist them in doing so.

III. Sub-theme 2: The mutual interaction and dependency of science and technology education with research and development

18. There is a high correlation between those countries with significant economic improvement and those that have made substantial investment in R&D. A growing base of R&D capabilities permits better and faster diffusion of new technologies within the economy, lowers the cost of technology transfer and captures more of the spillover benefits created by the operation of foreign firms. Furthermore, indigenous researchers are much more likely to be able to identify and capitalize on potential opportunities driven by local needs. The Inter-Academy Council recommends that developing countries increase their R&D expenditure to at least 1 per cent of GDP.[6] The education of a local domestic human resource base in S&T is one of the most critical elements for developing and fulfilling indigenous R&D capacity. In significant portions of the developing world, most notably in Latin America, more than 75 per cent of R&D activities are conducted in universities.

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[5] Grameenphone. <http://www.grameenphone.com/modules.php?name=Content&pa=showpage&pid=3:11:1>. Cited 27 January 2005.

[6] Inter-Academy Council (2003). Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology, http://www.interacademycouncil.net/report.asp?id=6258

A. Investing in the development of national S&T education and training infrastructure

19. The large difference in opportunities in education between countries is one of the basic causes of global inequality.[7] Education is the primary means of producing capable researchers, scientists, and technicians. Although universities develop and hone the skills of these professionals, primary and secondary education ignite the interest of, and lay the foundation for, pupils to pursue these professions. Developing countries should be encouraged to adopt curricula that ensure that all students complete secondary education. In addition, coursework on entrepreneurship and business management should also be part of school curricula. Such coursework both prepares students for the rigours of managing enterprises, as well as helps facilitate a culture of entrepreneurship.

20. Special efforts should be made to ensure that girls and women receive science and technical education, as women are central to socio-economic development through their productive, reproductive and community management responsibilities. Women make a major contribution to the production of food and the provision of energy, water, health care and family income in developing countries. A solid S&T education can enable them to apply this knowledge in the undertaking of their tasks and roles.

21. Currently, many faculties and researchers in developing countries are negatively influenced by a distorted reward system that reduces motivation, diverting R&D efforts away from national concerns. Within prominent international S&T communities, research agenda that would address the health, agricultural and other concerns of developing countries are not viewed as cutting-edge, and are thus considered to be of lesser merit. Accordingly, when researchers attempt to focus their attention and efforts on important problems in their country or region, they risk not being able to publish their findings in those academic journals or conferences most relevant to improving their standing and enabling them to attract funding.

22. In order to address this issue, a review of the academic reward system, particularly within developing countries is necessary. Incentives should be created to promote research directed to solving developmental problems. Developments must be combined with more innovative compensation and reward structures with universities aligned to national objectives.

23. For countries with limited educational resources, sending promising students abroad for S&T education remains the primary mode for developing a base of educated scientists and technologists. As students flow across economies, acquiring R&D-induced technological knowledge through education and job experience in their host country of study, they will, upon their return, contribute to an increase in productivity in their home country.

24. However, an over-reliance on foreign education could prove detrimental in the long run. The "brain drain" which results from the delayed return of a developing nation's foreign-educated students has been at the centre of considerable debate. By some estimates,[8] up to one-third of R&D professionals from the developing world reside and work in OECD countries. Presented with more robust research infrastructures and professional opportunities in developed nations, many foreign-trained students remain abroad, severely limiting the return on their home nation's investment. Some positive recent developments are found in higher education, where universities from the developed world set up campuses, with

[7] ILO (2004a). A Fair Globalization: Creating Opportunities for All, http://www.ilo.org/public/english/fairglobalization. Also see UN Millenium Project 2005, pp. 84-87.
[8] UNDP Commission on Private Sector and Development Report (2004). *Unleashing Entrepreneurship: Making Business Work for the Poor.* http://www.undp.org/cpsd/report/index.html.

accredited postgraduate level programmes in developing countries. This makes higher education in some areas such as business management more accessible, although it does not address the issue of the cost of higher education.

25. Developing countries with robust infrastructure, a highly trained workforce, adequate intellectual property protections and appealing domestic markets will be the most attractive to foreign companies and their investments. Foreign enterprises could provide other resources to help a developing nation's R&D commercialization system achieve scale, including management expertise, global supply and distribution chains, as well as access to external markets. In 2002 and 2003, developing countries and countries with economies in transition accounted for almost one-half of new FDI projects made by ICTs multinationals, growing from 41 per cent in 2002 to 51 per cent in 2003. A significant portion of this growth can be attributed to FDI activities in Asia-Pacific region and Central and Eastern Europe.[9]

26. Thus, delaying the development of national S&T education and training infrastructure will only perpetuate the deficit of engineers and scientists. Improving the S&T educational system will result in more domestically trained scientists, provide the type of infrastructure required to sufficiently challenge talented graduates and attract foreign enterprises interested in making R&D-related investments in developing countries. This last benefit is of particular importance, as increased R&D-related investment provide opportunities for learning and can create an upward spiral of development.

