UNITED NATIONS

TD

United Nations Conference on Trade and Development

Distr.
GENERAL

TD(XI)/BP/4
16 April 2004

Original: ENGLISH

Eleventh session
São Paulo, 13–18 June 2004

The role of science and technology in the achievement of the MDGs

Note by the UNCTAD secretariat

Executive summary

This report seeks to identify approaches for the effective promotion and use of science and technology to meet the development goals contained in the Millennium Declaration (MDGs). Many developing countries are not likely to meet these goals without concerted efforts to place science and technology at the centre of their development agenda. Achieving the MDGs, therefore, will require a reorientation of national science, technology and innovation policies to ensure that they serve the needs of development effectively. In particular, meeting the MDGs will require building a solid national science and technology base to enable the generation, use and diffusion of scientific and technological knowledge. Academia/government/industry partnerships are essential in building scientific and technological capabilities and fostering market-oriented policies and developments. Also essential is access to new and emerging technologies, which 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.

GE.04-50873

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Introduction

1. The Millennium Development Goals (MDGs) constitute a set of time-bound and measurable goals, targets and indicators for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women. They include, *inter alia*: halving the proportion of people whose income is less than one dollar a day; halving the proportion of people who suffer from hunger; achieving universal primary education and gender equality; reducing under-five mortality by two-thirds; reducing maternal mortality by three-quarters; reversing the spread of HIV/AIDS; and halving the proportion of people without access to safe water. Most of these targets are to be achieved by 2015.

2. Progress towards achieving the MDGs has been slow. Most developing countries will face serious challenges in meeting the goals by 2015 without building a solid science and technology base that would address national needs and contribute to development effectively. The most important elements of such a base include investment in science and technology education, the setting up of centres of excellence, facilitating the diffusion and use of new scientific and technological knowledge and ensuring full participation of women in society.

3. Science and technology, when used appropriately to take into account the differing needs of people, are central to facilitating the achievement of all MDGs. Science and technology can be powerful tools in combating poverty, through their contribution to sustained economic growth, enhanced market efficiency, and creation of employment opportunities. Application of science and technology in agriculture has the potential to increase food production through better soil management, efficient irrigation and high-yield crops with enhanced food value. Science and technology may also play a pivotal role in meeting health-related MDGs: drugs, vaccines, diagnostic systems, improved access to medical information, and monitoring systems for drug quality are indispensable in the fight against infant and maternal mortality, malaria, HIV/AIDS and other diseases. Information and communications technologies (ICTs), through distance learning, online knowledge networks and digital libraries, have an enormous potential for extending education and training to dispersed rural populations, women, and people with disabilities. Science and technology are also key in tackling the challenges associated with population growth and urbanization, climate change, water crisis, deforestation, biodiversity and energy sources. The use of technology can facilitate public/private partnerships as well as promoting transparency, accountability and good governance. Similarly, many technologies could be used as powerful tools to improve the lives of women. For example, simple technologies such as treatment of water with chlorine in homes can improve safety of water and sanitation. Improved technologies can increase women's food production, support their activities in natural resource management, reduce the burden of their work and improve the well-being of communities. Similarly, ICTs can bring educational, economic and employment opportunities for women, and enhance their participation in political decision-making.

4. The majority of the world's poor, however, have yet to benefit from the promises of science and technology. More than half of the world population lives on less than $2 a day,[1] and 30,000 people in the developing world die from treatable diseases each day. Many children die of illnesses such as diarrhoea 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.

5. The widening technological gap between nations is one of the causes of the rapidly expanding socio-economic gap between rich and poor nations. Today, high-income countries fund more than 80

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[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/.

per cent of the world's research and development (R&D) and spend 1.5 to 3.8 per cent of their GDP on R&D, while most developing countries spend less than 0.5 per cent, with some as low as 0.01 per cent. An enormous gap also exists between rich and poor nations in terms of the number of scientists and engineers, the number of research institutions, tertiary science enrolment, science and technology journal publications and patent applications.[3] There is, therefore, an urgent need for developing countries to transform the policy environment and make institutional adjustments to make science and technology work for the poor and realize its potential as the prime lever for development. Simply keeping the status quo would leave many developing countries further and further behind.

I. Strategies For Promoting the Application of Science and Technology to meet the MDGs

A. Improving the policy environment for the application of science and technology to developments

6. As technology is increasingly recognized as the key to building competitiveness of industries as well as enhancing social welfare, science policy in many countries has become an integral part of development strategy. Significant efforts have been devoted to development of optimum models and strategies to encourage innovation and application of technology. The work on national systems of innovation and clusters or industrial districts, among others, seeks to identify factors, interactions and relationships that are crucial in creating a conducive environment that promotes innovation and commercialization of technologies.

7. Creating a science and technology capacity that allows a country to meet its social and economic challenges requires the participation of a range of players, including academic institutions, R&D centres, manufacturing enterprises, financial institutions and government bodies. Regulatory, legal and administrative policies have a large influence on those players and their interactions, and this in turn determines how knowledge and resources flow among them. The challenge for the Government is to create a policy environment and institutions that are supportive of technology development and diffusion.

