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Report of the Secretary-General

Summary

The present report is submitted pursuant to General Assembly resolution 66/217 on human resources development. It examines the potential of science, technological knowledge and innovation to address key challenges to human resources development. In particular, it focuses on how science, technological knowledge and innovation and human resources development can interface in mutually reinforcing ways towards a virtuous circle of economic growth and human and social development. National experiences, lessons learned and good practices related to effective science, technological knowledge and innovation approaches for promoting human resources development are examined. The report also highlights the role of various actors — including governments and private sector — and the impact of international and regional cooperation in building capacity. It concludes with a number of recommendations that build on successful national interventions.

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I. Introduction

1. The General Assembly, in its resolution 66/217, requested the Secretary-General to submit a report assessing the contribution of science, technological knowledge and innovation in promoting human resources development in developing countries.

2. Despite efforts to promote human resources development, in many developing countries access to education and training, adequate health care and basic services remains limited. Weak labour markets are unable to absorb growing numbers of low-skilled labour. Unemployment, underemployment, brain drain and gender inequality continue to affect a number of countries, while limited resources and inadequate national strategies constrain the ability of many Governments to address such challenges. There is a need to identify new ways of addressing human resources development and to promote further progress in this area. The General Assembly recognized the potential of science, technological knowledge and innovation as important tools in that regard.

3. Science, technological knowledge and innovation have provided solutions to important human development challenges, which have led to positive transformations in people's lives. Today, in a global economy increasingly driven by technological innovation, scientific research and technological advancement are key drivers of economic growth, which is a critical factor in reducing poverty and generating the funding necessary for human resources development. The strategic use of science, technological knowledge and innovation, can provide new solutions to persistent human resources development challenges by opening up opportunities for training and building skills and enabling more equal access to prospects for economic and social advancement. Advances in human resources development, especially in terms of higher levels of education and human capital accumulation, are, in turn, critical for creating conditions conducive to further technological advancement. Reaching those objectives will require the alignment of science, technological knowledge and innovation policies and strategies with those for human resources development.

4. The present report examines the potential of science, technological knowledge and innovation to address some key challenges in human resources development. It focuses in particular on how science, technological knowledge and innovation and human resources development can interface in ways that are mutually reinforcing and lead to a virtuous circle of economic growth and human and social development. The report was prepared with inputs from various United Nations entities.[1] It builds on General Assembly resolution 62/207, on the role of information and communications technology (ICT) in promoting human resources development and on analyses contained in previous reports of the Secretary-General on human resources development.

[1] The Economic Commission for Africa, the Economic and Social Commission for Asia and the Pacific, the Economic and Social Commission for Western Asia, the Food and Agriculture Organization of the United Nations, the United Nations Children's Fund, the United Nations Conference on Trade and Development, the International Fund for Agricultural Development and the United Nations Human Settlements Programme.

II. Defining the contribution of science, technological knowledge and innovation to human resources development

A. Opportunities

5. Science, technological knowledge and innovation are increasingly recognized as central to any strategy aimed at reducing poverty and improving the quality of life of communities and individuals. Scientific and technological innovations in agriculture, biotechnology, biomedical science, communications, industry and transport, among others, have already produced a quantum leap in people's material and physical well-being.

6. Indeed, science, technological knowledge and innovation can help to overcome important physical, infrastructural and cultural barriers that prevent people, especially in poor and marginalized communities, from living a healthy and productive life. When strategically deployed, applications in the areas of science, technological knowledge and innovation have the potential to address critical economic, social and environmental constraints on further progress in human resources development.

7. Since the industrial revolution, economic growth throughout the world has been driven largely by science, technological knowledge and innovation. Such solutions increase economic productivity, competitiveness and growth, as well as access to new economic and social opportunities for broader sections of the population. They can thus play a critical role in reducing poverty and promoting sustainable growth in developing countries.

8. The transition to a low-carbon and resource-efficient economy is likely to generate a significant expansion of employment opportunities in "green" economic activities that either replace polluting activities with cleaner alternatives (e.g. renewable energy displacing fossil fuels) or provide environmental services (e.g. waste management and reforestation). On the basis of current assumptions regarding the expansion of renewable energy markets globally, the United Nations Environment Programme (UNEP) estimates that the energy sector can potentially generate more than 20 million jobs worldwide by 2030: approximately 2.1 million in wind energy production, 6.3 million in solar photovoltaic technology and 12.0 million in biofuel-related agriculture and industry. Similarly, the use of science, technological knowledge and innovation applications in the energy, water and agriculture sectors and related industries and services has the potential to stimulate economic growth and create new job opportunities for the growing number of students graduating each year in developing countries. The extent to which these employment prospects can materialize in developing countries will have to be weighed against a number of factors, such as the number of job losses in the traditional energy sector, the level of investment required to acquire and adapt the new technologies and the cost of training and retraining people to ensure effective operation.

9. Likewise, ICT has helped to lower functional, hierarchical and geographical barriers, opening new ways of communicating and acquiring information and drastically changing the way in which people participate in the economy and in society. Mobile technologies, for example, are providing new ways for isolated or disadvantaged groups to leverage resources to enter the marketplace. Smallholder producers can gain access to accurate and updated agricultural and market information from remote locations, reducing travel expenses, increasing the speed of

trade and enabling them to make informed decisions about what to grow, volume, storage, processing and marketing and investment opportunities.

