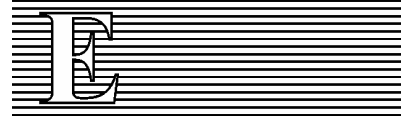




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**PROMOTING SCIENCE, TECHNOLOGY AND INNOVATION FOR
SUSTAINABLE DEVELOPMENT IN AFRICA¹**

Executive Summary

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A. INTRODUCTION

1. Technology and innovation have served as the foundations of social and economic well-being ever since the beginnings of human civilization more than 10,000 years ago. With each passing millennium, the forces of technology and innovation have gained in importance as fundamental tools for creating wealth and improving the quality of life, both globally and within individual societies.

2. Technology and innovation were important tools in the Bronze Age and in the Iron Age. They remained important tools through the rise and fall of the Greek and Roman empires. They helped shape and define the Islamic era of world dominance during the first millennium of the Common Era (CE). With the birth of modern science in Europe during the 17th century, a triumvirate of interrelated forces emerged as essential to the future welfare and advancement of human society – science, technology and innovation (STI). With the emergence of STI came a simple equation: countries with STI capabilities have the capacity to succeed; countries without STI capabilities do not.

3. This is a lesson in history that has direct implications for the future well-being of Africa, and it is a lesson that the continent ignores at its own peril – as the postcolonial history of Africa clearly and painfully reveals. Africa enters the 21st century facing monumental challenges to its survival and long-term sustainability. At the core of these challenges is the continent's ability to master STI and to successfully apply these forces to address critical problems related to health, food, water and the environment.

4. Africa today would be well advised to follow Asia's proven pathway to prosperity and social well-being. As the recent history of Asia illustrates, the STI pathway to success can now be cleared and traversed in just decades, not centuries. Everything in the 21st century is taking place at a faster clip, and that includes science-based economic growth. That, of course, means it is possible to be left farther and farther behind, as Africa knows all too well. But it also means that it is possible to catch up very quickly.

B. STATE OF SCIENCE, TECHNOLOGY AND INNOVATION (STI) IN AFRICA

Assets and opportunities

5. Despite its deep-seated poverty, Africa has a wide range of important assets, which if properly managed can provide enormous opportunities for STI-driven sustainable development in the continent. Rapid population growth translates into a youthful population. More than 40 per cent of Africa's population – nearly 400 million people (almost four-fifths of the total population of the European Union) - are less than 14 years of age. Africa's large and expanding youthful population stands in sharp contrast to the aging – and in some instances declining – populations of Europe, Japan and the United States. The continent's demographic profile could offer a distinct advantage in a world that is in need of a new generation of well-trained problem-solving scientists and scholars.

6. The potential of its people – its human resources – represents Africa's greatest asset. But that is not the continent's only resource. Africa has a plentiful supply of natural resources, ranging from oil in Nigeria and Angola to diamonds in Botswana, the Congo and Sierra Leone, to gold in South Africa and Ghana, and to other valuable minerals, including some of the largest deposits of copper, zinc and bauxite, in the world. Africa, in short, is endowed with a large and rich resource base that has the potential to create enormous economic wealth for its people.

7. However, the continent's resources have long generated enormous riches for only a few Africans (and their international benefactors). More equitable resource policies would make a huge difference in the lives of hundreds of millions of Africans. Science and technology can help in this effort. But ultimately this is a challenge that must be met by innovative, transparent and effective political and economic reforms intended to help the continent's people, especially the most marginalized. Beyond its treasure trove of oil, minerals and metals, Africa is home to a wide range of ecological zones, largely due to its vast and varied terrain and the fact that the equator cuts across its centre, thus creating a belt of biological "hotspots" that harbour a wide variety of species, many of them unique to the continent. There are, for example, some 14 classes of ecological zones, ranging from hot deserts to humid rainforests. Africa's ancient societies, combined with its rich resource base, have made it one of the world's foremost centres of indigenous knowledge. The skills inherent in traditional medical practices are now having increasing impacts on modern medicine.