BOX 3. Turning brain-drain into brain gain: The case of Pakistan

The Government of Pakistan has increased the budget for S&T 60-fold and the budget for education 10-fold. In recognition of the crucial importance of human resource development, especially in such key areas as basic sciences, engineering, IT, biotechnology and new materials, the Government plans to produce 1,500 PhD graduates each year, with 1,000 funded scholarships. In cutting-edge areas, students have been sent abroad to centres of excellence. Special measures have been adopted to prevent the "brain drain", including favourable working conditions and facilities, as well as highly competitive salaries for university researchers.

Significant efforts have been made to enhance networking among universities and research institutions. Cognizant of the crucial importance of access to journals for the scientific community, a database has been set up which provides full text access to several hundred international journals. This database is accessible by most universities and research institutions – the cost of access is borne by the Government.

Special incentives have been provided to encourage R&D in universities and industry. University faculty members have been awarded special research productivity allowance, S&T allowance and tenure track positions. A Professor conducting high impact research would be offered a salary nearly four times higher than that of a Federal Minister. Enterprises that interact with university-based research laboratories have been offered venture capital, tax benefits and other incentives.

B. Promoting R&D through networking

27. R&D in fields such as agricultural production, environmental management and public health is crucial for developing countries to meeting the MDGs. However, these fields are often under-funded. Research in malaria and other tropical diseases receives very low levels of funding. Some promising developments have recently emerged from the UN Millennium

[9] http://www.locomonitor.com.

Project Task Force Working Group on Genomics which concludes that recent advances in genomics and related biotechnologies can provide "radically improved tools" to help developing countries meet health-related MDGs.[10] Given that most of the technologies are beyond the reach of poor developing countries, the Working Group called for a governance mechanism that strikes a balance between the global public goods nature of genomics knowledge and the private goods nature of its application. It also called for the creation of a Global Genomics Initiative (GGI), made up of representatives of governments, private companies and other organizations from developed and developing countries to support genomics research and learning worldwide.

28. National governments could adopt a number of measures to mobilize funding. Governments should identify priority areas of research likely to meet the MDGs, and organize the R&D efforts of research institutions around specific research programmes. To generate funds, governments could give tax breaks in order to encourage private sector investment in R&D that is of strategic importance to meeting the MDGs.

29. International and regional scientific research networks are also an important instrument in the pooling of limited resources to conduct R&D relevant to development challenges. A successful example is CGIAR, which brings together public and private members supporting a system of 16 Future Harvest Centres that work in more than 100 countries to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment.

30. South-South networks are also important, particularly in the exchange of best practices experiences. Research conducted in one country can often be of value to other countries in the same region. For example, the Eastern and Central African region is composed of Burundi, the Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, the United Republic of Tanzania and Uganda. These countries have formed the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). ASARECA, in conjunction with the Agricultural Biotechnology Support Project (ABSP) at Michigan State University, have conducted a study that developed a list of agricultural research priorities for the region.[11]

31. In developing countries, there currently exist a number of outstanding scientific and technological institutions that can be qualified as centres of excellence. They form a sufficient critical mass, and have sufficient infrastructure undertaking R&D in science and technology. Many have become major sources of knowledge and conduits for the transfer and diffusion of scientific knowledge and information, particularly in new and emerging technologies. There is an urgent need to connect these developing country centres of excellence, thereby allowing facilities available at world-class centres to be made available to scientists and engineers in other developing countries.

[10] Genomics Working Group(2004). Genomics and Global Health: A Report of the Genomics Working Group of the Science and Technology Task Force of the United Nations Millennium Project, http://www.fic.nih.gov/news/genomics_global_health.pdf.

[11] UNCTAD(2004). The Biotechnology Promise - Capacity Building for Participation of Developing Countries in the Biotechnology, New York and Geneva.