A. 1. Strengthening government science advisory bodies

8. The role of a science and technology advisory body is to ensure that government makes decisions based on sound science, and that science is used as a tool for development by anticipating and minimizing risks and capitalising on opportunities. Science and technology has relevance to all policy areas and concerns all ministries and agencies of the Government. In addition, policy makers require continuous advice with regard to emerging technological developments. It is therefore important to set up a science advisory body within the Government whose role is to provide accurate, relevant and impartial advice on science and technology and help avoid confusion and duplication, as well as maintain coherence in government policy. This advisory body should also ensure that science and technology is integrated into the development plans of all branches of the Government.

9. The mandate of the advisory body should be legislated, and processes should be established to ensure that it is protected against undue political pressure from special interest groups. The advisory body should have its own budget to fund policy research.

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[3] Millennium Task Force (2004). "Interim Report".

A. 2. Enhancing the capacity of support institutions for policy advice and review

10. Given the complexity of science and technology issues, the advisory body needs to be supported by national scientific academies and universities. It can also benefit from a wide range of institutions with competence in science, such as independent research establishments and consumer groups. These institutions would not only provide a valuable pool of experts from whom the Government could obtain advice, but also keep the Government science and technology policy under scrutiny. They should, therefore, be strengthened to better fulfil this role. The Government should establish close links with these institutions to ensure that science and technology decisions on related issues reflect the best interests of the public and national development goals.

11. Technology support institutions should also work to raise public awareness and build confidence in new technologies. Creating awareness among government and industry leaders, as well as the public, on social and economic opportunities will be a useful contribution. These institutions should work to help reduce transaction costs associated with accessing, evaluating, acquiring, implementing and maintaining knowledge and technological alternatives.

A. 3. Involving society at large

12. In most developing countries, there exist only a few non-governmental organizations (NGOs) that have taken on the role of providing a balanced approach to the role of science and technology in society. Some NGOs, guided by the corporate view, emphasize only the positive aspects of technology, while other NGOs that are against transnational corporations (TNCs) and any technologies associated with them tend to emphasize the negative aspects of technology. It is critical at the national and international level to encourage the creation of a new family of civil society organizations that are devoted to a non-partisan and balanced approach to science and technology applications. In the absence of these institutions, developing countries might consistently take a precautionary view towards technology, which may exclude them from any benefits that might arise from new and emerging technologies.

A. 4. Gender dimensions in science and technology

13. 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. Efforts should be made to ensure that girls and women receive science and technical education, so that they can apply the knowledge in the performance of these tasks and roles.

14. In many communities in developing countries, women are the primary holders of indigenous knowledge and know-how on sustainable environmental use and management. It is therefore important that Governments involve women in the decision-making process.

A. 5. Tools for creating an enabling S & T policy environment

15. A sound policy environment should stimulate investment in the basic infrastructure and provide incentives to entrepreneurs and researchers. Measures Governments need to take to create such an environment include investment in human resource training, protection of intellectual property rights and financial support for R&D activities. Furthermore, Governments should promote entrepreneurship in institutions by developing independent and efficient managerial systems, promoting inter-agency cooperation, broadening the funding base and transforming the attitudes

towards a shared entrepreneurial culture.[4] Table 1 summarizes examples of policy tools Governments may employ to create a technology-friendly environment.

Table 1. S&T policy tools for creating a conducive environment

Policy tool	Examples
Financial	Grant loans, subsidies, provision of equipment, buildings and services, loan guarantees, export credit.
Taxation	Company, personal, indirect and payroll taxation, tax allowances.
Legal framework	Monopoly regulations, patent protection, inspectorate regimes, environment and health regulations.
Political	Awards for innovation, honours, encouraging mergers and joint ventures, public consultations and awareness.

Source: J. Z. Shyu and Y. Chiu (2002).
NB: Policy tools for the supply side (e.g. education, training) and demand side (e.g, procurement, public services) have not been included in the table.

16. The role of donors in science and technology is also important. Donor funding for R&D expenditure on agriculture was as high as 80 per cent in some countries in Africa.[5] Donors also play a significant role in transfer of technology. However, it is important to note that national priorities of recipients and donors may not always be compatible, even when they are focused on the same technology.

A. 6. Identification of strategic technologies through technology foresight

17. Science and technology policies should set clear priorities that are in line with national development goals, and outline strategies for funding and implementation. In this context, many countries have undertaken technology foresight exercises to establish priorities in science and technology policy and governmental programmes on research and education. A foresight exercise is essentially based on analysis of current trends and future expectations with the purpose of identifying technologies that could generate economic and social benefits.

18. While most policies of developing countries in the past have been designed to respond to consequences of technological changes, foresight allows countries to anticipate where the technological frontiers might be and develop policies to take advantage of emerging technologies. Two basic approaches have been applied in foresight. The first involves identification of future technological trends and their potential impact on human activity. The second involves identification of socio-economic challenges in the future and technologies that are likely to meet these needs. Often used in combination, these approaches are critical in the formulation of relevant policies that promote technological innovation and application. The process also provides an opportunity to bring representatives together from industry, academia and public sectors.

19. There have been examples where developing countries have practiced technology foresight in areas of economic importance. For example, in the late 1960s, Zambia embarked on solvent extraction

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[4] Clark, B. R. (1998).
[5] M. Maredia, D. Byerlee and P. Pee (1999).

electro-winning (SXEW) of copper when it was still under development in the laboratory and field trials.[6] Zambia built, at the time, a pilot project on a scale several orders of magnitude larger than anything that had been attempted, leading to a significant increase in copper production and purity and reduction in costs. The technology is now used in about 40 other mines and is a benchmark for copper grading. Similarly, Gencor, a South African company, pioneered the development of tank bioleaching process for gold in 1986.[7] Gold mining uses toxic chemicals and releases toxic gases. The bioleaching process, BioxTM, employs organisms that are safely used to dissolve gold ore. The technology has the advantage of being easy to deploy, cost-effective and environmentally friendly. It is now used in Australia, Brazil, Ghana and Peru, among others.