Weaknesses and challenges

8. While the people and resources of Africa offer hope for the future, today's reality is quite different. Africa's litany of woes has been reiterated in scholarly articles and books, in international and governmental reports and white papers, in the media, in novels, in plays and even at rock concerts. Thirty-five of the world's least developed countries (LDCs) are located in Africa. Nearly 70 per cent of the continent's people live on less than US\$2 a day. More than 26 million Africans are afflicted with AIDS, a disease that claims the lives of 2.5 million people in Africa each year. Nearly 1 million Africans die each year of malaria. More than 40 per cent of Africans do not have access to safe drinking water, and more than 70 per cent do not have access to electricity. Education on the continent, while recently enjoying some signs of resurgence, remains inadequate, and reliable health care continues to be out of reach for most Africans.

9. Global challenges such as climate change add to the continent's woes and often place progress at risk. Experts anticipate that the dry lands of Africa, which cover nearly two thirds of the continent and are home to nearly 400 million people (nearly half the population), will experience a significant loss in productivity as declining water supplies and higher temperatures put additional stress on these marginal agricultural lands. Experts also predict that climate change will spur the spread of sand dunes across sub-Saharan Africa, adding unwelcome air-borne dust particles to the blistering temperatures that will likely worsen the continent's health and environmental problems.

10. Africa's ability to adapt to climate change is suspect at best. The continent does not have the institutional capacity or scientific and technological know-how to effectively design and implement adaptation policies to blunt its effects. In addition, there are unexpected global events

that always seem to have the greatest impact on the world's poorest people, many of whom live in Africa. The recent spike in food prices is one such example. Between January and June 2008, the price of rice in Sierra Leone, where people spend 60 per cent of their income on food, rose 300 per cent. In Senegal and much of the rest of West Africa, it increased 50 per cent. The prices of such essential food commodities as palm oil, sugar and flour have also surged.

11. This troubling outcome is largely a consequence of broad international trends in economics and energy for which Africa bears no responsibility and over which it has no control, such as the growing wealth and changing dietary habits of China and India, the rise of biofuel crops, and extreme weather events in rich agricultural regions. As Peter Smerdon, a spokesperson for the United Nations World Food Programme, recently noted: "The people hit hardest" by the spike in food prices "are those living on the razor's edge of poverty."

12. Food price increases, all experts agree, will impact Africa more seriously – and perhaps more tragically – than any other continent. In April 2008, World Bank President, Robert B. Zoellick, stated that soaring food prices could push 100 million people deeper into poverty, reversing nearly seven years of work in the fight against poverty. Furthermore, officials at the United Nations Food and Agricultural Organization (FAO) estimate that 36 countries now face a food security crisis, and that 21 of these countries are in Africa. The consequences could be deadly. If current trends continue, a growing number of people in Africa may not have enough money to purchase sufficient amounts of food to meet their daily nutritional requirements.

The STI deficit

13. Amid all of these challenges lies a deficit that few international development agencies have spoken about directly until recently. Yet, it may be the most significant challenge that Africa faces: Africa does not have the scientific, technological or innovative capacity to effectively address the challenges that it confronts. Poverty reduction, environmental degradation, food and energy security, health care, climate change, wealth creation and sustainable development are all complex issues that demand their own set of responses if they are to be successfully addressed. But what all these problems have in common is a need for a critical mass of indigenous scientific and technological expertise that is capable of not just raising heartfelt concerns, but also producing concrete results.

14. The irony in Africa is that helping the continent's most marginalized communities requires investment in the continent's most successful citizens. The challenge necessitates a balanced strategy that addresses immediate social and economic needs while building Africa's capacities in STI. It won't be easy. But Africa will not succeed over the long term unless it finds a way to do both. Although Africa is home to more than 15 per cent of the world's population, it produces less than 1.5 per cent of the world's scientific knowledge – as measured by articles published in peer-reviewed international journals.

15. Although access to the Internet is improving, the continent remains far behind the rest of the world in information and communications technologies (ICTs). According to the World Bank, just 4 per cent of the population of sub-Saharan Africa has access to the Internet, compared to nearly 70 per cent in the United States and 10 per cent in China. Access to electronic information is now available in a growing number of African universities, but low bandwidth and high costs

(again both situations are improving but not fast enough) make it difficult for African researchers to review the most current literature in their fields.

16. Until African scientists are able to gain access to this information as quickly and as easily as their colleagues in other continents, they will remain hopelessly behind the rest of the global scientific community. In that case, Africa will also continue to lag behind the rest of the world in STI. Low pay, poor working conditions and limited opportunities for advancement have all prompted Africa's best and brightest scientists to pursue careers elsewhere. Brain drain represents not only a loss to the professional communities within their countries, but more importantly, it represents a loss to their societies as a whole. Africa needs skilled and dedicated scientists and technologists in sufficient numbers if it hopes to break the cycle of poverty and despair that has gripped the continent for far too long.