10. Communications and transportation technologies can also help to mitigate the brain drain from low-income countries by facilitating "brain circulation" — the flow of talent to and from developing countries for training or career purposes — with the aim of bringing important benefits to the country of origin. This process could facilitate the transfer of knowledge, technology and financial resources from highly skilled diaspora communities to the home countries. Diaspora business, cultural and knowledge networks incorporating various forms of learning related to research and development, intellectual property, technology licensing, know-how, joint ventures and technology sharing, can be effective channels in this regard. Successful examples of diaspora networks, such as associations of medical doctors, scientists and engineers who have emigrated from least developed countries with researchers, scientists and entrepreneurs in their countries of origin show that they can play an important role in promoting innovation at home and in facilitating the emergence of new businesses that can lead to two-way knowledge and technology exchange across countries.[2]

11. Mobile technologies, such as mobile money, can help to unlock the financial potential of migrants to their home country by securing a safe, cheap and quick passage of remittances and investments. Such resources significantly increase household income and can foster investment in modern technologies to expand farm and non-farm businesses in developing countries. Evidence also shows that aggressive science and technology policies supported by investments in research and development, higher education in science and engineering and science and technology infrastructure, such as technology parks and centres of excellence, can generate large inflows of returning migrants in these disciplines and thus help to transform "brain drain" into "brain gain".

12. On the social front, science, technological knowledge and innovation applications are critical in facilitating and expanding access to basic social services, including health care and education. For example, telemedicine and mobile health initiatives are expanding access to health care in rural and underserved areas in developing countries. Internet and open-source networks are providing new, more cost-effective methods of learning in both formal and informal education settings, increasing access to technical information and training for poor and disadvantaged communities, including women, youth, persons with disabilities, indigenous populations and those living in remote areas, thus enhancing their potential to contribute to economic activities. By allowing citizens to engage with public institutions, e-government and mobile government are contributing to more responsible, accountable and democratic governance, as well as to more effective service delivery.

13. Science, technological knowledge and innovation are and will continue to be critical in addressing environmental degradation, climate change, energy sustainability, food insecurity and disaster impact. Applications in those crucial areas can help to provide sustainable and cost-effective ways of gaining access to clean, safe and renewable energy sources, predicting and managing the effects of

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[2] See *Least Developed Countries Report 2012: Harnessing Remittances and Diaspora Knowledge to Build Productive Capacities* (United Nations publication, Sales No. E.12.II.D.18).

climate change and biodiversity shifts, providing access to clean water, managing natural resources and producing more and better food, thus improving the quality of life and the development prospects of millions of people.

14. Photovoltaic, geothermal and other technologies make it possible to generate energy from a broad range of renewable sources, such as sunlight, geothermal sources, wind and rain, providing sustainable energy especially to underserved, remote communities. Innovation in land-use patterns, crop rotation and other techniques can help to reduce environmental damage and increase agricultural output. The creation of new seeds that can withstand drought, thrive in floods and resist climate change can improve the capacity of farmers in vulnerable areas to adapt. Open data systems to retrieve census data on local populations, combined with Global Positioning System and remote-sensing technologies to get information on land use and land cover, can be used to assess the growth of human settlements in vulnerable locations and thus the design of appropriate policies.

15. The strategic and equitable use of science, technology and innovation potential can give disadvantaged groups unprecedented access to resources and services essential to their socioeconomic empowerment. This is critical in addressing long-standing challenges of unemployment, underemployment, marginalization and gender inequality, which are major causes of poverty and income inequality within and across countries.

B. Challenges

16. While the proliferation of technological innovations has led to remarkable economic development and social transformation around the world, the effective use of these tools presents considerable challenges. One of the most important is that many countries and social groups continue to be excluded from their benefits. Several factors contribute to this: limited national capacity for scientific and technological research; physical and other barriers — such as insufficient or obsolete equipment and infrastructure, language limitations and illiteracy — to scientific and technological knowledge; inadequate financial resources to develop science, technological knowledge and innovation infrastructure; an inadequate base of skilled workers; weak policy and regulatory frameworks; and the absence of a culture of learning and innovation.

17. Access to and utilization of science, technological knowledge and innovation applications require sufficient physical, institutional and human capacity across societies, as well as institutional and market capacity to absorb and adapt existing technologies to local needs. Weak or insufficient physical infrastructure and a primarily low-skilled workforce in many developing countries make access to those technologies more difficult and costly. Up-front costs for the infrastructure, hardware and technical skills needed to adopt and disseminate renewable energy technologies, for example, are likely to be prohibitive for most developing countries. The International Labour Organization estimates that jobs in green sectors are expected to require at least a solid grounding in science, technology, engineering and mathematics (STEM) skills.[3] This would require considerable investment in vocational education and training systems in developing countries.

[3] International Labour Organization, *Skills for Green Jobs: A Global View*, Geneva, 2011.

