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Role of innovation, science and technology in pursuing development in the context of globalization

Report of the Secretary-General

Summary

The important role of science, technology and innovation in enhancing economic well-being is widely recognized. The General Assembly in its resolution 60/204 of 22 December 2005 emphasized this crucial role. The 2005 World Summit Outcome adopted by the Assembly in its resolution 60/1 of 16 September 2005 also stressed the crucial role of science and technology in accomplishing the internationally agreed development goals. The second phase of the World Summit on the Information Society, held in Tunis in November 2005, highlighted the need to establish an inclusive and development-oriented information society, where everyone could create, access, utilize and share information and knowledge.

Accordingly, the present report highlights the multidimensional and key developmental role of science, technology and innovation. It also emphasizes that scientific and technological capacity requires sound institutional-building as well as the nurturing of a complex network of partnerships among a wide variety of stakeholders spread across the globe. The report also makes recommendations for action at the national and international levels.

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I. Introduction

1. Innovation drawn from scientific research and new technologies is a major driving force of long-term economic growth and social well-being. In an era of increasing competition in a globalizing economy, the key to enhancing national competitiveness and sustained economic growth lies in the rapid development and exploitation of new products, processes, services and systems, and the constant upgrading of existing technologies. Bearing in mind this crucial role of science, technology and innovation, the General Assembly in its resolution 60/204 of 22 December 2005 emphasized the importance of science and technology. It stressed the importance of information and communication technologies (ICT) for development, calling for a people-centred and inclusive information society so as to enhance digital opportunities in order to help bridge the digital divide. The 2005 World Summit Outcome[1] also stressed the crucial role of science and technology in accomplishing the development goals. The second phase of the World Summit on the Information Society, held in Tunis in November 2005, highlighted the need to establish an inclusive and development-oriented information society, where everyone could create, access, utilize and share information and knowledge.

2. Today, developing countries diverge greatly in terms of their abilities to access, diffuse and use scientific and technological knowledge, most of which is generated in developed countries and protected by intellectual property rights; they also have varying capacities to translate scientific and technological knowledge into goods and services and invest in human resources and entrepreneurial capacity-building. Similarly, they diverge in terms of their appreciation of the importance of science and technology for development. This "international technology gap" is one of the main causes of the rapidly expanding socio-economic gap between rich and poor nations and constitutes a major challenge for developing countries in their efforts to achieve the development goals. This gap is evident not only along the traditional North-South divide, but also among developing countries and economies in transition.

3. The presence of a "domestic technology gap" is also evident within many developing countries; that is to say, high-tech modern production units coexist with backward ones, hence large-scale corporations coexist with small urban firms, and large agro-business exists side by side with subsistence agriculture. Such differences in the ability to access, adapt and imitate technology affect overall production processes, thereby leading to inefficiencies. The domestic technology gap contributes to higher levels of inequality. Interventions bridging this gap require careful phasing and policy considerations that take into account the growth and the equity dimensions, with the objective of transforming the lives of the poor and underprivileged.

4. The present report addresses some of the most pressing concerns of developing countries and offers recommendations building on the premise that policies on science, technology and innovation have ultimately to be devised by countries according to their own unique needs, their priorities and their stages of development.

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[1] See General Assembly resolution 60/1.

II. Building scientific societies at the national level

5. At the national level, developing countries need to actively pursue policies that strengthen their innovation systems. Some areas where intervention would reap rich dividends are highlighted below.

A. Education

6. Investing in science and technology education is necessary for developing countries with respect to not only the generation of new technologies but also the acquisition of the capacities to imitate and adapt to local conditions science and technology developed elsewhere. Unfortunately, many developing countries are plagued by a large number of constraints: low levels of school enrolment; lack of a coherent policy framework that addresses scientific education; and lack of resources that can be devoted to scientific teaching. As a result, the quality of science education is low and the resources allocated to science in schools are generally few. The government has a key role to play in this regard, by encouraging the adoption of curricula that ensure that all students completing secondary school in any field will have been exposed to at least some scientific knowledge. Scientific and technological education should start at the primary level and be consolidated through the secondary level.

7. Changes are also required at the high school level. Curricula at the high school level should be updated to prepare students for further education in the area of science. Policies supporting scientific education should be developed bearing in mind the constantly evolving nature of technical and scientific learning. In this regard, the ongoing training of teachers and an improvement of the content and quality of education at all levels are critical. Also, sound technological, scientific and engineering education in relevant fields at an advanced level is crucial, as such education provides the basis for building a strong body of scientific talent. Increasing enrolment in courses on technical subjects at the tertiary level, by making them more attractive and allocating more resources to them, is essential. Rates of enrolment at the tertiary technical level differ among regions, with sub-Saharan Africa having the lowest rates of enrolment.