A. 7. Setting clear and achievable targets

20. Having identified strategic technologies, the Government needs to work with other stakeholders to set clear targets that could be evaluated over time. For example, the Republic of Korea's Biotech 2000 Plan of Action has three main phases: the acquisition and adaptation of bio-processing techniques and improvement in performance of R&D investment (1994-1997); consolidation of the scientific foundation for development of novel products (1998-2002); and biotechnology market expansion locally and internationally (2003-2007). To meet these goals, the Korean authorities initiated training programmes in universities, established specialized R&D centres and promoted private sector participation. Recently, the Republic of Korea announced an initiative to generate at least 600 biotechnology ventures by the end of 2003 and train 13,000 nanotechnology specialists by 2010.

A. 8. Identifying benefits and managing risks of new and emerging technologies

21. A central component of public policy research is to assess both the risks and benefits of new and emerging technologies because all technologies carry a level of risk along with potential benefits. For example, ICTs have opened up many new opportunities for development, but at the same time they have also brought risks of abuse and fraud. Similarly, biotechnologies have made enormous contributions to medical science and protection of the environment but are also associated with potential risks to human health and the environment.

A. 8. 1. Biotechnology

22. At present, two thirds of the world's poor – some 900 million people – live in rural areas, and many depend on agriculture for their livelihood. It is in this context that biotechnology, with its applications for agriculture, among others, has been recognized as a potent tool in improving food productivity and combating poverty.

23. Biotechnology is transforming agricultural, pharmaceutical, medical and other sectors of economies in very profound ways. In agriculture, biotechnology is being used to produce new plants and higher-quality food in environments that were perceived as of low or no productive potential. It is now possible to cultivate tropical crops in temperate zones. Plants and crops resistant to disease and environmental stress have been produced and are now being applied in agricultural and food production systems in many developing countries. Soil biotechnology is crucial to production and productivity in tropical countries and the stress on ground and surface water and use of land from housing and industry are having a serious effect on food security, safety and nutrition in poor countries. In medical and veterinary sciences, the development of diagnostics, vaccines and other

[6] Andrews, G.B. (1992).
[7] Billiton.

biopharmaceuticals is broadening the ability to manage diseases that were until very recently considered as incurable. Biotechnology also has a key role to play in improving safety of water and sanitation and reducing water-borne diseases.

24. However, the evolution and growth of biotechnology, including its application, are characterized by uncertainty. There is uncertainty about socio-economic and ecological benefits and risks. Public debate and anxiety over the potential negative environmental, economic and human health impacts of some of the products and processes of biotechnology have intensified in the past decade or so. This has been mainly because of the limited understanding of the nature of the risks. Indeed, while the stock of scientific knowledge on how to develop and apply biotechnology products has grown, our understanding of the potential risks is still weak. Understanding of new biotechnology among the public is usually superficial and focuses on often exaggerated potential positive and negative impacts, rather than on the content of the underlying science.

25. In this polarized debate, the potential benefits of transgenic crops – especially to developing countries – are not clear to the public. The perceived risks associated with genetically modified (GM) crops have resulted in strong resistance in many countries, particularly in Europe. There is concern that domination on the part of the transgenic crop may endanger biodiversity and lead to the extinction of valuable bio-resources. Opponents of genetically modified organisms (GMOs) argue that it is difficult to control the risks of GM crops once they are released in the fields. There are possibilities of cross-pollination with non-GM crop varieties by pollen drift. Even without the help of nature, human factors may contribute to the spread of GM varieties.

26. Additionally, there are economic risks associated with regulatory and administrative regimes, such as the proposed strict labelling and traceability requirements. Many developing country producers will find it difficult to manage segregation of GM and non-GM products of the same crop variety. StarLink[8] maize in the United States was a case of a failure of farmers to satisfy contractual requirements to segregate harvests. The case of BT cotton in India,[9] where local scientists and/or farmers are reported to have 'pirated' the approved GM cotton to produce a local GM variety thought to perform better, brings to the fore the difficulties in regulating GM crops and managing intellectual property rights. Other economic concerns relate to changes in location and patterns of production, which will affect small and poor farmers, a group in which women farmers are predominantly represented. There are also concerns that the new herbicide-tolerant crops will render farmers more dependent on biotech TNCs for chemicals.

27. With respect to traditional knowledge, a relatively small number of highly publicized cases of ‘biopiracy’ have led to considerable sensitivity about the use of natural resources in developing countries by foreign firms. The widespread and longstanding use of traditional medicines made from plant and animal materials in many developing countries is based on traditional knowledge, which is often uncodified. Some of this knowledge is held by women to a greater extent than men, and a small percentage may concern chemical compounds of potential interest to the pharmaceutical industry. Although the actual value of the raw materials is likely to be low, the possibilities for research collaboration and training may be worth pursuing. Relatively little attention has been paid to the particular role of women in the guardianship of traditional knowledge relevant to biotechnology.[10]

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[8] StarLink maize was approved only for animal feed as the stability of the 'Bt protein' Cry9C in heat and digestion was higher than normal, provoking fears of allergen. Farmers signed contracts not to mix it with other maize varieties and sell only for animal feed, but it found its way into human consumption.
[9] For details, see http://www.oneworld.net/article/archive/4547/
[10] Thomas, Sandy (2003).