18. Mobile technologies have the highest rates of penetration in low-income countries thanks to the relatively small amount of physical infrastructure required to reach remote areas. In recent years there has been an explosion of access to mobile technologies, with mobile telephone subscriptions reaching 6.8 billion and mobile broadband subscriptions growing more than 30 per cent annually over the past three years. In many developing countries, however, ICT infrastructure is still insufficient and expensive. Despite the growing affordability of ICT services globally, the difference in costs between developed and developing countries remains substantial. The United Nations Development Programme estimates that countries with low human development still spend about 15.75 per cent of monthly average per capita income on mobile technologies compared with 4.86 per cent in countries with a medium level of human development. It is also estimated that 40 per cent of people in least developed countries are not covered by a mobile network, while coverage in remote areas is often non-existent, entrenching divisions between urban and rural areas. Other information and communications technologies, such as Internet services, have higher entry barriers in terms of infrastructure and skill requirements, restricting their access mainly to well-educated urban dwellers. Marginalized communities, especially women and youth living in rural and remote areas, remain excluded.

19. The increasing diversification of skill requirements for constantly evolving technologies also contributes to a digital gap between and within countries. The educational systems of developing countries often lack the curricula and training opportunities in science, technology and innovation that would be necessary to develop a critical mass of flexible and skilled individuals that can consistently master and adapt new technologies. Such skills training is often not available or is limited to small elite groups, constraining developing countries' capacity to catch up and benefit from new technologies for poverty eradication and human and social development.

20. Many developing countries also have insufficient financial resources to build adequate science, technological knowledge and innovation capacity. The financial crisis and continuous uncertainty over global macroeconomic conditions have led to considerable reductions in social expenditure, particularly in the areas of health, education and training, and research and development, in most developing countries. This is likely to have a long-term negative impact on science, technological knowledge and innovation and human resources capacity. In a highly competitive global market, this means that the economic prospects of developing countries and their ability to cope with growing unemployment, income disparity, poverty and marginalization will be further restricted.

21. The inadequacy of policy and regulatory frameworks in protecting scientists, researchers and innovators and providing them with appropriate incentives, as well as the absence of a culture of learning and innovation are important challenges for many developing countries. Standard science, technology and innovation policies in these countries are generally not aligned with the objectives of other sectors of the economy. The disconnect between policies regarding science, technological knowledge and innovation, education, and industry, in particular, results in a workforce that is insufficiently flexible and skilled to respond to the needs of a knowledge-intensive economy; labour markets that struggle to absorb an abundant supply of unskilled workers; inadequate job creation for science, technology and innovation leaders, resulting in brain drain, high unemployment or underemployment; insufficient investment in small and medium-sized enterprises, potentially leading to low innovation and inadequate commercialization of scientific and technological

research; and innovation outputs that might not provide more affordable and adaptable solutions for the poor. Examples of the latter are innovations that do not result in more affordable versions of new products and services for low-income households or innovations that do not allow the poor to modernize their often informal and low-productivity businesses.

22. Understanding how science, technology and innovation can successfully interface with human resources development to ensure that policies and strategies in those sectors are mutually reinforcing will be central to addressing those challenges.

III. Science, technological knowledge and innovation systems and strategies to promote human resources development

23. National experiences and the degree of success in using science, technology and innovation as tools to effectively promote human resources development have varied, depending on countries' specific circumstances, level of development and policy choices. Successful policies and strategies are those that ultimately lead to a sustained stream of innovations and technological advances, supported by a critical mass of scientists, researchers and practitioners. It is important to draw lessons from those policies and strategies in order to reduce the technological divide between and within countries.

24. The Global Innovation Index provides a useful analysis of countries' performance in this regard. It identifies institutions, human capital and research, infrastructure and market and business sophistication as key elements of the national economy that can lead to a virtuous circle of innovation and human resources development. On this basis, performance in the area of innovation is categorized under three main clusters of countries according to income level: innovation leaders, learners and underperformers. Expanding on this categorization, some common trends, good practices and challenges can be identified for various countries, in particular developing countries. It is important to note that international cooperation and a favourable trade and macroeconomic environment are essential to success.

A. Innovation leaders

25. Countries in the "innovation leaders" category are generally high-income countries that have pursued comprehensive development approaches, encompassing education, research and business strategies, which have generated not only outstanding levels of innovation but also sustainable pools of highly skilled and mobile human resources. Strong relationships across all relevant stakeholders, including governments, universities, research institutions and businesses, have ensured that science, technological knowledge and innovation strategies and agendas are fully aligned with human resources development objectives. Their common characteristics are: (a) innovation-oriented education systems strongly anchored in applied science and technology teaching, especially in STEM disciplines, doctoral and postdoctoral research in science and technology, entrepreneurial skills and lifelong learning; (b) comprehensive human resources development policies, highly integrated with the research and development and business skill needs of the country that effectively address skill gaps and promote labour mobility; (c) a dynamic entrepreneurial environment promoting a culture of innovation, especially among

women and youth, and supporting small and medium-sized businesses; and (d) strong links among different stakeholders across the innovation chain. In these countries, science, technology and innovation are used effectively as tools to promote human resources development.