8. With trade and investment in the global economy having expanded since the 1980s, there has been an increase in the international trade in education services, particularly in higher education. The number of students enrolled in tertiary education in advanced countries has been growing rapidly. In developed countries, the number of foreign students enrolled in tertiary education increased from 864,000 in 1990 to 2 million in 2003. There is also a growing "mobility" of the service providers themselves, which, often with government support or encouragement, have been expanding partnerships with foreign educational institutions or even setting up branches of their own institutions abroad. In order to enhance domestic capacity to provide education at the higher levels and to reduce the foreign-exchange costs associated with study abroad, some developing countries are allowing, prestigious foreign universities to set up "branch campuses" in their territories, if not actively seeking out such institutions. Well-known institutions from developing countries are also actively setting up branches in other developing countries in the context of South-South cooperation, especially in management studies, engineering and information technology. For their part, developed countries

are interested in fostering such collaboration partly because the export of educational services can be an important source of income. Such a “globalization of education” has meant more partnerships, increased networks and increased mobility of skilled individuals. These changes are occurring because Governments, universities and corporations recognize that there is a global shortage of highly trained workers and are taking steps to expand their numbers.

9. Developing countries’ limitations restrict the conduct of cutting-edge scientific and technological research. Thus, much attention has been devoted to the process of transfer of technology from developed countries, which is never passive. Indeed, this is an active process of learning and adaptation, which represents a challenge for most developing countries. There is also the need to match innovations with basic local needs. Universities have an important role to play in all these processes. They can get involved with their communities, thereby gaining direct knowledge about social needs, some of which could be addressed through research and development (R&D) activities. Universities can also be encouraged through a mix of appropriate policies and institutions and adequate funding (public and private) to generate local technologies as well as adapt innovations produced abroad to local needs, and can be active participants as well in the operation of technology parks and similar entrepreneurial activities. Vocational training is also crucial. One determinant of an effective relationship between the university and industry is the degree of responsiveness of educational curricula and activities to the emergence of new areas of industrial technology or of specialized sectors. Both R&D and vocational training often entail establishing effective networks among institutions of higher education, technical and vocational training, research units, technical associations and industry.

10. Women continue to be underrepresented in science and engineering courses; and the fact that women are, as a result, underrepresented in the professions of science and technology limits their full participation in the labour market. Concrete measures to increase the enrolment of girls and women in scientific and engineering disciplines should thus be taken. Such measures should seek to make these fields more attractive to women, remove the gender barriers to science and engineering education and training, promote equal training opportunities in science and technology-related fields, and strengthen gender-sensitive curricula in formal and non-formal education for all.

B. Building capacities in agriculture

11. Three quarters of the world’s poor live in rural areas and are mainly engaged in agricultural activity in developing countries. It is therefore imperative that agricultural research and technological innovations be fostered so as to enable the rural poor to overcome poverty and participate in the global economy. Technological progress has enabled both increasing supplies of food to come from roughly the same cropland base and the real cost of food to decline over time. Technological advances in agriculture have taken the form of new varieties of crops and chemical inputs, as well as innovations in agricultural machinery and farm practices. More recently, R&D in agriculture has helped produce genetically modified crops. Agricultural R&D thus has the potential to help developing countries meet their nutritional goals. Genetic engineering, however, has given rise to environmental, food safety and broader development concerns, which should be fully addressed during the R&D process.

12. In advancing agricultural research, the role of the State is crucial. The success of the green revolution in Asia depended not just on the development of new hybrid "high-yield" seeds, but also on the infrastructure and support services developed by the State to produce the seeds and to deliver the attendant fertilizers, pesticides and irrigation. The region that is now most in need of an agricultural revolution is Africa, where net agricultural production per head is less than it was in the 1960s when the green revolution started to lift productivity in Asia. In this regard, there is an important role for the public sector to assume in ensuring that research is undertaken that may seem not to be profitable privately. In particular, agricultural needs in poor tropical countries differ significantly from those in temperate rich countries; yet, limited agricultural research is performed on products significant for the tropics and in tropical ecosystems. It has been suggested that such research concentrate on so-called orphan commodities — for example, low-value crops, such as cassava and sweet potatoes, that are important as staples for poor people in large parts of the developing world.

13. Agricultural R&D cannot be left entirely in the hands of the private sector. In developed countries, the public sector undertakes about half of agricultural R&D and in developing countries the proportion is much larger. To encourage private R&D in tropical agriculture, traditional funding of research may be usefully supplemented by a commitment to reward developers of specific new agricultural technologies with appropriate tax credits for R&D. Another possibility is to put in place a purchase-guarantee mechanism, whereby those who develop the new seeds would be assured of a reasonable income from sales. There is also a need for global agricultural research institutes that can focus on the needs of the poorest. Through its work, the Consultative Group on International Agricultural Research (CGIAR) has brought the benefits of modern science to poor farmers all over the world. The activities of the Consultative Group as well as South-South cooperation in this field should be strongly supported by the international community.

14. Another area that needs attention is that of exports of agricultural products. Developing countries account for approximately 30 per cent of world trade in agricultural products (US$ 783 billion in 2004). The ability to compete in the area of agricultural and food products is increasingly dependent on meeting safety, quality and environmental requirements (above and beyond price and basic conditions). The last decade has witnessed greater scrutiny of production and processing techniques as well as stricter traceability and labelling requirements across the food supply chain. While most sanitary and phytosanitary measures, such as those related to human health and safety, are embodied in technical regulations, there is also a discernible upward trend in the development of private standards, as retailers in developed economies impose stringent conditions.

15. While many in the developing countries perceive the increasing requirements as a potential and significant barrier to trade, the ability to raise capabilities in this field also presents a major opportunity for upgrading and catching up with other high-value food-exporting countries. Developing countries need to enhance the ability of private firms to comply with these requirements as well as strengthen the institutional infrastructure that helps demonstrate compliance. Since the requirements of a well-functioning system of sanitary and phytosanitary measures are relatively complex, it would not be realistic to expect that all the actors in developing economies (and especially in the least developed ones) can make significant progress in this area in a short period of time.