BOX 4. Top ten technologies most likely to help developing countries meet health-related MDGs.[12]

The Genomics Working Group of the Science and Technology Task Force of the United Nations Millennium Project, has identified the ten most promising technologies for health in developing countries:

- Easy-to-use molecular diagnostic tests for TB, hepatitis C, HIV-AIDS, malaria and other diseases, which detect the presence or absence of pathogen-associated molecules, such as DNA or protein, in a patient's blood or tissues;
- Recombinant vaccines against infectious diseases, produced through genetic engineering, which promises to be safer, cheaper and possibly easier to store and transport than traditional vaccines;
- Reducing pollution and making water safe to drink through bioremediation – the potential exploitation of micro-organisms with remarkable biochemical properties;
- Creating microbicides for female-controlled protection against sexually transmitted infections like HIV, both with and without contraceptive effect;
- Better drug and vaccine delivery methods that avoid the use of needles and reduce cross contamination;
- Bioinformatics to identify drug targets and to examine pathogen-host interactions;
- Nutrition-enriched crops to counter specific deficiencies, such as vitamin A-rich 'Golden Rice' to improve health for millions without a balanced diet;
- Sequence pathogen genomes to understand their biology and identify new antimicrobials;
- Recombinant technology to make therapeutic products (e.g. insulin, interferons) more affordable to help fight such diseases as diabetes, now emerging as a major public health problem throughout the world; and
- Combinatorial chemistry for drug discovery.

C. Improving linkages between universities and industry

32. Linkages between universities and industry in the conduct of R&D have become quite pronounced in the developed world, providing ample benefits to both parties. Industry obtains access to state-of-the-art university laboratories, talented research scientists, as well as a pool of potential recruits. Universities receive industry’s financial support, necessary to conduct their work and expand their resources. In contrast with their developed counterparts, many universities in developing countries lack such mutually beneficial linkages with industry.

33. The improvement and growth 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. With a significant amount of R&D activity occurring in the private sector, business enterprises serve as a primary source of demand for S&T specialists.

[12] Genomics Working Group (2004). Genomics and Global Health: A Report of the Genomics Working Group of the Science and Technology Task Force of the United Nations Millennium Project, http://www.fic.nih.gov/news/genomics_global_health.pdf.

BOX 5. Examples of concrete ways of strengthening the collaboration between university and industry:[13]

- University conducts R&D for industry;
- University establishes incubators or technology parks;
- University provides training and other programmes in entrepreneurship;
- University establishes relationships with venture capital enterprises;
- University establishes consortia with other universities, state agencies and industry;
- University sends faculty to work in industry on sabbatical, and invite industry researchers to participate in teaching and other university activities;
- Representative from the local industry functions as members of one or more university committees;
- Provide for students to serve as interns in industry and arrange recruitment relationships;
- One or more senior professor sits on the boards on local companies;
- One or more senior executive sits on the university's board;
- Company employees take distance education degrees from the university;
- Local companies invited to donate prizes for engineering students,
- Representatives from local businesses invited to help with designing and implementing a management of technology university degree;
- Executives invited to provide curriculum input for specific university courses;
- Company employees act as student mentors; and
- Local businesses provide advices on student placement services.

34. By providing employment opportunities and career paths for scientists and technologists, enterprises encourage students to enroll in scientific and technological fields. As more students graduate with relevant skills and motivation, this growing pool of human capital will, in turn, attract more enterprises to the region, thus creating a virtuous, self-reinforcing circle of technological capacity development and R&D activity.

35. Governments should create incentives for private enterprises, particularly small and medium-size enterprises (SMEs) to hire university graduates. Incentives could include tax breaks or financial aid to support internships or offset the initial cost of hiring and training new employees. Enterprises could also be encouraged to employ students as interns or part-time researchers, laying the foundation for later employment.

36. For universities to be able to fully contribute to S&T-based regional development, appropriate support mechanisms are necessary, including implementing tax incentives for research and industry/university collaboration and making capital available through venture financing or affordable loans. Governments can encourage university-industry R&D linkages by establishing formal institutional relationships. Research networks or consortia can provide

[13] OECD (2001). "Managing University/Industry relationships: the Role of Knowledge Management". http://www.oecd.org/dataoecd/11/7/2668224.pdf.

opportunities for cross-sector information-sharing and collaboration without requiring a major investment by individual parties.

37. Technology offices, technology parks and incubators have proven to be effective conduits to pool scarce resources – i.e. R&D, education and finance – needed to stimulate research commercialization and subsequent enterprise growth. Other similar mechanisms have also been used. For example, in Taiwan Province of China has successfully used R&D consortia to foster cooperation between laboratories in the government-funded Industrial Technology Research Institute (ITRI) and local enterprises. This joint effort has resulted in technology transfer and innovative processes and products.

38. In Turkey, the Technological Development Zones (TDZ) Law of 2000 promotes the establishment of science and technology parks under the guidance and lead of universities. The main goal of the TDZ Law is to increase university industry cooperation, especially in R&D. The Law provides two types of tax incentives to companies. The first is income tax exemption of the research personnel, including academics. The second incentive is corporate tax exemption provided for the portion of profit generated through research and software development activities.[14]

I. Sub-theme 3: Promoting gainful employment and enterprise development through the use of existing and emerging technologies

39. The most effective way for people to get out of poverty is through decent and productive work.[15] Enterprise development is central to economic growth and increased employment. In particular, SMEs are primary agents of such growth. Their small size simultaneously creates a need to be competitive to survive and provides them the agility to do so.[16,] SMEs are often at the leading edge of technological development and innovation.