B. Innovation learners

26. Countries in the category of “innovation learners” are generally middle-income economies that have pursued ambitious education policies intended to create a new generation of innovators that can help move away from resource-intensive, low-skilled labour sectors and facilitate technological catch-up. They have made progress in establishing relevant institutional frameworks, including patent institutions and intellectual property rights, and innovation infrastructures and have achieved deeper integration in global credit investment and trade markets. As a result, they are experiencing rising levels of innovation, despite the economic downturn.

27. Progress in most of those countries is not uniform, however. Innovation and skilled human capital tend to cluster around specific locations, generally urban areas where universities, research institutes and research and development centres and industries are concentrated. This generates considerable disparity within countries in terms of their capacity to capture knowledge flows at home and abroad. In many countries, these clusters of knowledge-intense activities have provided a strong scientific and technological base for innovation and for attracting foreign capital and technology. This has allowed their economy to move up the global value chain, but it has not yet translated into progress and investments in human resources development outside of those clusters.

28. Many developing countries in this category also continue to struggle with high levels of illiteracy, while trying to build highly skilled human capital. Some countries are trying to address this dual challenge by acting at all levels of the national education system, reaching out to marginalized populations and regions, which lack proper access to knowledge and opportunities for innovation, through nationwide education and ICT training, and pursuing the ambitious goal of increasing their research and development base by establishing new institutions and facilities to support researchers and attract members of diaspora communities for positions.

29. Countries in this category also continue to face challenges in adapting their workforce and science, technological knowledge and innovation systems to a rapidly changing technological landscape and job markets. More knowledge-intensive, open and decentralized economies require a more flexible and highly skilled workforce, which is often not sufficiently available in those countries. It is increasingly difficult to match skill supply with demand across the economy and for job markets to absorb the abundant supply of unskilled labour. Shortages of skilled workers are further exacerbated by brain drain, as highly qualified workers tend to migrate to countries that offer higher income and better working conditions. Addressing those challenges will require more comprehensive human resources development approaches that focus both on the need to create a qualified workforce to support relevant sectors of the economy and to empower marginalized groups to reduce extreme poverty and inequality.

C. Innovation underperformers

30. Countries in the "innovation underperformer" category include a mix of economies at different stages of development. The lower-middle-income economies typically lack adequate innovation infrastructures, while some upper-middle-income countries are characterized by poor linkages among the elements of the innovation ecosystems, the complex set of relationships among enterprises, universities, research institutions, policymakers and the like whose functional goal is to enable technology development and innovation. Many countries in this category have achieved considerable progress in human resources development regardless of their income, but human development strategies are generally disconnected from other relevant policies and sectors of the economy.

31. Oil-producing countries in the Arab region, for example, have achieved considerable progress in human development by investing oil returns in health, education, housing and infrastructure. Those investments, however, have not fed into productive activities and therefore have not resulted in economic diversification. The prevailing economic structures remain based mainly on low-skill, low-value added industries. In non-oil-producing countries in the Middle East and North Africa, brain drain and high rates of unemployment for graduates and unskilled youth are of major concern and are especially alarming in a region where youth comprise almost 50 per cent of the population.

32. While several countries in this category have national innovation policies that include human resources development objectives, most innovation budgets are allocated to education and related infrastructure, while investments in research and development and small and medium-sized enterprises are very limited. Scientific research, homegrown technology development and innovation are still at an early stage.

33. The capacity for innovation in the least developed countries, landlocked developing countries and small island developing States is not sufficiently robust to contribute to industrial promotion, job creation and economic development. Knowledge creation, transfer and utilization processes are constrained by various factors, including labour market limitations and weak policy and legal frameworks. Considerable financial challenges also constrain the ability of those countries to reorient their innovation strategies.

34. Countries in this group need to focus on the systemic dimension of innovation and on building strong linkages across the innovation ecosystem. More attention needs to be paid to the interplay of institutions and interactive processes in the creation, application and diffusion of knowledge, human capital and technology. Policymakers in particular should facilitate the transfer of scientific results and inventions and their application to local challenges.

D. United Nations system support for the application of science, technological knowledge and innovation for human resources development

35. Organizations in the United Nations system have focused broadly on building human capacity to use ICT to gain access to knowledge, services and technologies in critical sectors for human resources development.

36. The Asian and Pacific Training Centre for Information and Communication Technology for Development of the Economic and Social Commission for Asia and the Pacific (ESCAP) offers a number of ICT capacity-development programmes, such as the “Academy of ICT essentials for government leaders” and “Turning today’s youth into tomorrow’s leaders”, to develop knowledge and skills for leveraging ICT for socioeconomic development. The Information Technology Centre for Africa of the Economic Commission for Africa (ECA) offers online courses on ICT development for policymakers in partnership with Cisco Systems and trains African women in the Cisco Internet Networking Academy programme.