16. At first, developing countries need to enhance policymaking capabilities, including the updating of legislation to enable food safety control agencies to respond to current challenges. Technological capacities of food standards and quality control agencies need to be enhanced. Public-private cooperation for the effective functioning of the food safety system needs to be encouraged. However, this should be achieved by adapting necessary technologies to local conditions, as far as possible with the help of indigenous capabilities.

17. Another issue that arises through the progress of agricultural R&D is the protection of intellectual property rights, which are central to the private sector's motivation to engage in R&D. The World Trade Organization Agreement on Trade-related Aspects of Intellectual Property Rights[2] came into force on 1 January 1995 and the developing countries agreed to bring their laws on intellectual property rights into line with those of other members. New legislation had to be drafted to extend property rights protection to plant varieties, and staff had to be trained. This protection, together with the costs of implementing sanitary and phytosanitary regulations for trade purposes, can be expensive for developing countries. What the long-term effects will be of tighter protection of intellectual property rights on agricultural production in developing countries is not clear. Ideally, such protection, by creating monopoly rents for the developer of the new product, should encourage firms in developed countries to undertake research on crops that are appropriate for developing countries. On the other hand, if intellectual property rights are operative, there is no incentive for private firms to disclose the results of any discoveries that cannot be patented, and so the pool of knowledge released into the public domain will be smaller. Under the current regime of the Agreement on Trade-related Aspects of Intellectual Property Rights, all members of the World Trade Organization are obliged to provide patents on all forms of technology — including biotechnology. There are a few exceptions and those relating to agriculture and biodiversity are contained in article 27.3 (b) of the Agreement, which states that plants and animals, but not micro-organisms, can be excluded from patentability in national laws. However, while plants do not have to be patented, "plant varieties" must be made subject to some form of intellectual property protection, "either by patents or by an effective sui generis system or by any combination thereof". (The role of the Agreement is further examined in sect. III below.) The 1961 International Convention for the Protection of New Varieties of Plants[3] which established the International Union for the Protection of New Varieties of Plants has some inherent advantages over patents. A related concern is the issue of "farmers' rights". Farmers' rights are protected under the 2001 International Treaty on Plant Genetic Resources for Food and Agriculture of the Food and Agriculture Organization of the United Nations (FAO). Farmers' rights are, however, not yet operational. The Treaty is vital in ensuring the continued availability of the plant genetic resources that countries will need in order to feed their people.

18. Policies that have an impact on farming and other agricultural processes cannot ignore their impact on ecosystems and their biodiversity. There is an increasing emphasis on research oriented towards preserving the ecosystems. The overexploitation of land for agricultural gain can have long-term negative effects on

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[2] See *Legal Instruments Embodying the Results of the Uruguay Round of Multilateral Trade Negotiations, done at Marrakesh on 15 April 1994* (GATT secretariat publication, Sales No. GATT/1994-7); also available from www.wto.org/english/tratop_e/trips_e/t_agm0_e.htm.

[3] United Nations, *Treaty Series*, vol. 815, No. 11609.

the biodiversity of a region. Research on ecosystems will thus have important ramifications for agricultural policy. Such research should be encouraged and supported. In a related manner, there has been a growing emphasis on organic agriculture which is described by FAO as “a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity” (FAO/World Health Organization (WHO) Codex Alimentarius Commission, 1999). Such types of agricultural practices that focus on sustainable agriculture with the ecosystem in mind need to be nurtured.

C. Promoting private technological transfer and research

19. While a complex set of factors determine the volume and direction of foreign direct investment (FDI), there is a growing recognition of the important role that it plays in transferring technology to low- and middle-income countries. However, it is very unevenly distributed among developing countries, with low-income countries being a relatively marginal destination for such investments.

20. In order to derive long-term benefits from FDI, especially through technology transfer, countries need to have the necessary absorptive capacity. Countries need to invest in skill creation and infrastructure. They need to provide strategic policy direction and an efficient administration. On the other hand, when FDI is attracted in response to major tax incentives, or as a result of trade policy distortions, without a simultaneous build-up of local capabilities, and without the creation of linkages between foreign affiliates and local firms, there is limited scope for long-term benefits of FDI. Yet, increasing competition among countries for limited investment flows in the world market has led to more enhanced incentive packages meant to attract investors. These packages erode the benefits from such investment; hence, it is unclear what benefits accrue to the host country. At the same time, World Trade Organization rules prohibit mechanisms that were widely used in the past to increase the benefits for host countries (see below).

21. Technological innovation and adaptation require funding, but funding alone is not sufficient. Networks of private firms, research institutions and government also play a crucial role. Such horizontal networks are essential conduits for knowledge, capital, products and talent. Firms that can develop strong links to research institutions, financiers, partners, suppliers and customers have an advantage in respect of acquiring, modifying and then commercializing new technology.