40. A variety of mechanisms are available to policy makers to facilitate and encourage the formation and growth of enterprises. Policy options include tax incentives, R&D funds, economic development agencies, incentives for networking and joint ventures. In addition, Governments can support employment and enterprise development by removing obstacles to business activity, such as cumbersome bureaucratic procedures, inappropriate intellectual property protection regimes and complex accounting standards.

A. The role of the informal sector in generating employment opportunities

41. The informal sector (i.e., small entrepreneurs, often self-employed and operate outside of the formal sector) is large, particularly in developing countries. The estimated share of non-agricultural workforce that is informal is 30 per cent in Portugal; 38 per cent in Chile; 40 per cent in Mexico; 50 per cent in Thailand, Turkey and Brazil; 70 per cent in India, Indonesia, Pakistan and the Philippines; and 80 per cent in sub-Saharan Africa. Micro-entrepreneurs in the informal economy, the majority women, most often have no access to financing and long-term capital. Developing country governments should reduce the share of the informal sector in an economy, through reform of the overall enabling environment for the

[14] UNCTAD XI. Summary of Technology Fair of the Future, Mimeo.

[15] ILO (2004b). World Employment Report 2004-2005: Employment, Productivity and Poverty Reduction, http://www.ilo.org/public/english/employment/strat/wer2004.htm.

16 UNCTAD (2000). "Development Strategies and Support Services for SMEs: Proceedings of four Intergovernmental expert meetings", UNCTAD/ITE/EDS/Misc.18.

formal economy.[17] However, in most developing countries, business registration takes a long time and is costly. Complex regulations and government requirements, high compliance costs, ineffective bankruptcy laws, as well as bribery and corruption, are some of the main factors for poor people to remain informal.[18]

B. Facilitating enterprise creation

42. Governments can adopt a number of mechanisms to support and promote the creation of new enterprises. Economic development agencies, technology promotion units, incubators and technology parks have all been used successfully in both developed and developing countries. Incubators provide business support functions, including physical space and logistics, to ease the formation and running of new enterprises. By easing bureaucratic procedures, entrepreneurs are able to concentrate their efforts on higher-value activities such as product development and sales. Therefore, business incubators not only increase the SMEs likelihood of survival, they also accelerate their growth. Within OECD countries, non-incubated enterprises run a 30 per cent to 50 per cent chance of survival. With incubator support, this rate jumps from 80 per cent to 85 per cent[19].

43. Technology parks are another government-sponsored mechanism to facilitate technology research, development and commercialization. Technology parks can range in complexity from designated areas for technology enterprises, to complex public/private arrangements involving university participation, newly developed research facilities, incubators and technology transfer offices. Governments can provide funding, real estate, staff and a special designation as tax-abated enterprise development zones. Special incentives are often provided to companies willing to relocate to these zones.

44. By clustering academics, researchers and entrepreneurs, technology parks can facilitate the development of productive networks. Linkages are forged between those that develop a technology to those that can identify and execute commercial applications of the technology. Investors, researchers, suppliers and customers can work together to promote innovation and establish SMEs. Cooperation will occur naturally as the agents identify mutual dependencies, synergies and opportunities to provide services products or ideas to one another.

C. Financing SMEs

45. In order to ensure sustainable economic growth and employment creation, it is necessary to move beyond the initial start-up phase of new enterprises. In this respect, access to finance for new and expanding firms greatly influences firm development and growth. The widely documented success story of the Grameen Bank of Bangladesh, which provided credit and micro-finance to small rural businesses and women, is now being replicated in more than 30 countries, with support from the World Bank. However, despite their significant contributions to employment, SMEs have traditionally faced difficulty in obtaining finance both through credit and equity arrangements. Banks and investors consider them to be high-risk due to their limited assets, low level or lack of collateral, lack of business history and market volatility. In developing markets, one of the principal obstacles facing SME access to capital is the lack of adequate information on their financial condition and creditworthiness.

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17 UNDP Commission on Private Sector and Development Report (2004). Unleashing Entrepreneurship: Making Business Work for the Poor. http://www.undp.org/cpsd/report/index.html.

18 Ibid.

19 OECD (1997). *Technology Incubators: Nurturing Small Firms*. OCDE/GD(97)202.

46. Perhaps the greatest opportunity for improvement can be found in addressing the information asymmetry problem. Providing banks and investors with more accurate and comprehensive information for SME applicants can dramatically reduce the risk of the investment or loan. Two sets of infrastructure are needed to address information asymmetry, both of which can be aided through the application of ICTs:

- Production of reliable and timely financial information;
- Efficient mechanisms to process and analyse vast amounts of data.