37. The European Commission/Food and Agriculture Organization of the United Nations (FAO) Programme on Information Systems to Improve Food Security Decision-making in the European Neighbourhood Policy East Area uses e-learning to build a solid knowledge base in the areas of food security and poverty reduction. The World Health Organization, FAO, UNEP and the World Intellectual Property Organization facilitated four “Research4Life” programmes, namely the Health InterNetwork Access to Research Initiative, Access to Global Online Research in Agriculture, Online Access to Research in the Environment and Access to Research for Development and Innovation, to give over 6,000 institutions in developing countries free or low-cost access to more than 17,000 peer-reviewed international scientific journals, books and databases. The Habitat Partner University Initiative of the United Nations Human Settlements Programme helps to bridge the gap between research and practice related to cities and urban development through a network of academic and research partners.

38. The regional technology centre of the Economic and Social Commission for Western Asia monitors and supports technology research and innovation and facilitates the emergence of homegrown science, technological knowledge and innovation solutions. Between 2005 and 2007, the Asian and Pacific Centre for Transfer of Technology of ESCAP trained more than 1,150 participants from government ministries, industry, academia and research and development institutes on the concept of national innovation system policy frameworks and their linkages with sectoral and subnational innovation systems to promote grass-roots innovation for socioeconomic development. The programme for those workshops was developed by the Centre in consultation with partner institutions of the host countries to meet specific areas of national interest. ECA developed the African Innovation Framework for the successful deployment of science, technological knowledge and innovation for sustained economic growth and poverty reduction. The multi-year “Engineering expertise to improve health outcomes in Africa” project of ECA supports capacity-building for the installation, maintenance design and production of biomedical devices.

39. The University/Industry/Science Partnership programme of the United Nations Educational, Scientific and Cultural Organization supports universities in developing countries in forging partnerships with industry to strengthen their innovation capacity. The Support Programme for the Rural Microenterprise Poles and Regional Economies project of the International Fund for Agricultural Development in Madagascar seeks to promote human resources development through an apprenticeship system, placing young rural people with small businesses specializing in the use and provision of modern technologies. Under the project, young people receive extensive skills training and mentorship as well as increased access to technology and financial services. The World Meteorological Organization provides fellowships to personnel

in developing countries, primarily from national meteorological and hydrological services to supplement local capacity-development activities.

E. Regional initiatives

40. Initiatives to share experiences related to science, technological knowledge and innovation policies and strategies within and between regions can be helpful in disseminating successful approaches to promoting human resources development. This is especially useful in regions where there is a technology gap. Education and training agreements, guest worker programmes and standardization of education and training curricula are among some of the initiatives that have been successful in disseminating good practices in modernizing education and training systems.

41. Initiatives of this type, such as the European Union Tempus programme, have been deployed in Eastern Europe, Central Asia, the Western Balkans and the Mediterranean region to support the modernization of higher education. Another project of the European Union, CReATE, funded under the "Regions of knowledge" initiative, is aimed at strengthening the research potential of European regions, in particular by encouraging and supporting the development across Europe of regional research-driven clusters, associating universities, research centres, enterprises and regional authorities. African regional bodies, such as the East African Community, the Southern African Development Community, the African Union and the New Partnership for Africa's Development, have launched similar initiatives focused largely on developing their members' research and development capacities. Those initiatives, however, focus mainly on training and place little emphasis on technological innovation, which is critical in turning scientific and technological knowledge into goods and services.

42. Nonetheless, such regional cooperation initiatives give countries an opportunity to gain access to scientific and technological knowledge and good practices to boost national education and innovation systems in a more cost-effective way. They might also become instruments useful in promoting a culture of innovation within regions and in helping countries to build effective and sustainable innovation capacity.

F. Lessons learned

43. There is no blueprint for a national innovation system based on scientific research and focused on human resources development that can be effectively transferred to countries. Such systems have to be developed and continuously adapted to meet national and local conditions, including cultural and traditional sensitivities and indigenous knowledge and technologies. Nonetheless, a number of lessons and good practices can be learned from current national and regional experiences that can provide useful insights in designing national science, technological knowledge and innovation policies and systems to reduce poverty and promote sustainable growth and human resources development.

44. Successful experiences in some developing countries show that science, technological knowledge and innovation policies that are well integrated into national development strategies and are combined with institutional and organizational

change can raise productivity, improve competitiveness, support faster growth and create jobs.[4] To achieve this, however, such policies need to address the specific features of innovation in developing countries, such as the weight of traditional sectors in the economy and the importance of incremental or adaptive innovation. The particular role of foreign direct investment, access by firms to skilled workers and capital, technology-related infrastructure and intellectual property rights regimes are all important considerations.

45. The existence of a comprehensive and coherent science, technological knowledge and innovation strategy has enabled many Governments to prepare their workforces to be attuned to future labour market needs and ready to take advantage of opportunities brought about by new technologies. Countries that have been successful in this regard have committed national resources and set in place integrated mechanisms to advance research and development, training, infrastructure and investment incentives.[5]

46. In a resource-constrained context, countries that maintain investments in science, technology and innovation and in human resources development as part of their overall national development strategies have continued to grow and innovate. Countries that have adopted policies aimed at increasing the demand for and mobility of highly skilled workers, including through lifelong learning programmes, were also able to maintain their science, technological knowledge and innovation capacity along with the long-term employability of their workers, especially youth.