22. Thus, the government should strive to engage the private sector and promote business activities in R&D. Fiscal incentives and, direct public sector credit and subsidies can lower the cost of technological innovation and adaptation, and reduce the uncertainty that surrounds innovative activities. Fiscal incentives may take the form of tax deductions and credits for particular types of innovative activities. Direct public credit may take the form of loans for innovative investment and the acquisition of technology by development banks, which may grant preferential interest rates and favourable repayment schedules. Subsidies may be allocated to entrepreneurs through competition according to their projects’ potential to bring about technological upgrading, as well as spillovers in the form of learning or the creation of forward and backward linkages. In any case, any incentive system

should be regularly evaluated on the basis of its contribution towards building domestic technological capacities.

23. Business and technology incubators, which typically exercise an important function in supporting small and medium-sized enterprises, could be supported through public policies. Policies that facilitate the creation of venture capital, technology parks, and networks (involving national as well as international actors) that help small and medium-sized enterprises access highly skilled labour and pool business services, foster private partnerships for mentoring and marketing.

24. Articles III and XI of the General Agreement on Tariffs and Trade (GATT) prohibit measures that run counter to the principle of national treatment or imply quantitative restrictions. Measures that are explicitly prohibited include local content and trade-balancing requirements, and restrictions on foreign exchange flows related to enterprises. Other measures that are explicitly prohibited, conditioned or discouraged include those on joint-venture requirements, location of headquarters, technology transfers and restrictions on sales in the domestic market. These measures were used by many developing countries in the past to promote industrialization and exports. The World Trade Organization Agreement on Subsidies and Countervailing Measures[4] does, however, allow for technology subsidies. It is important to evaluate the current system in the context of the net benefits for developing countries in terms of technological development. Carefully tailored incentives for investment in capital goods, innovation, manufacturing capabilities and participation in skills upgrading certainly facilitate technology transfer, assimilation and trade.

D. Improving infrastructure for promoting technology and innovation

25. The creation and application of scientific innovation also require basic infrastructure. Such infrastructure includes a sound network of roads and transportation, reliable supplies of electricity and sound telecommunications networks and other public utilities. Infrastructure services are intermediate inputs into production processes, as they impact the productivity of other factors of production.

26. However, putting proper infrastructure in place itself requires innovative technology. Thus, infrastructure development can provide a foundation for technological learning, involving the use of a wide range of technologies, institutional arrangements and appropriate policies. The United Nations Millennium Project (2005) has pointed out that Governments rarely recognize that infrastructure and technological innovation for development reinforce each other. It has stressed that policymakers need to be aware of the dynamic role of infrastructure development and to take the initiative in acquiring the technical knowledge available through international and indigenous construction and engineering firms. For infrastructure to become more effective and extensive, developing countries

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[4] See *Legal Instruments Embodying the Results of the Uruguay Round of Multilateral Trade Negotiations, done at Marrakesh on 15 April 1994* (GATT secretariat publication, Sales No. GATT/1994-7); also available from www.wto.org/english/tratop_e/scm_e/scm_e.htm.

need to adopt and enforce national standards that are consistent with international benchmarks. Standards should be such that they do not create barriers to innovation.

E. Making effective use of information and communication technologies (ICT)

27. It has been argued that the dissemination of information and communication technologies (ICT) has the potential to exert a sustained, long-lasting impact on productivity and economic growth, provided that policymakers implement strategies that facilitate a faster rate of ICT diffusion and more rational and holistic approaches to its uses. In providing benefits ranging from long-distance learning to improved financial and non-financial services to local farmers and microenterprises, ICT is thus becoming a necessity in developing countries. Recent findings in emerging economies suggest that those developing countries that managed to introduce ICT in local economies are the best performers in terms of their international competitiveness. For example, a technology that is significantly transforming economies and societies in developing countries is mobile telephony. Since 2003, developing countries have more cellular subscribers than do developed countries. In Africa alone, the number of mobile phone subscribers increased from 15 million in 2000 to over 80 million in 2004, an increase of 433 per cent. It is argued that mobile telephony, when used appropriately, has been the information and communication technology with the most significant impact on development. In developing countries, mobile phones are used for more than simple communication: often, they constitute a business tool by means of which producers and buyers can be fully informed before they make economic decisions.

28. Despite the massive potential of ICT to enable higher productivity and greater business participation, numerous obstacles remain in respect of their adoption by business, 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 resistance to online trading and discourage adoption of ICT, particularly within small and medium-sized enterprises. Governments need to ensure that national policies are in place for the transfer and appropriation of ICT as they pursue their country’s goal of sustained economic growth and social development. Furthermore, for countries to be competitive in the global ICT market, it is important that they acquire a “critical mass” of experts in the technology sector. Building ICT capacity among women and girls would enhance the competitiveness capacity and contribute to a gender-equal society.

29. Noting the crucial role of ICT for development, the World Summit on the Information Society, during its first phase held in Geneva in December 2003, adopted its Declaration of Principle (see A/C.2/59/3, annex, chap. I, sect. A), expressing the resolution “to build a people-centred, inclusive and development-oriented Information Society, where everyone can create, access, utilize and share information and knowledge, enabling individuals, communities and peoples to achieve their full potential in promoting their sustainable development and improving their quality of life”. In this regard, the Tunis Agenda for the Information

Society, adopted by its Summit during its second phase, held in Tunis in November 2005 (see the report contained in document A/60/687, chap. I, sect. B), encourages Governments to elaborate comprehensive, forward-looking and sustainable national e-strategies, including ICT strategies and sectoral e-strategies, as an integral part of national development plans and poverty reduction strategies (para. 85).