28. The Government has the responsibility to decide whether or not cultivation of GM crops is beneficial to the country. The approach of Governments may differ from country to country, depending on the preferences of the population and socio-economic conditions surrounding the country. The degree of risk needs to be assessed on a case-by-case basis. Mexico, for example, grows GM soya beans but not GM corn. This may reflect the fact that cross-pollination is possible with corn but not with soya beans. It is therefore important that government regulate GM crops in order to allow co-existence of GM and non-GM crops and adopt a "bio-vigilance" approach, similar to the one taken with regard to the use of new medicine.

29. Many developing countries lack scientific and administrative expertise to put in place the necessary regulatory regime. Providing a regulatory framework itself should not present many difficulties. Many regulatory regimes have already been proposed by the Food and Agriculture Organization (FAO), the United Nations Industrial Development Organization (UNIDO), the United Nations Environment Programme (UNEP), the European Union (EU), and the International Service for National Agricultural Research (ISNAR), among others, and these frameworks can be adapted to suit each country's special circumstances. However, implementation of a safety regime may encounter difficulties due to lack of technical capacity in developing countries. One possible way forward is to build regional capabilities to oversee the implementation of the safety regime. Countries could pool resources together on a regional basis to develop regional scientific and administrative capabilities for the implementation of safety regimes.

A. 8. 2. Information and communication technologies

30. ICTs cut across all sectors and have enormous potential for accelerating progress towards achieving the MDGs. Under favourable conditions, ICTs could be powerful tools in increasing productivity, generating economic growth, enhancing access to health care and health information, facilitating government operations and services, improving access to education and training, and improving the quality of life of all.[11] Attempting to meet the MDGs without promoting ICT development will both increase the cost and reduce the likelihood of attaining the goals.[12]

31. ICTs can be powerful tools for economic growth and poverty eradication. For example, they can increase access to market information and lower transaction costs for farmers and traders. Access to the Internet can be especially beneficial to commodity producers in that it allows them to have direct access to consumers without the need to pass through middlemen and intermediaries. In e-commerce, there is scope for state initiatives in establishing online information and trading exchanges for products. ICTs have been proven to be important tools to publicize and promote tourism, which is important to many developing countries as an earner of hard currency.

32. Notwithstanding their enormous benefits, ICTs give rise to a wide range of concerns. For example, the dominance of the Internet by a few corporations through ownership of main nodes could open the possibility of monopoly and abuse. Another potential risk associated with ICTs relates to security. As the "dependency" on ICTs increases, identifying and monitoring of risks involved in ICTs have become an important task. Breaches of security in communications and data storage pose a threat not only to the privacy of individuals but also to the competitiveness of industries as well as to national security of countries.

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[11] Declaration of Principles, "Building the Information Society: a global challenge in the new millennium" WSIS, http://www.itu.org/wsis

[12] World Bank (2003).

33. Wireless technologies are a particular risk factor in this aspect; the location of mobile phone owners is easily identified, even when the phone is only in passive mode. Wireless technology has been recognized as the most cost-effective means of connecting people in remote areas, and the number of wireless Internet nodes (hotspots) worldwide is on the rise. It is therefore important to consider safety measures to deal with potential abuse.

34. One such measure is the use of open source software (OSS). OSS refers to software whose source code is in the public domain, thus allowing security loopholes to be checked. However, it must be noted that checking an entire piece of software, such as Linux operating systems, requires resources that are beyond the means of small companies or even countries.

35. Each security measure has cost implications. Thus, different levels of security measures need to be adopted according to the sensitivity of the data to be stored or transmitted through electronic means. There is a need to put in place mechanisms for identification, evaluation and monitoring of the risks involved in ICTs. The Plan of Action,[13] which was adopted at the first phase of the World Summit on the Information Society (WSIS) in December 2003, addresses confidence and security as among the "main pillars of the Information Society" and calls on national Governments to develop guidelines, in collaboration with the private sector, in order to prevent, detect and respond to cyber-crime and misuse of ICTs, and consider legislation that allows for effective investigation and prosecution of misuse. It also calls on the strengthening of institutional support at the international level for preventing, detecting and recovering from such incidents.

B. Strengthening basic and applied research in developing countries and promoting international scientific networking

36. Developing countries may make use of known technologies and rely on foreign research capabilities, if these means offer a cost-effective approach to the problem they encounter. Countries such as Japan and the Republic of Korea depended heavily on imported technologies at their early stages of development. The availability of foreign resources in science and technology, however, does not eliminate the need for R&D capabilities in developing countries. Using new technologies is not an automatic or simple process. It entails building "technological capabilities", a mixture of information, skills, interactions and routines to handle the tacit elements of technology. To master more complex technologies, R&D is required to understand their underlying principles, adapt them and develop them further for local needs.

37. The so-called "frontiers of research" are situated in many different places, and the concept of innovation has been broadened to include the diffusion, absorption and use of innovation. It has been argued that the Republic of Korea was an 'active' learner while Brazil was a 'passive' learner.[14] They both imported foreign technologies but their development paths have been different due to their differences in innovation based on acquired technologies. Globalization may have expanded the opportunities for international division of production processes and increased the dependence of all economies, but countries still need the capacity to innovate in order to take part in high-value-added activities.