47. Countries that have continued to prioritize and invest in ICT infrastructure and training and promote their strategic use, especially in areas relevant to human resources development (e.g. health and education), have increased their access to and benefits from global science, technological knowledge and innovation activities. This in turn has enabled changes to be made in their business and institutional cultures that promote a strong convergence of higher education, scientific and applied research and innovation in a mutually reinforcing way.

IV. Imperatives for building capacity in the areas of science, technological knowledge and innovation and human resources development

48. In a global economy driven by innovation, the competitiveness of national economies and diversified growth prospects will increasingly depend on the ability to transform scientific and technological knowledge into innovative products and services that can successfully compete in the global market. Improvements in skills and greater focus on higher education, especially STEM education, are crucial in order for developing economies to move up the value chain from low-value, low-wage production to more knowledge-intensive, high value added activities.[6] The number of active scientists and researchers has a strong positive effect on outcomes on the ability of a nation to harness its full potential for human resources and sustainable development. Many developing countries, however, lack a critical mass

[4] *Technology and Innovation Report, 2012* (United Nations publication, Sales No. E.12.II.D.13).
[5] *OECD Science, Technology and Industry Outlook 2012*, chap. 8.
[6] See Organization for Economic Cooperation and Development, “Moving up the value chain: staying competitive in the global economy” (2007).

of scientists, researchers and practitioners, which is fundamental for the success of science, technological knowledge and innovation-led development. This hinders their ability both to innovate and to generate technological advancement that can help to reduce poverty and promote human resources development.

49. The underrepresentation of women and girls in the areas of science, technological knowledge and innovation, particularly in the physical sciences and engineering, in which women account for less than a quarter of the global workforce, results in not only the underutilization of talent and suboptimal development of capacity in those areas, but also in a lack of innovative solutions for issues that are highly relevant to women and their households. Gender disparities in STEM education and access to employment opportunities in those fields are likely to undermine the future productivity of women and girls, who risk becoming further marginalized. The limited access of women and girls to education and employment opportunities exacerbate poverty trends.

50. Building science, technology and innovation capacity should be a horizontal undertaking that incorporates education, science policy and support for small and medium-sized enterprises. In other words, it should be an integral part of a more holistic approach to national planning and strategy development, where national strategies in the areas of science, technological knowledge and innovation, agriculture, services and industrial development are aligned with human resources development strategies and policies.

51. This can be accomplished only if policymakers recognize that human resources development and scientific and technological education are national strategic priorities. Investing in human capital; science, technological knowledge and innovation infrastructure; and technological capacity-building is essential in order to catch up with technological advances. Policies and agendas are needed in the areas of science, technological knowledge and innovation and research and development that are driven not only by the objective of advancement in science and technology or by the need to promote economic productivity and competitiveness, but also by the need to identify solutions that address barriers to human development. Human resources development policies, on the other hand, should focus on supporting the emergence of a sufficiently wide and deep pool of operational, engineering, managerial and research skills, especially among women and youth, which represent the largest segment of the workforce in many developing countries. This requires well-sequenced investments in basic education, vocational training, on-the-job training and more advanced managerial, engineering and scientific education to increase the supply of technological knowledge that can be absorbed by national innovation systems.

52. Strengthening national science, technology and innovation capacity is a complex process that involves harnessing the participation of governments, businesses, research and development institutions and academia, among others. This in turn requires policy frameworks, budgets and institutions that facilitate interlinkages between those actors to ensure that science, technological knowledge and innovation and human resources development strategies and investments, as well as their outcomes, are mutually reinforcing in adding value for society at large.

A. Enabling environment to strengthen science, technological knowledge and innovation capacity

53. An enabling environment is critical for the emergence of science, technology and innovation strategies and systems that are focused on reducing poverty, promoting sustainable production and consumption and advancing human resources development. Such an environment requires adequate infrastructure, institutions, policies and incentives that promote scientific research and technological innovation. Elements of such an enabling environment are appropriate intellectual property rights frameworks that, together with the free use of publicly financed innovations and research, technology transfer platforms and trade regimes, incentivize and protect national innovators, and tax incentives and subsidies that help remove regulatory and financial barriers to scientific research. Investments in physical infrastructure, especially ICTs, and human resources capacity are critical in enabling access to knowledge and technology. Encouraging "open-society"[7] structures that facilitate the free circulation of ideas and information and the emergence of knowledge networks are important to the diffusion of scientific and technological knowledge and innovation.

B. Role of government

54. Governments play a key role in developing science, technological knowledge and innovation strategies whose outcomes generate gains for society as a whole. Governments set in place policy, regulatory and institutional frameworks in a range of areas, from the general domestic environment to international trade and investment.

55. The role of government is especially critical in ensuring that science, technology and innovation are key components of national development strategies. Governments also play a key role in ensuring that human resources development strategies emphasize the building of flexible capacity attuned to current and future science, technological knowledge and innovation needs and that the workforce is ready to take advantage of opportunities brought about by new technologies and innovations. In this regard, strengthening STEM education and encouraging careers in the natural sciences and engineering, especially for women, creating quality doctoral programmes in key disciplines, enhancing lifelong learning opportunities in science and technology and building science, technological knowledge and innovation-driven entrepreneurial capacities, especially for young people, will be essential.