F. Technology foresight

30. Most industrialized countries set priorities in science and technology through foresight programmes. These involve stakeholders from industry, academia, research institutes, services, financial institutions and the government who participate for the purpose of determining the technological priority needs. A number of developing countries, including India, the Republic of Korea, Thailand and several Latin American countries, have conducted forecasting exercises. These exercises create strong awareness among all stakeholders of the country's technological needs, emerging global trends and the implications for national competitiveness and priorities. They are critical in the formulation of relevant policies that promote technological innovation, and strategies for funding and implementation, as well as planning and decision-making in different sectors of the economy. Technology foresight also allows countries to anticipate where the technological frontiers might be and develop policies through which to take advantage of emerging technologies such as ICT, biotechnology and nanotechnology.

G. Nurturing appropriate institutions

31. Scientists need the opportunity to apply their knowledge and to pursue rewarding careers in their chosen scientific fields. Horizontal networks could be one means of ensuring that scientific talent is not lost and that scientific learning and research are maintained. Thus, linkages between technology-based industry, academia and government need to be created, so that technologies appropriate to national needs are developed. In this manner, scientists and researchers can be employed in industry while maintaining their links to academia as well. Such linkages are not well developed in many developing countries, causing academics and researchers to pursue jobs elsewhere. Besides, owing to a lack of attractive opportunities at home, developing countries face the risk of departure of their highly skilled scientists and researchers.

32. Policies designed to retain such talent and stem brain drain should be developed. Some countries have indeed benefited from "brain circulation" where "circulating" highly skilled immigrants brought back valuable experience and know-how to their local economies. A widely cited example concerns the ICT sector in India. However, in most developing countries, losses from brain drain are much greater than the benefits from "brain circulation". In South Africa, for instance, the Department of Health estimates that over a quarter of the vacancies for nurses could not be filled in 2001, and the emigration of workers in this and other fields is even more common in other sub-Saharan countries. The absence of highly skilled individuals is likely to hinder innovation and the adoption of new technologies, reduce the quality of social services, and slow down, if not prevent, institution-building. However, highly skilled emigrants can contribute to the home economy from afar by being the source of knowledge transfer, as well as trade,

investment and remittances. Efforts at attracting expatriate scientists connected to industries and research institutions at home are increasingly common. For example, there is the programme of the International Organization for Migration on “Migration for Development in Africa”, a recent initiative that seeks to mobilize competencies acquired by African scientists abroad for the benefit of Africa’s development. It helps African Governments manage and transfer skills and financial resources acquired in the diasporas for use in national development programmes.

33. Academic faculties in many developing countries do not have the requisite resources or the incentives to keep up with the latest developments in their field. This situation can be changed by creating knowledge networks through encouragement of partnerships among universities at the national, regional and global levels. Most developing countries still distinguish between industrial policies that emphasize building manufacturing capabilities, including policies designed to generate new knowledge through support for R&D, and those dedicated to education. Combining these through integrated national innovation systems would help in focusing attention on the use of existing technologies while building a foundation for long-term R&D.

34. Overcoming the “domestic technology gap” should be a major objective of national innovations systems. This implies guaranteeing the access to technology of farmers and small urban producers. It requires developing the systems needed to generate and adapt technologies that are appropriate, and to disseminate them among small producers. The design of such systems should recognize that the reduction of existing technological dualisms is essential to reducing poverty and income inequality, but also that small producers can become a powerful production force when they have the adequate access to the factors of production complementary to the labour that they possess. In this regard, the promise of ICT and the potential of the technologies for small businesses and farmers need to be effectively tapped. The dissemination and use of ICT and other technologies for the poor would be greatly enhanced through better affordability and, in many cases, through community-based approaches.

35. Science and technology have relevance to most policy areas and concern most ministries and agencies of the government. Therefore, what is crucial is the establishment of appropriate intragovernmental coordination mechanisms with the participation of all stakeholders. In addition, policymakers require continuous advice with regard to emerging scientific and technological developments. It is therefore important that there be set up within the government a science and technology advisory body whose role would be to provide accurate, relevant and impartial advice on science and technology and help prevent confusion and duplication, as well as maintain coherence in government policy. This advisory body should also ensure that science and technology are integrated into the development plans of all branches of the government. 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.

36. Given the complexity of innovation and science and technology issues, advisory bodies have to be supported by national scientific academies and universities which can also benefit from a wide range of partnerships, including public-private alliances and partnerships with institutions with competence in science, such as independent research establishments and consumer groups.

Governments 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.

III. Role of international strategies in fostering knowledge and innovation

37. The process of technological innovation has become intricately linked to the globalization of the world economic system. However, despite the globalization of technology, the involvement of developing countries in producing new technologies is almost negligible. Most new technologies are produced in developed countries. In this regard, the globalization of the activities of multinational corporations is still not reflected in the location of their R&D, which is still overwhelmingly concentrated in industrialized countries. However, there are a few newly industrialized economies that have made some inroads into technology-generation through their domestic research efforts. While there is a need for developing countries to improve their national innovation system, there is also a need for more to be done at the international level.