47. External information providers offer evidence of creditworthiness, strengthen credit negotiations with banks and reinforce the position of SMEs relative to their competitors and business partners. The use of ICTs enables consistency, accountability and transparency. ICTs-enabled finance tools include credit or payment cards for export financing or short-term working capital. Such mechanisms can increase SME confidence in e-business processes and tools and encourage their adoption, potentially reducing their costs and expanding their supply and sales channels.

D. Facilitating training and skills development

48. In order to gauge the internal needs and requirements of developing countries, it is essential to increase the awareness of local business people and entrepreneurs of the breadth of existing technologies that may be available to them, particularly those that have been successfully applied elsewhere, as well as those that have potential for novel applications. Costa Rica, for example, is now a technological hub in Latin America, with the highest software exports per capita in the region; this is largely the result of its heavy investment in basic education and technical training. Educational institutions, governments and intergovernmental agencies can help by actively marketing promising technologies, and establishing linkages between businesses and researchers. Trade shows, workshops, databases, newsletters and the Internet can all be used to promote promising existing technologies to showcase best practices and innovative applications.

E. Making effective use of existing technologies, especially ICTs and biotechnologies

49. Although extensive discussion has been placed on developing capabilities in cutting-edge technologies, policy makers must not overlook the importance of existing technologies in achieving development objectives. Existing technologies provide lower-risk, lower-cost opportunities for new businesses to gain footholds by applying such technologies to address specific local needs. The UN Millennium Project Task Force recommends that developing countries should focus on platform technologies that have broad applications or impacts in the economy, such as information and communications technology (ICT), biotechnology, and new materials[20]. For example, agricultural activities can be greatly enhanced through more mature technologies such as small-scale irrigation, quality fertilizers, farm mechanization and enhanced crop seed. As 75 per cent of the world's poor live in rural areas where agriculture is the main stay of the economy, raising agricultural productivity has real impact on poverty reduction. Significant strides in health care can be made through existing drinking water systems and generic drug manufacturing. ICTs offer opportunities for innovative applications to increase productivity and address local problems.

[20] UN Millennium Project (2005). Investing in Development: A Practical Plan to Achieve the Millennium Development Goals, http://www.unmillenniumproject.org.

E.1. Opportunities in ICTs

50. ICTs have been at the centre of an economic and social transformation that is affecting all countries. ICTs have opened pathways to education, commerce and health, with substantial potential to aid progress in every one of the MDGs. They enable greater participation and new perspectives across all sectors.[21]

51. ICTs have repeatedly been shown to support development activities by overcoming obstacles of geographic isolation, lack of access to information and challenges in communications. The Plan of Action, endorsed by the first phase of the World Summit on the Information Society (WSIS), calls for the promotion of "development-oriented ICTs applications for all, in particular, the use of ICTs by SMEs to foster innovation, realize gains in productivity, reduce transaction costs and combat poverty."

E.1.1. Enhancing productivity and competitiveness

52. The application of ICTs to enterprise development can be considered in two broad categories:

- Enhancing enterprise productivity and competitiveness (e.g. supply chain management); and
- Creating new enterprises (e.g. a start-up company in software).

Effective implementation of ICTs enable enterprises to improve capacity, productivity and competitiveness through:

- Reduced transaction costs involved in the production, purchase and sale of goods and services;
- Increased efficiency of operational functions;
- Increased and improved exchange and access to information;
- Direct access to consumers;
- Elimination of geographical constraints to the sale and acquisition of products and services;
- Marketing and sale of exports via the Internet; and
- Reduced intermediaries and empowered producers.

53. The price of ICTs goods and services has fallen because of technological advances, increased competition and loosening trade restrictions. This has allowed enterprises, including SMEs, to replace other forms of capital and labour with information technology equipment, thus driving down overall costs.[22] The aggregation of these benefits, if successfully exploited, allows countries to enhance their competitiveness and shift toward the production and provision of higher value-added services.

54. Online exchanges demonstrate several of these capabilities simultaneously, directly linking suppliers and buyers and increasing the efficiency of pricing and individual transactions. Such mechanisms can be used across sectors. Over the past several years,

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[21] UNCTAD (2003). Ecommerce and Development Report 2003, UNCTAD/SIDTE/ECB/2003/1.

[22] Quiang, C., Pitt A. and Ayers S. (2003). "*Contribution of Information Communication Technologies to Growth*". http://www.ugabytes.org.

online markets have been established for commodities such as coffee, cotton, grain, soybeans and cattle. Kenyan entrepreneurs have used fairly inexpensive technology to successfully organize online auctions for coffee, increasing their reach and reducing their costs of sale.