C. WHAT NEEDS TO BE DONE

Government policy and commitment

17. The growth of STI and the ability to apply these tools to address the socio-economic needs of African countries is, in the final analysis, mainly the responsibility of Africa's governments. While it appears that most leaders in Africa are now convinced that the only way their nations can meet the Millennium Development Goals (MDGs) is through science-based development, there remains an urgent need to translate this conviction into a clear and convincing plan of action.

18. Indeed four levels of action demand the immediate attention of Africa's governments. First, political and scientific leaders in each African country must take immediate steps to work together to design national policies for the development of STI based on their nation's technological and industrial needs and the best available STI knowledge. It is imperative that a politically independent science policy agency also be created. The agency should be composed of knowledgeable science managers and advisers who are granted sufficient independence and responsibility to create and implement a national plan for building capacity in STI. The agency should also be given responsibility for coordinating all scientific and technological activities within the country and for forging collaborative exchanges with scientists and scientific institutions in other countries.

19. Second, as indicated earlier, the science policy should be fully integrated into each nation's development plan. This will help ensure that the scientific and technological knowledge generated by the nation's research institutions is responsive to the socio-economic needs of the country. Furthermore, interconnectivity between national economic development plans and national science and technology policies will both broaden and deepen the involvement of the nation's private sector in research and development, and help to promote mission-oriented scientific and technological research in support of the economy. Africa has some successful examples of such interconnectivity, but these examples remain too few in number to have become the rule rather than the exception.

20. Third, governments must ensure that adequate and stable funding is provided for the implementation of the national science and technology plan. Without a firm commitment by

African governments to increase the level of funding for research and development to at least 1 per cent of the gross domestic product (GDP), as recommended by the African Union (AU) Summit in January 2007, no science policy will be able to effectively build indigenous scientific and technological capacity, let alone transform that capacity into concrete action that helps to alleviate poverty and grow the economy. The average proportion of GDP allocated to research and development in Africa, which stands at about 0.2 percent, is the lowest compared to other regions in the world.

21. Fourth, recent pan-African initiatives for capacity-building in STI, launched by such diverse organizations as Economic Commission for Africa, African Development Bank, African Union /New Partnership for Africa's Development, Network of African Scientific Academies, must be encouraged and supported. Rapid and sustained progress in STI in Africa will never take place unless Africans take joint actions in the design and execution of their STI strategies. ECA, for example, can take the lead in two important initiatives: (i) Convene a meeting involving leading experts and heads of the STI sections of ECA, AfDB, AU/NEPAD and NASAC, in order to harmonize and coordinate their STI strategies and agree on one comprehensive strategic action agenda for promoting STI in the continent; (ii) Convene periodic workshops and discussion meetings involving leading scientists, development practitioners, ministers of science and technology and ministers of planning and finance, in order to debate and agree upon the ways and means of implementing the above-mentioned joint strategic action agenda.

Human resource and scientific talent development

22. One of the priorities of any national science policy must be to develop a critical mass of leaders in STI. It may not be possible to quantify what the exact number should be, but it is clear that the absence of a critical mass of leaders in STI exerts significant pressure on a country's ability to develop a sustainable path to development. The dearth of qualified scientists and technologists in most African countries has impeded the development and application of science and technology, as well as the ability to address the critical environmental challenges faced by the continent. This is also a key factor responsible for the presence of a large number of foreign technical consultants in many African countries, who come with an estimated price tag of more than US\$1 billion per year. The average number of African-born scientists and engineers per million people in Africa is less than 200 as compared to 3,000 per million people in developed countries. The scant size of the scientific community in Africa is one of the primary reasons why science-driven development has failed to take root on the continent.

23. For African-born scientists who decide to fight the odds and remain in Africa, a lack of basic equipment, laboratory supplies and scientific literature presents formidable impediments to their productivity. In most cases, these scientists would require just modest financial support to successfully pursue their research, but modest support often never arrives. It is in recognition of this problem that the Academy of sciences for the developing world (TWAS) instituted a research grants programme in basic sciences in 1986. Under the programme, a competent researcher-scientist in Africa is offered financial assistance amounting to \$US10,000 per project. In addition, since 2004, the Academy has provided funding to research units in the LDCs, in an effort to build institutional capacity in the world's poorest countries. Currently, TWAS supports 25 research units in 15 African countries.