A. Promoting international research and development (R&D) networks through open access regimes

38. The Internet has made possible increased cooperation among scientists across the globe, facilitating speedy exchange of ideas and scientific information. The number of internationally co-authored articles in scientific journals doubled between 1990 and 2000. There has also been a rise in the numbers of open and collaborative projects designed to create “knowledge public goods”. These projects, often referred to as open access regimes, include free and open source software (FOSS), the human genome project, the World Wide Web, the single nucleotide polymorphisms (SNPs) consortium and open academic and scientific journals. Locking in knowledge behind restrictive licensing regimes may not be the optimal choice if technological development is to be achieved in developing countries. As shown in particular by the experience of free and open source software, open access is more supportive of technological development in directions that are specifically relevant to the needs, demands and concerns of users, this being particularly important for developing countries. It also reinforces human capacity-building in science and technology and generally contributes to the generation of national capacity to achieve the internationally agreed development goals.

39. It is essential that legal regimes relating to patents do not affect the way scientific research and publishing are organized and conducted and maintain the practice of “open” science in the world’s academic research communities. The promotion of knowledge public goods, whose expansion promises “additional user” benefits or positive network externalities, must be ensured. Examples in this regard include open access for scientific publishing, global communication and transport systems, and informal norms. Efforts to increase the inclusiveness of these goods will widen the range of users, globalizing the benefits and costs. It is therefore critical to examine in more detail the various building blocks of public goods, exploring especially the types of incentives that different actors — public, private,

national and international, including multilateral institutions — might require in order to be motivated and able to deliver their expected contributions to the development of a particular public good. The United Nations is already at the forefront of the drive to establish open access to information and technology. Its role in this area should be further strengthened.

40. Another source of scientific knowledge is publicly funded R&D. A new report on the scientific publishing industry by the Organization for Economic Cooperation and Development (2005) finds that Governments would boost innovation and secure a better return on their investment, in particular social returns, in publicly funded research if they made research findings more widely available. To that end, the report suggests that coordinated efforts at national and international levels are needed to broaden access to data from publicly funded research and contribute to the advancement of scientific research and innovation. There is a need to consider the establishment of an international database on publicly funded R&D that would assist developing countries in accessing technologies based on their needs.

B. Development dimensions of intellectual property rights

41. While intellectual property rights are important, there remain significant disagreements as to their development dimensions. The history of intellectual property rights protection shows that countries with low levels of technological capacity had generally had weak standards until they reached a level of development at which their industries could benefit from such protection. However, today, patent regimes play an increasingly important role in technology markets. Despite some initiatives undertaken regarding the issues facing developing countries in different sectors, important gaps remain with respect to understanding the changing role of patents in fostering knowledge creation and diffusion. New technologies, such as biotechnology, nanotechnology and ICT, are of particular relevance in this context.

42. About 95 per cent of all patents are held by developed countries. As a consequence, they can exert influence over key aspects of science and technology. The Agreement on Trade-related Aspects of Intellectual Property Rights severely restricts reverse engineering and other forms of imitative innovations that were used widely in the past by developing countries and that are used even now by industrialized countries. It also makes access of developing countries to proprietary knowledge more costly. The kinds of limitations introduced by the Agreement implies an asymmetry that favours the producers and holders of protected intellectual property — mainly in developed countries — at the expense of those trying to gain access to protected intellectual property — mainly in developing countries. Moreover, the Agreement requires developing countries to expand and enhance their intellectual property regimes, while containing very few provisions aimed at effectively facilitating and promoting their access to technology.

43. Even higher levels of patent protection are sought through regional and bilateral free trade agreements. The “TRIPS-plus” obligations included in these agreements often eliminate the limited options developing countries now have with respect to adapting their legislation to meet their needs by using the flexibilities allowed under the rules of the Agreement on Trade-related Aspects of Intellectual Property Rights. This amounts to a push for even higher standards and modifies the benchmarks established when the Agreement was being negotiated. At the time the

Agreement was negotiated, it was agreed that developing countries would not be required to confront even higher levels of protection for the various forms of intellectual property.

44. Currently, patents apply only in the country where they are granted, although there are proposals to move to a global patenting system. Besides the need to consider the benefits that global patents could yield in terms of reducing time and patent office fees, there exists an even greater need — that of focusing on the requirements of developing countries and treating intellectual property as one of many tools for development. Unlike developed countries, which tend to view the World Intellectual Property Organization (WIPO) and the World Trade Organization as bodies providing them with the opportunity to ensure higher intellectual property standards, developing countries tend to view both organizations, and the treaties they embody, as the tools of development policy.

45. There is growing consensus among the international development community on the need for WIPO to examine and address all features of existing intellectual property rights, including the economic and social costs that intellectual protection may impose on developing countries, and on consumers of knowledge and technology both in developed and in developing countries. A four-point proposal to establish a "development agenda" and reform WIPO has been put forward to WIPO members by 14 developing countries in the Group of Friends of Development (World Intellectual Property Organization, 2004). The development agenda process has been viewed by some countries as an opportunity for WIPO members to mainstream development concerns into WIPO activities and to ensure that international intellectual property systems take into account development goals.

46. One important aspect of intellectual property protection is the protection of traditional knowledge held by local communities and indigenous people in respect of conserving biological diversity. The fact that, currently, there is no effective protection system for such knowledge has led to cases of biopiracy. There need to be effective measures for the protection of such knowledge as well as for the equitable sharing of the benefits arising out of the use of such knowledge. The issue is being addressed in such bodies as the Convention on Biological Diversity secretariat, WIPO and the World Trade Organization.