BOX 6. Enhancing agricultural productivity through the use of ICTs: Agricultural expert system of China.

The Ministry of Science and Technology of China, within its National High-Tech R&D Programme, initiated an Agricultural Expert System. The system was designed to empower farmers, increase the yield of crops and reduce costs and pollution. In addition, the system assists farmers to access market information. The system provides agricultural knowledge and techniques on its web-based platforms. Moreover, it contains an interactive system, which can address specific questions of farmers, based on their environmental and economic parameters.

More than 150 agricultural expert systems have been developed. Twenty-three demonstration districts for agricultural expert systems have been established, covering more than 800 countries. About six million farmers benefited from the project, increasing grain output by 3 million tons, earning RMB 2.5 billion, and saving RMB 700 million in input. For farmers without Internet access, information was repackaged and distributed on CD-ROM, community radio or other media.

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55. Despite the massive potential for ICTs to enable higher productivity and greater business participation, numerous obstacles remain in business adoption of ICTs, including low-income levels, low literacy rates, lack of native language content and widespread lack of Internet awareness in business. In addition, insufficient telecommunications infrastructure and Internet connectivity; expensive hardware; software and Internet access; absence of adequate legal and regulatory frameworks; a lack of payment systems that can support online transactions; and a shortage of technically competent human capital, all create cultural resistance to online trading and discourage adoption of ICTs, particularly within SMEs.

56. Regulatory frameworks need to be established to provide enterprises and consumers with confidence in the security of e-commerce, storage of personal and financial information and online transactions. Without concrete and rapid security solutions, everyday users and potential users may lose confidence in business transactions over the Internet.

E.1.2. Creating new economic and trade opportunities

57. ICTs are expanding the possibilities of developing economies to participate in international markets. The Internet is dramatically changing the way goods and services are produced, delivered, sold and purchased. ICTs has made it much easier for developing country producers, processors and exporters to identify potential new markets and explore market entry barriers and potential solutions. Evidence shows that growth in ICT goods and services trade has been higher than growth in total trade. In addition, ICTs enable trade in other sectors by enhancing market access and broadening the customer base, facilitating customs, transport and logistics.

58. Empirical evidence has shown that the growth in trade of ICT goods and services has grown at a faster pace than growth in total trade and remains high despite an overall global slow down in the trade of such goods. The ICT producing sector has long shaped the geography of trade, with countries of the south (especially in South-East Asia) having developed into centres of IT manufacturing and created new regional trade relationships

(South-South trade). Trade in ICT products grew tremendously over the last decade and was worth over $900 billion in 2000. In particular, exports of ICT products from developing countries grew at a compound annual growth rate (CAGR) of 23.5 per cent over the last decade, while exports from developed countries grew at a CAGR of 10.8 per cent. As a consequence, the share of developing countries and economies in transition in ICT exports grew from 15.6 per cent of exports in 1990 to 35.5 per cent in 2000 (UNCTAD, 2003).

E.1.3. Enabling the creation of new enterprises

59. Advances in ICTs, combined with the rise in globalization, have made it possible for countries to provide products and services unconstrained by location or distance to potential clients. As enterprises seek to reduce operational costs, they have the option to outsource non-core activities to countries that can provide a high level of service with much lower labour costs. Known as business process outsourcing (BPO)[23], it allows enterprises to contract a service provider to manage, deliver and operate one or more of its functions. By spreading its operations across the globe, companies are able to pursue strategies in which they are able to serve customers and conduct operations twenty-four hours a day in a cost-effective manner.

60. BPO is now extensively applied to a variety of corporate functions, including information technology management, call centre operations, medical analysis, finance, banking, accounting, insurance services, mortgage services, human resource activities, sales and marketing, software development, web related services and customer services. The market for BPO is expanding, with some sources projecting the value of BPO to reach the range of $300 billion to $585 billion by 2005.

61. For developing countries to be competitive in attracting BPO, several factors must be considered, such as the availability of adequate internet infrastructure, strong government support for BPO activities, adequate investment capital, a skilled and capable labour force and client language proficiency.

E.2. Opportunities in biotechnology[24]

62. Biotechnology encompasses a wide range of techniques, many of which provide opportunities for developing countries to enhance food security, improve healthcare, and achieve environmental sustainability. In agriculture and the agro-industry, biotechnology could facilitate the development of improved crops and new products and contribute toward improving production. Developments in biotechnology have provided opportunities for improved disease diagnosis and more rapid development of vaccines and therapeutic drugs.

63. Developments in the Human Genome Project (HGP) has great implications for the future treatment of genetic diseases and may provide opportunities for new therapies, new drugs and new understandings of how humans function. Pharmocogenomics is a very recent, but fast-moving area of research, which is likely to revolutionize health care in developing countries, where the expected benefits include more effective drugs and prevention of over-treatment or ineffective use of drugs.