24. Attention must be paid to the discovery and development of scientific talent at the earliest stages of education. Gifted children need to be nurtured in an environment that is responsive to their innate inquisitiveness and intellectual capabilities. It is simply not sufficient to invest in universities and research institutes at the expense of improving primary and secondary education. Indeed, all levels of education must be upgraded to lay a solid and enduring foundation for nurturing well-educated workers capable of reaching their full potential.

25. Career development, in short, must begin in the first years of school and continue throughout the pre-university years, with an emphasis on continuous learning. This is well illustrated in South Korea where in the 1960s the Government established five specialized science secondary schools for the purpose of training gifted school children, and an institute of technology (KIT) for talented undergraduate university students. The establishment of a similar system of elite schools and colleges should be undertaken in Africa at both the national and the regional levels. This effort could serve as the cornerstone of a broad strategy to rapidly increase the supply of highly qualified and talented leaders in science and technology. The difference would be felt within a generation.

26. Human resource development in STI is a long-term process that must be deeply rooted to a nation's entire educational system. In most African countries, there is an urgent need to promote learning, especially in science and technology, in both schools and universities. In the 1960s and early 1970s, Africa's governments made a major effort to develop universities of excellence and to create scientific research units of international standing. The universities of Khartoum in the Sudan, Ibadan in Nigeria, Dar-es-Salaam in Tanzania, Makerere in Uganda and Nairobi in Kenya were among the universities that embarked on this path, attracting some of the best young minds on the continent and serving as training grounds for some of Africa's eminent scientists.

27. Maintaining the scientific infrastructure in universities, however, became a low priority in the mid-1970s as political tension and conflict rose and the promise of sustainable development faded. As a result, many highly qualified scientists from Africa left their countries in search of better jobs and research opportunities elsewhere. In addition to rebuilding the continent's system of higher education, there is a need for curriculum reforms that emphasize new methods of teaching and learning, including inquiry-based instruction and problem-solving research. There is also a need to provide adequate salaries and incentives to attract and retain the best teachers and researchers. Standards for quality and excellence should also be established to serve as benchmarks for university administrators and students alike. Such benchmarks would allow administrators to fix and achieve goals that have been objectively set by others. At the same time, they would allow talented students to seek their education at the highest-ranked universities in the country. National and regional boards composed of education experts from Africa and abroad should be responsible both for creating the quality standards and for reviewing the performance of universities to determine if these standards are being met.

28. Higher education should be made available to as many qualified students as possible and at an affordable price. Indeed, cost-free university education is something African countries should maintain, in furtherance of the notion held by many scholars and researchers that education at all levels is a right and not a privilege. This does not mean, however, that students should be allowed to enrol in the university of their choice regardless of their capabilities. Indeed,

one of the hallmarks of higher education is a quest for excellence and that quest begins with choosing the best students for the best universities.

29. Africa should strive to create a wide variety of universities that offer education to students with varying capabilities. Most importantly, each nation should establish research units of excellence within its existing universities and, at the same time, construct at least one world-class university that can be worthy of comparison with Cambridge, Harvard and Stanford. A university of international excellence would not only serve as a magnet for the nation's (and region's) top students (thus rewarding excellence), but would also serve as a model for universities in other countries. Reforming and strengthening universities in general and scientific research and training programmes in particular, would represent a critical step forward in Africa's efforts to revitalize its scientific enterprise. More importantly, long-term efforts to promote sustainable economic development will be seriously compromised unless Africa (indeed each nation within Africa) has a strong university system staffed by a vigorous and committed faculty capable of educating the continent's next generation of scientists and of engaging the international community as full and equal partners in research projects that address scientific issues of importance to Africa.

30. The newly launched African University of Science and Technology (AUST) – supported by the Nigerian Government, the World Bank, the African Development Bank and the Indian Institute of Technology Bombay – is an excellent example of such an initiative. AUST, which has just opened its first campus in Abuja, Nigeria, will soon open its second campus in Arusha, Tanzania. Another example is the newly established International Centre for Genetic Engineering and Biotechnology (ICGEB) in Cape Town, South Africa, which is being largely funded by the South African Government. The South African centre that opened in September 2007 joins the two ICGEB centres in Trieste, Italy and in New Delhi, India that were established in 1987 and that have largely been funded by the Italian and Indian Governments.