[13] See http://www.itu.int/wsis
[14] Viotti (2001).

B. 1. Facilitating institutional learning

38. It has been widely recognized that the innovation process is neither simply "pushed" by discoveries through scientific research, nor "pulled" by market demand or need. Instead, it is an interactive process in which "enterprises in interaction with each other and supported by institutions and organizations – such as industry associations, R&D, innovation and productivity centers, standard setting bodies, universities and vocational training centers, information gathering and analysis services and banking and other financing mechanisms – play a key role in bringing new products, new processes and new forms of organization into economic use."[15]

39. There is a need to strengthen national systems of innovation in developing countries. Public-sector knowledge-producing institutions need constantly to update their skills and improve their understanding of technological trends. Educational institutions need to provide students with not only an understanding of fundamental principles and technological trends, but also applied skills and industry-specific technological knowledge. The interactions between these institutions facilitate the generation of new ideas and stimulate innovation. The capability of national economies to learn about, adapt and change their institutional frameworks to engage in 'institutional learning' is of crucial importance for the development of their international competitiveness.[16]

40. As economic activities become more knowledge-based, universities and research institutions play an increasingly important role in industrial activities. Academia/industry/government relations have been in existence for a long time but their nature has changed.[17] The boundaries between public/private, science/technology, and university/industry are becoming porous. In scientifically advanced countries, some fundamental changes have taken place in recent years: R&D activities of private firms are being located in universities, private companies are owned by public institutions, and training of students takes place in industries.

B. 2. Strengthening universities and research institutions

41. It is important for Governments to increase funding for universities and research institutions in order to strengthen indigenous scientific and technological capabilities. All countries that have significantly improved their economies in the recent past made substantial investment in R&D. For example, some 20 years ago, the R&D expenditure of the Republic of Korea was 0.2 per cent of GDP, with 80 per cent of that coming from the public sector. Today, total R&D is over 3 per cent of GDP, with over 80 per cent coming from the private sector.[18] It has been argued that developing countries should increase their R&D expenditure to at least 1 per cent of GDP or preferably close to 1.5 per cent.[19]

42. Formal R&D assumes increasing significance with industrial maturity, even in developing countries that have not reached the "frontiers" of innovation. As more complex technologies are imported and deployed, R&D is vital in order to absorb their underlying principles. It is also vital as a means of keeping track of new technologies as they emerge. A growing base of R&D capabilities also 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.

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[15] Mytelka (2000).
[16] Johnson (1992).
[17] Leydesdorff and Etzkowitz (2001).
[18] UNCTAD (2003).
[19] InterAcademy Council (2004).

B. 3. Promoting international scientific networking

43. Scientific research networks, as an organizational mechanism for linking scientists and institutions that are committed to sharing information and working together, are increasingly regarded as an important instrument in closing the research gap between the North and the South.

44. Several types of North-South research networks have emerged. A successful example is CGIAR,[20] 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. The CGIAR partnership includes 24 developing and 22 industrialized countries, 4 private foundations, and 13 regional and international organizations that provide financing, technical support, and strategic direction. The Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Development Programme (UNDP) and the World Bank serve as co-sponsors.

45. South-South research networks are important for their optimal use of complementarities and economies of scale, especially at the regional level. One such example is the University of Science, Humanities and Engineering Partnerships in Africa (USHEPiA),[21] a programme made up of eight universities in sub-Saharan Africa. Built on the basis of a vision to create a "world-class African university", USHEPiA provides post-graduate fellowships, lecturing exchanges and short courses, and conducts joint research projects on malaria, HIV/AIDS and tuberculosis. Another example is the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA),[22] which brings together the National Agricultural Research Institutes (NARIs) of 10 African countries. ASARECA aims at increasing the efficiency of agricultural research in the region with a view to facilitating economic growth, food security and export competitiveness through productive and sustainable agriculture.

B. 3. 1. Internet for scientific networking

46. The Internet has made it possible to share scientific knowledge that is relevant to local development needs more widely than ever before. Through access to digital libraries and databases, university curricula worldwide, and other electronic resources, scientists and engineers in developing countries could easily take advantage of such knowledge to develop local programmes and projects.

47. However, some of the databases are proprietary, and the most recent research findings in academic journals are often not free. The United Nations should encourage mechanisms for providing access to scientific publications and information to scientists in the developing countries. Such mechanisms might include the digitization of back issues of academic journals for open access on the web, and reduced costs for access to electronic journals by users from developing countries.

B. 4. Promoting science education; reducing the negative impact of brain drain

48. Education, especially science education, is important not only for increasing general science and technology literacy, but also for enabling developing countries to build a critical mass of scientific and technological capabilities. However, in many countries, the percentage of university enrolment in science, mathematics and engineering has been decreasing. Concerted efforts are

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[20] http://www.cgiar.org
[21] http://web.uct.ac.za/misc/iapo/ush.htm
[22] http://www.asareca.org/

urgently needed to reverse this trend. Governments should also reshape their universities and education institutions to make them consistent with their development priorities.

49. Most developing countries have made efforts to expand science and technology education. However, lack of basic infrastructure and financial support in developing countries has resulted in a brain drain from developing 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 required to create active research communities.

50. 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 even offers of collaborative research opportunities from well-funded institutions. This creates a situation where the scarce resources in developing countries are diverted to benefit developed countries.