C. Nurturing new alliances: South-South cooperation

47. There are numerous factors that impede technology transfers from developed to developing countries including:

(a) The continuing shift of research activities in developed countries from the public to the private sector. This limits the avenues for collaborative research between developed and developing countries, since the latter continue to rely on public funding for scientific research and private corporations are reluctant to share technology with them;

(b) The fact that technological advances made in developed countries have limited impact on or are not necessarily tailored to the needs of developing countries. Even if technologies are transferred or partnerships are developed, the needs of developing countries are not going to be met. This is especially true if the system is market-driven. While the demand for science and technology solutions exists in poor countries, the market-based incentives necessary to actively respond to such demand are missing. The area of infectious diseases is a good example. Most global biomedical research has focused on the problems of developed countries. In fact, only 1 per cent of the medicines developed over the past 25 years address tuberculosis and tropical diseases, which, according to WHO, account for 11 per cent of the global disease burden.

48. These factors have led to the increasing attention directed towards cooperation among developing countries themselves for the purpose of finding scientific solutions to their developmental problems, that is to say, South-South cooperation. This process is also driven by the emergence of countries such as Brazil, China, India and South Africa as regional actors with increasing technological capabilities. Such cooperation has helped poor countries find appropriate, low-cost and sustainable solutions to their problems. For example, science ministers from Brazil, India and South Africa have been working together to identify areas for cooperation in preventing and treating HIV infections and AIDS. In efforts to address the tropical Chagas' disease, Costa Rica, in partnership with Brazil, Chile, Uruguay, Argentina and Mexico, brokered a deal with the United States National Aeronautics and Space Administration (NASA). The arrangement was to fly proteins derived from the parasite that causes Chagas' disease on the space shuttle to study their structure and there have been promising results. Regional cooperative efforts in scientific research are also gaining ground. The Arab Science and Technology Foundation, created in 2002, provides research support for regionally relevant issues such as water management and solar energy.

49. Another significant trend emerging in global R&D is the increasing cooperation among multinational corporations of the South: firms from Malaysia, the Republic of Korea, Singapore and Thailand recently initiated R&D activities in India. This trend highlights the expansion of South-South cooperation beyond Government-to-Government collaboration, and thus represents a potential for development driven by R&D.

50. Such alliances should be encouraged and nurtured. South-South cooperation on issues related to technology is an integral part of globalization. Such cooperation should be designed as a strategic approach to leveraging technical knowledge from wherever it is located in order that it may be applied wherever it is needed. The starting point could be regional cooperation, which could then be extended to other developing countries and eventually to the global economy.

IV. Role of the United Nations

51. The United Nations is already playing a significant role in disseminating useful scientific information to developing countries. The Commission on Science and Technology for Development has contributed to efforts to bridge the technology gap between developed and developing countries. However, the role of the Commission needs to be strengthened further. In this regard, the Economic and Social Council on 28 July 2006, adopted resolution 2006/46 entitled "Follow-up to the World Summit on the Information Society and review of the Commission on Science and Technology for Development". The Partnership on Measuring ICT for Development, established in 2004 by the United Nations system and its development partners (including the International Telecommunication Union,

OECD, United Nations Conference on Trade and Development (UNCTAD), the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics, four regional commissions, namely the Economic Commission for Africa (ECA), the Economic Commission for Latin America and the Caribbean (ECLAC), the Economic and Social Commission for Asia and the Pacific (ESCAP) and the Economic and Social Commission for Western Asia (ESCWA), the information and communication technologies (ICT) Task Force and the World Bank), developed a common set of core ICT indicators for a coherent and structured approach to advancing the development of ICT globally.

52. UNESCO has been at the forefront in respect of promoting scientific learning in its member States. Following the recommendations of the World Conference on Science (Budapest, June-July 1999), UNESCO launched a joint initiative involving its Education and Science Sectors to promote education and capacity-building in science and technology in its member States. UNESCO aims to encourage and assist all its member States in developing effective science and technology education programmes in line with the Education for All goals in the formal and non-formal sectors.

53. In order to keep policy relevant to the evolving market needs and development of science, technology and innovation, UNCTAD undertakes science, technology and innovation policy reviews, which aim to help developing countries identify and adjust their policies and institutions in order to support the technological transformation, capacity-building and innovation of their enterprises. Policy reviews help countries meet the market needs of the science, technology and innovation systems as well as new and emerging science, technology and innovation sectors.

54. The outcomes of the two phases (Geneva and Tunis) of the World Summit on the Information Society represent the international consensus on how a major set of technologies, namely, ICT, are to be harnessed and put at the service of development. Many United Nations organizations and other entities have a role to play in the implementation of these Summit outcomes in their respective fields of expertise. They should also collaborate closely with the Economic and Social Council, through the Commission on Science and Technology for Development, in its system-wide oversight role, as provided for in the Tunis Agenda for the Information Society (para. 105). The United Nations system should also actively facilitate South-South cooperation to generate research relevant to industrial and technological development, and the exchange of knowledge and best practices.