31. These examples of North-South cooperation in science are encouraging, and should serve as models for other institutions interested in promoting Africa's long-term efforts to create a critical mass of world-class scientists. Indeed, existing models for research and training that have proven successful must be emulated. At the same time, new models must be devised and implemented to find more effective ways of building and sustaining the critical mass of scientists and technologists that Africa so desperately needs.

Linking science to action

32. The above measures aimed at building STI capacity in Africa, while important, are not sufficient to guarantee that knowledge can be used to create a better future for Africa. The research systems in universities and institutes must also forge strong links with society to ensure that the impact of their work is not confined to the world of science, but reaches out to the world at large. A case in point is the impact of basic research on camel diseases carried out at the Camel Research Centre of Khartoum University in the Sudan. In the world beyond science, what counts is concrete action, not long-winded debates over, for example, the definition of basic and applied science. That is why it is important for Africa to establish technology and innovation centres with research agendas that focus on developing simple and affordable technologies to address such critical needs as increasing access to safe drinking water and expanding the supply

of renewable energy. These centres should not compete with universities but instead serve as nodes that bring universities, governments and industries together to devise strategies for developing and diffusing successful technologies.

33. The experiences of these centres and other institutions should be compiled to allow others to learn from Africa's "best practices" in applying STI to solve real-life problems. Such an ever-expanding "living library" of experiences, described on the Internet and in print, would not only help to broaden the use of successful technologies across the continent (and elsewhere), but also instill a sense of pride among the African institutions that have been singled out for their excellence. Reforming education at all levels is crucial, and developing and diffusing knowledge of "best practices" in STI is essential applications. But the only way to ensure that changes take place at a pace and scale that can truly make a difference in the lives of millions of Africans is to link science directly to policy. Simply put, the best available scientific and technological knowledge must be integrated into national strategies for sustainable economic development. Again, Africa has made some progress on this front. Individual countries such as Rwanda have recently devised national economic development strategies revolving around STI.

Strengthening African science academies

34. Science academies have enjoyed a long and storied history. Records show that centres of scientific research and learning were a central part of the intellectual life of Baghdad in the 8th and 9th centuries before the Common Era and could be found in Alexandria in the 3rd century before the Common Era. The first science academy of the Western world, the Accademia dei Lincei, was established in Italy in 1603 and included Galileo among its founding members. The oldest science academy in Africa is the Institut d'Egypte, founded in Cairo in 1798 by Napoleon. Today, the Royal Society in the United Kingdom and the United States of America National Academy of Sciences are exemplary institutions both within their own nations and in the international scientific community.

35. History strongly suggests that ideas are meant to be shared, that accomplishments are meant to be recognized and honoured, and that individuals who have the same interests have an inherent need to meet and to discuss what they have in common. Scientists are no exception to these universal aspects of human behaviour, and science academies have been one of the most important instruments that have been put in place to help scientists satisfy these human qualities of timeless appeal.

36. Yet, in most countries, science academies have rarely fulfilled their promise as essential institutions for public discourse of critical science-related issues. Instead, academies have often served the needs of their members more successfully than the needs of their societies. They have functioned more like leisure men's clubs than dynamic institutions willing to actively engage with those outside their circle of like-minded elite researchers.

37. Such attitudes have been changing recently, thanks in part to the efforts of the InterAcademy Panel on International Issues (IAP), a global network of nearly 100 science academies that is dedicated to building the capacity of its member institutions to interact with their societies. Specifically, IAP seeks to help science academies provide independent evidence-based advice to policymakers and to participate in broad public policy debates on science policy

issues, serving as a key voice for science in these discussions. To this end, IAP sponsors capacity-building workshops for its members and issues statements on such critical policy issues as science education, biosecurity and scientific capacity-building.

38. Africa has been a key recipient of IAP assistance. One important factor to note is that Africa, a continent with 53 countries, currently has only 17 merit-based science academies. That, nevertheless, is twice the number of academies Africa had just five years ago. Several African countries have recently created science academies thanks in part to the work of IAP. Perhaps even more importantly, these new academies are a reflection of the growing commitment to STI that is taking hold across Africa, even among its poorest, science-deprived countries.