51. Governments should maintain close ties with their expatriates, who often generate funds for research in their countries of origin through collaborative projects. These links often provide sources of new technologies through investment in the home countries. Some countries, such as India and Israel, have benefited from expatriate scientists or those who have returned from abroad.[23] A number of developing countries are opening up R&D centres in advanced countries where both their expatriates and other experts could work together on national activities. It has also been argued that Governments should consider providing special working conditions for their best science and technology talent, especially those who are young, as a mechanism to enhance future leadership for science and technology.[24]

B. 5. Promoting public and private partnerships

52. Moving from research to commercialization is difficult. First, a successful applied research programme must have the potential to provide intellectual property rights (IPRs) for the inventor and for his/her institution. Second, even when encouraging results are obtained from research, the developmental stages of getting the product to market are extremely expensive. It is, therefore, difficult to mobilize funds for this purpose in developing countries.

53. Nevertheless, the emergence of various forms of innovative public/private partnerships has enabled universities in developing countries to successfully incubate and commercialize products. For example, SunSpace is a South African company that has made micro-satellites for the US space agency NASA, for Australia's micro-satellite programme and for Germany and the Republic of Korea. It was created in 1999, out of a project by the University of Stellenbosch, to build the country's first micro-satellite. Partly owned by the University, the company is now a multi-million-rand space technology business. It has positioned South Africa as a world leader in the field, and has helped lure back some of the country’s top scientists. The initial project was developed in partnership with universities in the United Kingdom and received funding from the Government and the university.

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[23] India has given special incentives for its nationals abroad wishing to invest in the country. In biotechnology, it formed an overseas advisory committee that feeds directly into the Department of Biotechnology. Nigeria has also established a database of its nationals in the United States that it hopes to use in contractual and consultancy work. These activities are following the Republic of Korea’s strategy.

[24] InterAcademy Council (2004).

54. Science and technology parks and incubators have played an important role in the creation of business ventures that focus on technology commercialization and diffusion. They have contributed to recent innovation and technological advances in such fields as ICTs, biotechnology, electronics, nanotechnologies, transportation, health, energy and the environment. Science and technology parks provide support for scientific research, technological innovation and business incubation by building strong ties with sources of knowledge, such as universities, research institutions or large technology firms. Technology parks provide space and opportunities for start-up firms and R&D units of established firms. Often located in close proximity to university and research facilities, they facilitate technology transfer operations, allow the incubation of spin-off enterprises by university staff, and promote the flow of knowledge and technology between academia and business.

55. Government should promote the creation of financial institutions, such as venture capital firms, banks, credit guarantee companies and others, to help channel funds for commercialization of research results. In the absence of local financing sources, scientists have collaborated with developed country firms or TNCs. The private sector in developed countries, especially TNCs, has not only the resources but also the expertise in management and commercialization. Agreements on collaboration should include definite proposals to involve the developed country partner in a programme to help enhance the scientific infrastructure of the developing country.

56. There are other ways in which research centres in developing countries have successfully raised resources. Many African and Asian research centres have developed into specialized units that conduct clinical studies for firms in developed countries and the World Health Organization (WHO) on disease prevalent in their regions. Such contracts help transfer knowledge and improve research conditions and the reputation of the institution. They also provide institutions with additional funding and knowledge sources.

C. Promoting universal Internet access and building strategic partnerships for development and competitiveness

57. Not only are ICTs powerful tools in facilitating the achievements of all MDGs, access to ICTs is an MDG target in its own right. The promise of ICTs remains unfulfilled in many developing countries due to limited diffusion of Internet use. The issues surrounding poor usage of the Internet include local regulatory regimes, infrastructure, international governance of technology and the gender divide.[25] In sub-Saharan Africa, for example, irregular or non-existent electricity supplies in rural areas are a major barrier to the use of ICTs.[26]

58. The WSIS Plan of Action calls for the development of ICT applications that are user-friendly, accessible to all, affordable, adapted to local needs in terms of languages and cultures, and in line with sustainable development. The Plan of Action also urges Governments to adopt national e-strategies by 2005, with a view to achieving the following targets by 2015:

- To connect villages with ICTs and establish community access points;
- To connect universities, colleges, secondary schools and primary schools with ICTs;
- To connect scientific and research centres with ICTs;
- To connect public libraries, cultural centres, museums, post offices and archives with ICTs;
- To connect health centres and hospitals with ICTs;

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[25] In the vast majority of developing countries, the percentage of female Internet users is less than 30 per cent and often less than 10 per cent. See Huyer, S. and S. Mitter (2003).
[26] Jensen, Mike (2002).

- To connect all local and central government departments and establish websites and email addresses;
- To adapt all primary and secondary school curricula to meet the challenges of the information society, taking into account national circumstances;
- To ensure that all of the world's population have access to television and radio services;
- To encourage the development of content and to put in place technical conditions in order to facilitate the presence and use of all world languages on the Internet.

59. Universal access to the Internet, therefore, should be a priority in all countries. As the Internet has become an indispensable tool for science and technology professions, the need to provide the scientific community with sufficient Internet access should also be emphasized.

60. In order to facilitate and promote ICT use in developing countries, it is essential that Governments build a sound human capital base and put in place a credible and focused national e-strategy. This will require taking actions to achieve gender equality in ICT training and education and to include gender equality concerns and experts in the development and implementation of national strategy. There is also a need to enhance partnership of Governments, the private sector, academic institutions and civil society. Relevant bodies of the United Nations system should also facilitate cooperation between the various stakeholders and assist developing countries in the design and implementation of national strategies.