56. Governments can also facilitate cooperation among all relevant partners in the innovation chain. This will ensure that ideas emerging from all sectors of the economy can be transformed into products and services that can benefit society at large. The use of specific incentives, including public financing tools, such as tax incentives for research and development, public-private partnerships and public investment in key research and development sectors, subsidized interest rates for enterprise development in strategic sectors and government guarantees that act as

[7] Karl Popper introduced this term for the first time to define an association of free individuals respecting each other's rights within the framework of mutual protection supplied by the state, and achieving, through the making of responsible, rational decisions, a growing measure of humane and enlightened life. Karl Popper, *The Open Society and Its Enemies*, vols. 1 and 2 (London: Routledge, 1945).

collateral or seed funding can also encourage socially sound research and development and innovation.

57. Successful partnerships among innovation actors and stakeholders are imperative for linking innovation activities to development goals. Governments can promote strong public-private partnerships to strengthen human and institutional capacity for science, technology and innovation that is focused on human resources development. Science and technology parks where university and industry come together through collaborative research and development initiatives are examples of this type of partnership. Such initiatives are important in driving innovation and translating knowledge into enterprise. Other examples are partnerships aimed at developing formal and informal education in science, technology and engineering, with a specific focus on enhancing employability, career development of scientists and researchers and entrepreneurial activities driven by science, technological knowledge and innovation.

58. Beyond providing a conduit for collaboration, the economic impact of these networks may become increasingly meaningful, as policymakers are often tasked with allocating resources to fund university education, including scientific and applied research and innovation programmes. With improved interaction among researchers working in academia and those in public enterprises and private firms, the scope for collaborative research and, consequently, its financing can grow to complement public spending and meet current and future demand for science, technological knowledge and innovation in developing countries. In the future, leading universities in developing countries are likely to develop strong research activities performed and funded in close collaboration with local and national firms and public and private service providers.

59. Joint ventures formed with foreign partners, including universities and research institutes, or through the joint filing of patents by a domestic and foreign inventor are other effective mechanisms for increasing national scientific and applied research capacity and promoting innovation. It is critical, however, to ensure that innovative solutions emerging from these initiatives address human resources development challenges. The role of government in financing science, technological knowledge and innovation programmes that promote human resources development and the appropriate mechanisms for sharing risk between the public and the private sectors will continue to be essential.

60. Government can also play a key role in establishing a platform for continuous dialogue between scientists, policymakers and decision makers and society at large in order to increase the access of innovators to high-quality information, including patent documents. Promoting the sharing and dissemination of knowledge and the emergence of a culture of innovation are central to the role of government in science, technological knowledge and innovation and human resources development. Greater collaboration among research communities, the private sector and civil society also improves the potential for governments to practice scientifically sound evidence-based decision-making.

61. Furthermore, it is essential that governments focus on building systems of rules and practices in the area of intellectual property rights to ensure that they continue to stimulate innovation and ensure access to knowledge by all groups in society. Governments should reduce the level of control given to owners of intellectual property rights so as to foster competition and should promote the fair

use and diffusion of technology. Such interventions should be balanced by the discouragement of counterfeiting and piracy and the provision of adequate protection for creativity and innovation.

C. Role of the private sector

62. The private sector plays an important role in ensuring that the outcomes of scientific research, new technologies and ideas are transformed into commercial products and services. It also plays an important role in promoting human resources development by providing training and by financing highly skilled workers who can absorb, adapt and generate new technologies. The private sector can therefore drive investments in both innovation and human resources development to increase the availability of a skilled workforce that strengthens industry competitiveness.

63. The development of a technology-based economy that is responsive to the needs of industry and society, however, requires strong engagement of both the private sector and government to reconcile the public good and private objectives.

D. Role of the international community

64. Current innovation systems are complex, building on internationalized, collaborative and open innovation models and knowledge systems involving a broad range of actors and stakeholders at the national and international levels. Knowledge networks linking various actors and processes in the innovation chain are critical in supporting the optimal infrastructure for innovation systems as well as facilitating the emergence of solutions to global challenges.

65. Such networks are also instrumental in making existing technology-based solutions and innovations accessible to countries and individuals. Collaboration at the international and regional levels can help in disseminating knowledge to developing countries so as to build an adequate pool of human resources that can absorb existing technologies and adapt them to local circumstances.

66. Promoting the international mobility of researchers and students and their active participation in scientific and technological research and development initiatives is essential in this regard. It ensures that researchers are able to keep abreast of the latest scientific innovations and develop personal and institutional networks through which scientific knowledge is disseminated. Student mobility also constitutes an important element in sharing best practices and generating new ideas. International and regional cooperation is key to facilitating such mobility and mitigating potential negative implications for domestic scientific capabilities caused by the migration of scientists abroad. Collaboration initiatives at the international and regional levels should strive to strike a balance between encouraging the participation of scientists and students in international knowledge networks and preventing brain drain in order to increase the net benefits of international mobility.

67. Research and development projects and innovations that address the challenges of developing countries can be promoted and supported through scientific collaboration at the international and regional levels. Such collaboration can be designed to address the production of more and better food and cheaper medicines, improved access to medical services, clean water and basic sanitation and the availability of modern energy for cooking, heating and lighting, for example.