39. At the initiative of the African Academy of Sciences (AAS) and under the sponsorship of the InterAcademy Panel (IAP), the Network of African Science Academies (NASAC) was formed in December 2001 with nine founding member academies. The AAS, having initiated the process of forming the network, agreed also to host the NASAC secretariat. NASAC currently has 13 member academies with four additional new academies having been established after 2001. The overall objective of NASAC is to act as an independent African forum that brings together academies of science in the continent to discuss the scientific aspects of problems of common concern, to make common statements on major issues relevant to Africa, and to provide mutual support to member academies. In pursuing this objective, the network collaborates with other academies inside and outside the continent as well as with regional and international organizations concerned with African problems.

40. NASAC has adopted a set of principles similar to those of IAP, but its principles and actions have been tailored to the particular needs of science and society in Africa. This has meant paying special attention to meeting the Millennium Development Goals (MDGs) by addressing issues such as better access to safe drinking water and renewable energies, and by providing quality education for all children. For NASAC, this has also meant building the capacity of existing science academies and helping to develop merit-based academies in African countries where they do not currently exist. The ultimate goal of NASAC is to provide another effective instrument to address the continent's most critical social needs.

41. NASAC has come a long way since its early days in 2001 as a fledgling organization with grand ideas but little capacity or money to realize its vision. Today, it not only has ideas but the financial resources and growing capacity to meet its challenges. To advance its goals, NASAC has received a €1.5 million grant from the Dutch Ministry of Foreign Affairs to implement its strategic action agenda, in close partnership with academies of science in the G-8 countries. Accordingly, NASAC has issued statements in collaboration with academies of science in the G-8 countries such as "Building science, technology and innovative capacities in Africa", which was submitted to the African Union (AU), and "Science and technology for African development" and "Sustainability, energy efficiency and climate change", which were submitted to the G-8+5 summits in the United Kingdom and Germany.

42. A more recent initiative of NASAC is to examine the strategic plans of the Economic Commission for Africa (ECA), the African Union (AU), the New Partnership for Africa's Development (NEPAD) and the African Development Bank (AfDB), to determine how to harmonize their overlapping goals in order to create a more coordinated blueprint for

accelerating science-based sustainable development across the continent. NASAC hopes to submit its assessment by the end of 2008.

43. What, therefore, should the priorities of NASAC be as it seeks to participate directly in Africa's overall pursuit of science-based sustained economic growth? First, it must continue to work hard to put its own house in order, allowing the organization to serve as a model institution that uncompromisingly supports transparency and innovation. Second, NASAC must seek to reinvigorate Africa's scientific community by advocating – and supporting – reforms to assist the continent's best young scientists. Success on this front can be measured by how many doctorate and post-doctorate fellowships are offered to young students; how much money is being invested in state-of-the-art electronic communications networks; how many professors and students have access to broad-band internet services; how much funding is being invested in laboratory equipment and travel; and how many papers by African scientists are being published in peer-reviewed international journals. Third, NASAC should also develop and hone the skills that are necessary to provide credible information to policymakers. This means acquiring communication capabilities to lobby political leaders and decision makers, to speak out on scientific issues of critical importance to society (in ways the public can understand), and to prepare reports capable of reaching a broad audience.

44. NASAC will not be successful unless policymakers also acquire the capacity to appreciate the need for independent, sound and authoritative advice on complex science-based issues, and display a willingness to accept advice from the STI communities even when it does not fit into their immediate political agenda. Political leaders must also integrate STI capacity-building strategies into their national development plans. Such integration is the only way to ensure that science, technology and innovation will become key elements in the overall efforts for sustainable economic growth. African governments, therefore, have the obligation to encourage their scientific communities to establish merit-based academies and to generously support these academies to fulfill their mandate. In addition, leading intergovernmental organizations in the continent, including ECA, AU and AfDB, should invite NASAC to become their independent advisor on all issues related to STI.

Harnessing frontier STI

45. This article began with a plea to Africa – and those who wish to help Africa – to broaden the definition of innovation beyond the conventional notion of cutting-edge science and technology, to include administrative, management and policy innovations that may have a greater impact on Africa's economic, social and ultimately scientific capacity in both the short and long term than discoveries in cutting-edge science. However, innovation in science and technology in Africa does not have to wait for broader innovations in policy and management to take hold. Indeed, there are cutting-edge technologies – biotechnology, information technology and nanotechnology – which could be put to work to solve some of Africa's most critical problems.