61. ICTs are not a panacea for development or a substitute for real world processes. If real world processes are flawed, deficient or absent, ICTs cannot make good these flaws or make up for these deficiencies. If a government process is bureaucratic, convoluted and subject to delays, moving it online may not make it any more efficient, and instant transmission may not necessarily make it faster. If controls over financial systems are inadequate or missing, making systems electronic will not make them effective. It is important to have well thought out, well established, clear real world processes, before moving them online.

C. 1. Internet cost

62. According to ITU's World Telecommunication Development Report 2003,[27] 20 hours of Internet use cost $23.27 in high-income countries and $57.28 in low-income countries, representing 1.7 per cent and 246.4 per cent of per capita income per month respectively.

63. The dial-up and cyber café end-user costs in many developing countries are generally not high in comparison to those in the OECD countries. However, given the low incomes of end-users in developing countries, these costs are still beyond the reach of large sections of society. The costs of long distance calls and leased line charges are higher in many developing countries than in the OECD countries. These high charges present obstacles to the spread of Internet use not only in households but also in the business community.

64. The rapid growth of public Internet access centres in developing countries is testimony to the demand for the service in the face of constraints. The Indian Market Research Bureau (IMRB), for example, estimates that the number of cyber cafes doubled between 2000 and 2001, while that of major cities (New Delhi and Mumbai) grew by 154 per cent. Internet cafes are a popular means, sometimes the only means, of accessing the Internet in developing countries.

[27] Figures as of August 2003.

C. 2. The policy environment for Internet growth and penetration

65. Reducing the cost of hardware remains a challenge. The cost of PCs has remained stable (around $1,000) over the last few years. New innovations continue to improve the capability of computers but have also kept the price constant, while old versions, which may still be useful, are no longer manufactured. Flexible financing options in developed countries that enable individuals to buy and use computers are generally not available in poorer countries. Similar arrangements could work in developing countries, especially in establishing community telecentres. Other arrangements, such as exchanging advertisement space at public places for provision of Internet facilities, could be encouraged.

66. Regulatory policies should be flexible to minimize interference in the use and management of the Internet. They should also promote innovations that encourage expansion of services and lower the costs. The provision of government loans or guarantees to develop Internet access facilities is another possible measure for promoting Internet use.

67. Developing countries also need to liberalize the ICT market and lower the cost of telephone calls. They should encourage private firms to charge a flat rate on local access and increase the local content on the Internet to limit international browsing and utilize the limited international bandwidth effectively. They should stimulate application of lower-cost technologies, such as wireless and radio communication platforms that could be deployed easily.

C. 3. Development of user-friendly tools

68. While the Internet may be accessed from mobile phones, the primary means of access has remained personal computers. The use of alternative inexpensive Internet tools is still very limited. The use of currently available household devices, such as televisions, could expand access to the Internet.

69. The needs of the disadvantaged should also be taken into consideration in the development of Internet access devices and software. Accessibility tools for the disabled need to be made more widely available. Use of standardized icons and improved voice recognition tools could empower the physically disabled to access Internet services. Similarly, the problems of language and illiteracy should be addressed. Currently, the predominance of the English language in software design and the urban bias in the location of service centres limit the use of the Internet, while the high rate of illiteracy among women restricts their ability to use and benefit from ICTs.

70. Infrastructure requirements are different according to the purpose for which ICT usage is intended. To provide universal access to the Internet, it is important to have a large number of low-capacity access points. In contrast, research institutions and universities require high-capacity Internet access. Thus, ICTs might be introduced at two levels: one requiring low-capacity ICT applications, for use by the public at large, and the other requiring high-capacity technology for research institutions and universities.

C. 4. Strategic partnerships for development and competitiveness

71. Strategic alliances are one of the most significant developments in the structure of the global technology industry. They are usually created to reduce the risks associated with the development of new products and facilitate information exchange. Partnering arrangements with industries may help research institutions overcome funding difficulties through licensing and other arrangements. Such arrangements are particularly important in areas with limited access to other forms of financing. Even where venture capital is available, these arrangements still serve an important risk-reducing function.

72. Partnering activities are naturally more concentrated in the industrialized countries, but they are being extended to developing countries, especially in knowledge-intensive fields. In addition to the risk-reducing benefits mentioned above, partnership arrangements could also play a key role in the development of technological capabilities in firms and institutions in developing countries. Partnering would also be useful in promoting the adoption of good management and industrial production standards in developing countries.

73. One example of partnership in Internet development is the agreement between Cisco Systems and UNDP to provide Internet education to the Asia-Pacific region in 1999.[28] Cisco Systems and UNDP's Asia-Pacific Development Information Programme (APDIP) jointly funded 10 Cisco Networking Academies (CNAs) in nine developing countries to provide advance information technology (IT) training in designing, building and maintaining networks. The CNAs prepare students for the Cisco Certified Network Associate exam, which puts graduates in a competitive position on the global job market, where there is a shortage of IT experts. By 2002, CNAs had trained 150 students and had another 500 in training in the region. The number of CNA centres in the region has grown to 18, surpassing the original target.