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[23] See the World Investment Report 2004 for details on the latest trends in foreign direct investment and BPO.

[24] This section draws heavily on the findings of UNCTAD (2004). The Biotechnology Promise - Capacity Building for Participation of Developing Countries in the Biotechnology, New York and Geneva.

64. Biotechnology-related applications and products have permeated all sectors of the economy. Opportunities and challenges exist for developing countries to adopt, develop and use new biotechnology, which has the potential to meet the demands of the 800 million people in developing countries who are chronically malnourished, and the 2.5 billion people who lack adequate sanitation.

E.2.1. Upgrading traditional economic sectors though enhanced productivity

65. Safe applications of biotechnology have the potential to benefit almost all productive sectors. Applications of industrial and environmental biotechnology promise to cut the cost of production, the number of processing steps and energy consumption. Harnessed effectively, advanced agricultural biotechnology can contribute to solving some of the most common problems faced by developing countries through:

- Increasing productivity and competitiveness at national, regional and international levels (within the framework of competition policy);
- Protecting environment and biological diversity, while reducing agricultural inputs (water, fertilizers and biocides), improve soil fertility and conservation (e.g. biological nitrogen fixation), and increase nitrogen and phosphorus absorption by crops;
- Diversifying agri-food production so as to meet the changing needs of the consumers and food industry.

Biofertilizers, for example, hold great promise for increasing food productivity. Biological nitrogen fixation (BNF) could help to improve soil fertility and crop productivity. Biofertilizers have been used in Kenya, the United Republic of Tanzania, Zambia and Zimbabwe. The technology needed to produce them is not complex, and they could be easily produced locally.

66. Plant biotechnology is an important source of renewable fuels, degradable plastics, rubbers, adhesives and other products derived from fossil fuels, which can play a central role in the production of pharmaceuticals, fine chemicals, industrial enzymes and other products. Unfortunately, its importance is often overlooked in the debate over the safety of genetically modified organisms (GMOs) for human health and the environment. Some drugs, such as aspirin and menthol, were derived from plants but are synthesized chemically to meet economic and quality considerations. Biotechnology may offer alternative production systems of plant products by either boosting levels of the desired ingredient(s) in the plant or improving the efficient recovery and quality of final product. This field is still developing and poor countries with excellent growing conditions for tobacco, potatoes and corn, among others may become the future home for bio-farming centres. Countries with the capacity to purify, produce and package these products may have an added advantage.

BOX 7. Tissue culture in the horticulture industry in Kenya and Zambia

Over the last two decades, a booming vegetable and cut flowers industry has developed on the shores of Lake Naivasha in Kenya. The population has expanded from 50,000 to 250,000, the majority of whom are women who have been drawn by the opportunities to participate in the production of vitroplants and cuttings, which feed the industry. This is a highly valued horticulture industry that is spurred by simple and efficient biotechnology. The industry in Kenya earns between $300 to $500 million a year. Similarly, Zambia is now the third largest producer and exporter of cut flowers in Africa, just behind Kenya and Zimbabwe. Flower acreage is currently estimated at 135 hectares, most of which is planted with over 40 rose varieties.

Zambia exports more than 90 per cent of its flowers to the Netherlands. Tissue culture is also used in banana and cassava production among other crops.

E.2.2. Challenges to biotechnology commercialization in developing countries

67. Most of the biotechnology research in developing countries take place in universities, and promoted by government programmes. While private sector biotechnology development in some developing countries is picking up, it remains small. Developing countries are slowly but steadily adopting transgenic products. The number of countries growing transgenic crops has grown from three in 1996 to eight in 2001. Similarly, the area planted with transgenic crops in developing countries has grown from 1.3 million hectares to 14 million hectares over the last 6 years.

68. For biotechnology to contribute significantly to national objectives to meet the MDGs, particular with regard to reducing poverty, improving health and the environment, developing countries must build capacity to select, acquire and develop appropriate biotechnologies and manage them in such a way as to avoid or minimize potential threats to health, the environment and socio-economic well being. The opportunities for developing countries in this area would be enhanced if national and international norms helped to balance the interests of technology producers and technology users, particularly those in low-income countries, and enhanced the transfer of relevant knowledge and technology.

IV. Main findings

69. Science, technology and innovation are crucial inputs to the competitiveness and growth prospects of countries. However, S&T institutions in many developing countries are fragmented, uncoordinated and poorly adapted to meeting the development challenges.

70. Science and engineering education is of critical importance to developing countries – both in addressing development problems of national priority, and in helping enterprises remain competitive in the global economy. However, vocational institutes, polytechnics and universities in developing countries are often accorded low priority. Moreover, university curricula are often outdated and bear little connection to the productive sector and society at large. A review of the academic system, particularly within developing countries is a necessary starting point. Policies and programmes are needed to provide incentives for private enterprises to hire university graduates and to encourage industry and university collaboration.