46. At the same time, initiatives designed to promote biotechnology in Africa, although controversial, could increase crop yields through the creation of genetically engineered plants that are more resistant to drought and that ward off insects and disease without the use of high levels of chemicals. This is not only an issue related to agricultural productivity and the

environment (less intensive use of chemicals would help improve soil and water quality). It is increasingly an economic issue as well, as the rising cost of chemical pesticides has increased the cost of agricultural inputs.

47. For these reasons, African nations should continue conducting studies to examine the safety of genetically engineered crops and should support the work of biosafety committees responsible for examining and verifying the safety of genetically modified plants. Nanotechnology could prove to be a "transformative" technology similar in its impact to the steam engine in the 18th century, electricity in the 20th century, and the Internet in contemporary society. A number of developing countries, most notably China and India, have begun to invest substantial sums of money in nanoscience and nanotechnology. South Africa has joined this effort by establishing national nanotechnology centres and by investing some US\$26 million over three years in nano-research.

Linking science to society: the role of science centres

48. Science centres and science museums are important institutions for bringing science to the public and promoting scientific awareness and public understanding of science. Of the 2,400 science centres worldwide, just 23 are in Africa, and they are concentrated in five countries: Egypt, Tunisia, Botswana, Mauritius and, most notably, South Africa, which has 17 such centres. There is an urgent need to establish at least one science centre in every African country. As science gains prominence among LDCs, it is important to create and support institutions for life-long learning that enable people to understand what science-based development means for them and the role that science can play in poverty alleviation and sustainable growth.

Promoting partnerships with other countries

49. Africa must take advantage of the expanding initiatives for South-South cooperation in STI. Brazil's pro-Africa programme, although modest in scope, represents an excellent opportunity for Africa to work closely with and learn from a more advanced developing country, while pursuing valuable initiatives that will help address the continent's critical social and economic needs in the short term. Important among the projects pursued under this programme is helping African scientific institutions to build their capacity by linking them to world-class institutions in Brazil.

50. China's development fund for Africa, which calls for the world's most rapidly growing economy to spend US\$6 billion on economic development programmes in Africa over the next five years, holds great promise for providing much-needed capital to help Africa grow. But STI must be integrated fully into this initiative for it to have an enduring impact on sustainable development in Africa. A trilateral developmental initiative involving India, Brazil and South Africa (IBSA) launched in 2003 to promote South-South cooperation and exchange awaits details and full implementation. But if and when it does get off the ground in earnest, IBSA could serve as a model of multilateral initiatives capable of channelling substantial funds to the development of STI in Africa.

51. There are also such programmes as the South-South fellowship programme of TWAS for graduate and post-graduate students that provides broad opportunities for young scientists in

Africa to receive advanced training by attending leading universities and research centres in countries throughout the developing world. The project, which is co-sponsored by the Governments of Brazil, China, India, Mexico and Pakistan, currently offers more than 250 fellowships a year, making it the largest of its kind in the world.

52. Third, North-South cooperation in STI will also be necessary to achieve the level of development that advocates for Africa's future hope to achieve. Recent efforts by the European Union to improve broadband access to the Internet in Africa, and particularly in universities, are a welcome development. This is precisely the kind of capacity-building initiative in STI, that would help Africans acquire the tools that they need to succeed in today's knowledge-based global society. The Tokyo International Conference for Africa's Development (TICAD), a major global framework for Asia and Africa to collaborate on promoting Africa's development, also marks an important step forward.

53. The future of Africa, and to a large extent, that of the world depends on global action to end poverty and increase wealth in the world's poorest regions, as well as on efforts that enable Africa to become a peaceful, prosperous and active partner of the international community. In a world shaped by the forces of globalization, no region can be marginalized without global consequences that will affect all of us. Yet, thanks in part to some positive indicators, at least some signs seem to be pointing upward. It is this backstage drama of Africa's ongoing efforts to extricate itself from extreme poverty - unfolding in ministries of science, universities, research centres, laboratories and schools - that deserves greater attention and support. The bottom line is that STI alone cannot save Africa, but Africa cannot be saved without STI. It is a lesson in recent history that the region - and its international partners - can no longer afford to ignore. That may be the greatest source of hope of all.