74. In 2000, the partners expanded the CNAs to include a number of least developed countries (LDCs). Currently, 37 of the 49 LDCs have established national CNA nodes. The programme benefits from the United Nations Volunteer programme and from the support of the United States Agency for International Development (USAID) through the Leyland Initiative. In 2002, the International Telecommunication Union (ITU) became a partner of the Cisco programme, thus providing further support, as well as recognition of its achievement.

75. This programme provides a basis for partnerships that involve local partners, TNCs, donor agencies and international organizations in delivering a quality service. It taps global skills and resources to empower those who do not have the means but have the willingness to learn. The national experts that are trained would play an integral role in development and maintenance of a reliable Internet service.

76. Another project, HealthNet,[29] run by SATELLIFE, was conceived in the 1980s to use space as a platform for exchanging health-related information. It provided a satellite-based e-mail and literature-searching system for health care workers in developing countries. This project involves a low-orbit (850 km) sun-synchronous satellite, which passes over each location three times a day to deliver e-mails. Since the mid-1990s, the programme has been implemented in 15 African countries, three Latin American countries and three Asian countries, including China.[30]

77. Concerted efforts are needed to reach those who are poor and still marginalized to empower them politically, socially and economically, as well as to enable them to contribute to and be part of knowledge societies. Strategic alliances, such as Grameen Mobile Telecommunication for Villages in Bangladesh,[31] are designed to assist the marginalized. Increased cooperation among the donor community, Governments, the scientific community, not-for-profit organizations, multilateral

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[28] For further information, see http://www.cisco.com, http://www.itu.int/wsis/ and www.undp.org
[29] See SATELLIFE for details (www.healthnet.org/)
[30] http://solar.rtd.utk.edu/kaact/sept95/bakuchi2.html
[31] GrameenPhone, a mobile phone service provider, introduced the Village Phone in 1997 on an owner-operated pay phone. This service provides income mainly to rural women and offers a service to rural communities that cannot become regular subscribers. This model has proved to be profitable for the company as well, with 26,000 village phones in operation in 50 districts and access to 50 million people. The service was provided in partnership with Grameen Telecommunication and Grameen Bank, a leading micro-credit institution.

institutions and the private sector will be needed to achieve universal Internet access. The experience gained through the first Internet revolution provides a basis for future development.

II. Findings and Recommendations

A. Main findings

78. Most developing countries are unlikely to meet the millennium development goals without making science and technology top priorities in their development agenda.

79. The application of science and technology, building upon local knowledge, skills and materials, is central in facilitating the achievement of all MDGs, especially in such areas as combating poverty, improving the lives of women, and combating diseases.

80. For developing countries to meet the MDGs, they need access to new and emerging technologies, which requires technology transfer, technical cooperation and building a scientific and technological capacity to participate in the development and adaptation of these technologies to local conditions.

81. Promoting the development and application of new and emerging technologies, most notably biotechnology and ICTs, will both reduce the cost and increase the likelihood of attaining the MDGs.

82. Academia/government/industry partnerships are essential in building scientific and technological capabilities and fostering market-oriented policies and developments. Technology and business incubators are effective mechanisms for promoting academia/government/industry partnerships and entrepreneurship.

83. The current North-South gap in the generation and application of new and emerging technologies and their contribution to economic and social development constitutes a "technological divide" that must be bridged if developing countries are to participate effectively in a global inclusive knowledge society.

84. ICTs may be introduced at two levels: one requiring low-capacity ICT applications, for use by the public at large, and the other requiring high-capacity applications for research institutions and universities.

85. Capacity building in biotechnology is needed at both institutions of higher learning and the industry level. States need to invest in publicly funded universities to improve infrastructure and human resources.

86. Despite the efforts of various development agencies, poverty still persists in many parts of the world. There is a need to coordinate technical cooperation programmes and to monitor progress to ensure policy coherence and socio-economic benefits for the poor. Similarly, review and analysis of national science, technology and innovation policies are urgently needed to ensure that they serve the needs of development effectively.

87. The lack of a solid science and technology base does not only result from poor human and capital resources, but also stems from a lack of appreciation of the critical role of science and

technology in development, as well as from an incoherent methodology for establishing such a base and an absence of a coherent policy addressing national needs and human and capital resources.[32]

B. Recommendations

National Governments should consider the following:

(a) Strengthening national science advisory bodies and their linkages to provide expert opinion to the Government on a regular basis, with the involvement of representatives of organizations promoting women's contributions to science;

(b) Promoting public awareness of the benefits and risks of new and emerging technologies;

(c) Encouraging universities and research institutions to contribute to national development;

(d) Increasing investment in tertiary science education and adopting concrete measures to increase the enrolment of girls and women;

(e) Adopting special measures to retain and attract young and talented scientists and technologists, and establishing close ties with expatriate scientists and engineers;

(f) Establishing centres of excellence, technology incubators and parks to apply knowledge and to facilitate commercialization and diffusion of technology;

(g) Increasing R&D expenditure to at least 1 per cent of GDP and encouraging R&D that address the needs of the poor;

(h) Taking advantage of the CSTD ICT benchmarking tool to assess connectivity and monitor progress in efforts to provide universal Internet access and implement the WSIS Plan of Action;

(i) Providing incentives for industrial R&D, such as tax benefits, simplified licensing procedures, customs exemption;

(j) Encouraging venture capital from both public and private sources to assist product development and commercialization of new and emerging technologies.

[32] Zewail, Ahmed (2001).

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