55. At the operational level, the United Nations could play an equally critical role. The United Nations could provide a forum where developing countries would share success stories and lessons learned from their respective national efforts to apply science and technology for development. It could provide expertise and analytical studies on integrating science, technology and innovation policies into national development strategies and utilizing them as effective tools for achieving the Millennium Development Goals and other internationally agreed development goals. More importantly, the United Nations could facilitate the establishment of a network of centres of excellences in developing countries to support interaction among scientists and engineers and to maximize use of the research facilities in those countries for development purposes. This, in turn, would encourage countries to establish regional and subregional science and technology cooperation systems and carry out cooperative R&D programmes.

V. Conclusions and policy recommendations

56. **The growing gulf in technological and scientific capabilities between developed and developing countries has been a continuing concern for decades. This technology gap impedes the capacity of many developing countries to participate fully in the global economy. Recently, a few emerging economies have made significant breakthroughs in their scientific and technological capacities with a strong demonstration effect on other developing countries. Forward-looking economic policies that successfully engaged the private sector, academia and industry led to beneficial networks that have made possible the use of scientific and technical knowledge in accomplishing their developmental goals. Some of the countries with large market potential have moved on to become regional players and have fostered South-South cooperation in advancing scientific knowledge and research. Much more needs to be done at both the national and international levels. Poorer countries first need to develop a sound scientific base in terms of human talent as well as infrastructure that can encourage the application of scientific solutions to their domestic developmental concerns. At the international level, global rules governing scientific knowledge need to be flexible so that scientific learning and application can be fostered. Multilateral institutions as well as regional development organizations have a critical role to play in this regard. This report has highlighted some key concerns of developing countries and their possible solutions. The following recommendations deserve attention.**

57. **At the national level:**

- **Initiation of scientific and technological education should start at the primary level and be consolidated through the secondary level. Policies supporting scientific education should be developed, bearing in mind the constantly evolving nature of technical and scientific learning. In this regard, ongoing training of teachers and improvement of the content and quality of education at all levels are critical**

- **It is essential that there be increasing enrolment in courses on technical subjects at the tertiary level, which would be achieved by making them more attractive and allocating more resources to them. A proper mix of supportive policies and institutions tailored to local and national needs will help in this regard**

- **Policies to retain scientific talent and stem the brain drain and encourage "brain circulation" need to be developed. Efforts to keep expatriate scientists connected, through scientific diasporas, to industries and research institutions at home should be promoted**

- **Linkages between technology-based industry, academia and government need to be created, so that technologies appropriate to national needs are developed. Knowledge networks must be created by encouraging partnerships among universities at the national, regional and global levels**

- **Governments need to engage the private sector and promote business activities in science through fiscal incentives, direct public credit and subsidies that lower the cost of innovative investment. Policies that**

encourage business and technology incubators, and the creation of venture capital should be implemented

- **Policy forums should be organized at the subnational level where the directors of public research institutes could exchange R&D strategies, discuss ways and means to promote the transfer of technology and identify joint projects**
- **Governments should recognize that infrastructure and technological innovation for development reinforce each other and should take the initiative in acquiring the technical knowledge available through international and indigenous construction and engineering firms**
- **Diffusion of ICT should be ensured through low-cost access and connectivity through investments in infrastructure, research and development. Resource mobilization for this purpose should be recognized as part of national development strategies**
- **National innovation systems in developing countries should give central attention to overcoming the "domestic technology gap". This means guaranteeing the access to technology of farmers and small urban producers, and thus developing adequate systems to generate and adapt technologies that are appropriate, and to disseminate them among small producers**
- **Government advisory bodies could be created to monitor the implementation of appropriate policies through which to promote science and technology**

58. **At the international level, efforts must be enhanced to:**

- **Create an international database on knowledge and research information resulting from publicly funded R&D projects so as to assist developing countries in accessing technologies and know-how for creating technology-based enterprises and upgrading existing industries**
- **Facilitate regional, subregional and interregional joint R&D projects by mobilizing existing scientific and R&D resources and, where feasible, constructing and supporting cyber-research laboratories by networking sophisticated scientific facilities and research equipment**
- **Establish a technology development consortium among companies by mobilizing and pooling R&D resources**
- **Create a network of major R&D institutions and industrial enterprises able to meet human resource training needs and other demands of the industrial sector on a cost-sharing basis, with linkage to institutions in advanced countries, so as to encourage better utilization of limited resources in the region**
- **Develop a network of knowledge-sharing among innovation actors (for example, industry, academia and research institutes) by area and subregion**
- **Ensure that the development dimensions are mainstreamed into global intellectual property rights regimes, guaranteeing an adequate diffusion of**

scientific and technical knowledge and avoiding excessively high costs of proprietary technology. Such regimes should also be revised to eliminate adverse effects on vulnerable groups in society, in particular by ensuring affordable access to medicines by all, and the diffusion of technical knowledge among small farmers and urban producers

- **Ensure farmers' rights and protect traditional knowledge for the conservation and sustainable use of plant genetic resources**
- **Ensure that South-South cooperation is designed so as to leverage technical knowledge from wherever it is located and apply wherever it is needed. The starting point could be regional cooperation which could then be extended to other developing countries and eventually to the global economy**
- **Assure that, in pursuance of the mandates given by the World Summit on the Information Society and the 2005 World Summit, the United Nations plays an increasingly active role in ensuring that developing countries are able to achieve their goals in the area of innovation, science and technology**

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