68. Regional knowledge clusters and technology parks are examples of how this form of collaboration could work and be used to help promote people-centred, sustainable innovation systems at the national level.

69. International cooperation can help developing countries to use resources effectively to bypass developmental stages, reducing development gaps and avoiding carbon-intensive growth strategies. Access to ICTs has been especially important in this regard in many developing countries, as it facilitates access to quality education, employment opportunities and markets, as well as the delivery of basic social services to many disadvantaged communities.

70. Given the growing importance of human resources development and science, technological knowledge and innovation for a country's future prosperity, building national capacity for innovation should become a key priority for the international development cooperation agenda.

V. Conclusions

71. The General Assembly may wish to take note of the following conclusions:

(a) Ensuring that science, technological knowledge and innovation benefit society as a whole requires science, technological knowledge and innovation systems that are aligned with national development objectives, fully integrated with national human resources development and poverty eradication strategies and supported by appropriate institutional and policy frameworks;

(b) Comprehensive approaches to human resources development that address poverty eradication and the creation of a skilled workforce are critical in reducing unemployment and brain drain and in promoting greater social inclusion;

(c) Ensuring the effective use of science, technological knowledge and innovation to promote human resources development requires mutually reinforcing policies and strategies;

(d) Science, technological knowledge and innovation policies should take into account the specific features of the economy in developing countries, including the size of the traditional sector, the importance of indigenous knowledge, the limited access to skilled labour and capital, weak infrastructure and inadequate institutional frameworks in order to generate solutions that address the specific challenges of those countries;

(e) A comprehensive and flexible science, technological knowledge and innovation strategy that encompasses the needs of all sectors of the economy is critical for addressing human resources needs and ensuring that skills are attuned with labour market demand;

(f) Investing in ICT infrastructure and training and promoting the strategic use of ICTs is essential in increasing access to science, technological knowledge and innovation and in ensuring a strong convergence of higher education and scientific and applied research;

(g) Long-term continuous investment in science, technological knowledge and innovation and human resources development is necessary to ensure the growth and sustainability of both sectors. Integrated mechanisms to advance research and development, training, finance, infrastructure and investment incentives are also critical;

(h) Building science, technology and innovation capacity should be a horizontal undertaking that incorporates education, science policy and support for small and medium-sized enterprises. It should be an integral part of a holistic approach to national planning and strategy development, where national strategies in the areas of science, technological knowledge and innovation, agriculture, services and industrial development are aligned with human resources development strategies and policies;

(i) Human resources development policies should focus on supporting the emergence of a sufficiently wide and deep pool of operational, engineering, managerial and research skills, especially among women and youth, as they represent the largest segment of the workforce in many developing countries. This requires well-sequenced investments in basic education and vocational and on-the-job training as well as more advanced managerial, engineering and scientific education to increase the supply of technological knowledge that can be absorbed by national innovation systems;

(j) Building a flexible and highly skilled pool of workers is needed in order to adapt and benefit from a constantly changing technology landscape. Education systems that are anchored in applied science and technology, especially STEM disciplines, and responsive to research and development and business skill needs should be central to any strategy for promoting science, technological knowledge and innovation-led development;

(k) Increasing the participation of women, youth and other disadvantaged groups in STEM education and employment opportunities is critical not only in reducing poverty and marginalization of those groups, but also in effectively utilizing existing talents to achieve sustainable development;

(l) Universities and research centres in developing countries should assume a leading position in enhancing applied research and promoting technology transfer by working more closely with all relevant actors in the innovation chain, especially the business sector;

(m) Cooperation among all relevant partners in the innovation chain, from policymakers to research and development institutions, academia, industry, the business sector and civil society, is critical in ensuring that ideas emerging from all sectors of the economy are transformed into products and services that can benefit all. The role of government is essential in supporting successful partnership frameworks that focus on socially sound research and development and innovation among those actors;

(n) Sharing experiences, lessons learned and good practices at the international and regional levels on successful science, technological knowledge and innovation approaches in promoting human resources development is important in building national capacity and reducing the technology gap between and within countries;

(o) Building national science, technological knowledge and innovation capacity in developing countries should become a key priority for international development cooperation;

(p) Policymakers should facilitate the transfer of scientific results and inventions and their application to local challenges. Government should reduce the level of control with given to owners of intellectual property rights so as to foster competition and should promote the fair use and diffusion of technology. Such interventions should be balanced by the discouragement of counterfeiting and piracy and the provision of adequate protection for creativity and innovation;

(q) Research and technology clusters and techno-parks, associating universities, research centres, enterprises and regional authorities are important in facilitating knowledge and technology transfer and promoting a culture of innovation;

(r) International cooperation should promote knowledge networks that facilitate the sharing of good practices in the areas of science, technological knowledge and innovation among relevant actors, as well as technological research and innovation that address challenges in developing countries;

(s) Collaboration initiatives at the international and regional levels should strive to strike a balance between seeking to encourage the participation of scientists and students in international knowledge networks and preventing a brain drain, so as to increase the net benefits of international mobility.