71. R&D in critical areas such as agriculture, health and environmental management, are under-funded. Public R&D institutions and universities can play a critical role by conducting basic research and providing specialized knowledge inputs. Governments should therefore invest in R&D a minimum of 1 per cent of GDP. Scientific networking is an important instrument in scaling up research in areas of critical importance to developing countries. There is an urgent need to connect centers of excellence in developing countries to allow scientists to interact with each other and for the facilities to be made available to scientists and engineers in other developing countries.

72. There are currently a number of open and collaborative projects to create public goods. These projects, often referred to as open access regimes, include free and open source software, the human genome project, the world wide web, the single nucleotide polymorphisms (SNPs) consortium, open academic and scientific journals.

These publicly available projects are extremely important, as they affect the ability of countries to achieve the MDGs.

73. Infrastructure development provides not only the foundation for technological activities, but also the opportunity for technological learning. In addition, it heavily involves and impacts private and foreign investment. As such, infrastructure planning should form a fundamental element of the science, technology and innovation systems of countries. All substantial projects involving foreign investment should have "local resource development" as part of the contractual agreement. Moreover, to help ensure that liberalization and privatization measures would enhance the quality and operational efficiency of infrastructure at reasonable cost, such measures should be accompanied by appropriate competition policies, sectoral regulations and/or contractual requirements.

74. The development of enterprises, especially SMEs, is critical to economic growth and to achieving the MDGs. A variety of measures could be adopted by national governments to encourage and facilitate the creation and development of innovative enterprises, including through venture capital or affordable loans; balanced intellectual property protection, and the setting up of incubators and science parks. Efforts should also be made, in collaboration with the private sector and international organizations, to provide continuous training, and facilitating the establishment of networks. The informal sector is a critical area that requires immediate policy attention, which would have direct impact on poverty reduction.

75. Effective harnessing of existing and emerging technologies, will both reduce costs of, and increase the likelihood of achieving the MDGs. Applications in ICTs and biotechnologies in particular, hold enormous promise for the achievements of MDGs. Innovative strategies are needed to combine the benefits of existing technologies along with the potential growth enabled from new emerging technologies. The opportunities in this respect for developing countries would be enhanced if national and international norms helped to balance the interests of technology producers and technology users, particularly those in low-income countries, and enhanced the transfer of relevant knowledge and technology.

V. Recommendations

76. The CSTD panel has put forward the recommendations set out below for consideration by the Commission at its seventh session. These recommendations are directed to Governments, the CSTD and the United Nations system.

The CSTD should consider the following:

- In collaboration with international scientific organizations, facilitate the establishment of a network of centres of excellence in developing countries to allow scientists and engineers to interact with each other and make use of state-of-the-art research facilities offered by these centres;
- Collect and compile “best practices” case studies, especially of newly industrializing countries that showcase the link between S&T and socio-economic development.

National Governments should consider the following:

- Ensure that science, technology and innovation strategies are incorporated in national poverty reduction strategies;
- Encourage the establishment of incubators and science and technology parks;

- Create innovative compensation and reward structures to promote research directed to solving developmental problems aligned to national objectives such as agriculture, health, or mitigation of natural disasters;
- Strengthen S&T educational systems, including the introduction of entrepreneurial skills, relevant IPR issues, and the protection of tradition knowledge;
- Incorporate social science courses in the education of scientists, technologists and engineers and encourage them to focus their attention and effort to address indigenous issues of importance to their country or region;
- Improve national mechanisms for the promotion of knowledge-based and innovative enterprises through various interventions and incentives, as well as for the transfer of knowledge and technology;
- Support venture capital and ensure that adequate funding is allocated for infrastructure projects for S&T development, taking into account their own needs for technological upgrading and development;
- Ensure that FDI projects in infrastructure have a maximum local component and participation in order to facilitate technology transfer to developing countries and the future sustainability of the project;
- Adopt and implement competition policies, sectoral regulations and/or contractual requirements in order to enhance the quality and operational efficiency of infrastructure at reasonable cost.
- Involve representatives from industry, academia and public sectors in carrying out a comprehensive technology foresight exercise with the purpose of identifying technologies that are likely to help address pressing socio-economic issues and establish accordingly priorities in S&T policy and governmental programmes on research and education;
- Provide S&T graduates with incentives and resources to start innovative enterprises, with a view to improving gainful employment;
- Provide opportunities for continuing education to personnel employed in traditional enterprises, with a view to strengthening the innovative capabilities of these enterprises.
- Strengthen linkages between public research and private industry, and tap into regional and international R&D networks.

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