4th World Water Forum, Mexico, 2006

Baseline paper | Application of Science, Technology and Knowledge

Cross cutting perspective D

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1 | Introduction – role and importance of science, technology & knowledge

There is an explicit correlation between a country's scientific and technological status and its economic performance and affluence, and the gap between poor and rich countries in terms of real income is largely accounted for by differences in the accumulation and utilization of science and technology. Closing this gap will require deliberate measures to build scientific and technological capabilities of poor countries. The international community is increasingly recognizing this. For example, in September 2000 the United Nations General Assembly adopted the United Nations Millennium Declaration in which world leaders pledged to

"*…halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger and, by the same date*."

In particular, they agreed to,

"*…take special measures to address the challenges of poverty eradication and sustainable development in Developing countries, including debt cancellation, improved market access, enhanced Official Development Assistance and increased flows of Foreign Direct Investment, as well as transfers of technology*."

The World Summit on Sustainable Development (WSSD) held in Johannesburg 2002 gave more political currency to the importance of science and technology as determinants of sustainable development. The Plan of Implementation adopted by governments at the WSSD gives significant attention to the role of science and technology in meeting sustainable development goals. Many of its recommendations are about mobilizing and directing science and technology to solve problems associated with energy deficiency, food insecurity, environmental degradation, diseases, water insecurity and many other sustainable development challenges. The Plan requires the international community to,

"*[p]romote technology development, transfer and diffusion to developing countries and further develop technology and knowledge available in developing countries centres of excellence; and [s]upport developing countries to develop effective science and technology institutions and research activities capable of developing and adapting to world class technologies*".

Yet beyond this policy oriented pronouncements, the practical importance of science and technology to modern societies, and the role of a technologically informed population in promoting social and economic development, have been well documented. For example, advances in information technologies are creating new methods of communication and information handling, which have profound effects on society at large as they bring unprecedented opportunities and challenges for scientific endeavours. Low, middle and transitional income countries that have not sufficiently addressed the acquisition of scientific and technological knowledge will be left with little option but to redouble their efforts by popularizing science and its application to development.

There are several reasons why a focus on science and technology to benefit the poor in developing countries is both appropriate and timely. Most important among them is that the number and rate of growth of people living below the poverty line. Take sub-Saharan Africa, for example, where the number of people living below the poverty threshold grew during the 1990s from 242 million to 300 million. Secondly, science and technology is the most important, readily available means for empowering the poor. Developing countries need the capacity to explore the socio-economic implications of new technologies, especially to be able to predict their impact on society, to identify emerging opportunities, and to serve as an early-warning system to forecast technological threats. For this, new approaches are needed which would shift the direction of scientific development from its current programmes that are elitist and conservative, to new initiatives that are inclusive and populist, and which would be of more direct benefit to the poor.

The rapid growth and unprecedented influence of new technologies, especially the information and communication technologies including the Internet, is raising global awareness of the power of technology as a whole. It is increasingly important for developing countries to invest in these or risk widening the gap between them and the rest of the world. It is this realization that should bring science and technology, and the strategies for making them work, to the top of the international development agenda. The key issue should be the adequate empowerment of individuals and groups to use scientific knowledge and technological know-how to address such pressing public health crises as water supply, sanitation, wastewater treatment, prevention and treatment of HIV/AIDS and other issues including food security, nutrition, high unemployment and drought.

2 | Challenges for science, technology and knowledge development

Understanding of science and technology is an essential pre-requisite for making wise choices in the acquisition and utilization of knowledge resources, which can then be fully deployed for the purposes of human development and welfare. Attempts to bring the benefits of science to society require capacity to understand science and its implications, and to recognize the daily opportunities to make science work for people. This is not the only limiting factor to its adoption. The following section outlines a generic series of the main operating constraints identified across existing literature and experiences.

2.1 | Weak links between science & technology and political institutions

A common limiting factor is that for many countries there are weak links between science enterprises and political institutions; typically, political organizations have not accorded science and technology much attention in their manifestos or parliamentary activities. Technological change is a complex process that is influenced by many political factors. To engage in and manage this process, countries require the support of high-level political institutions. These institutions often determine the nature and levels of resources that go into public research and development activities and the overall governance of science and innovation. There is, thus, a need to build strong political constituencies for science and technology development in developing countries.

2.2 | Existing science and technology policies are outdated

Most developing countries formulated their science and technology policies in the 1970s and 1980s when development imperatives and technological opportunities were difficult. Many

of these policies were focused on organizational aspects and not on programmatic issues. Countries were overly preoccupied with the creation of commissions or secretariats to promote science and technology, and paid little attention to long-term programmatic aspects of science and technology development. These commissions and secretariats emerged to give an administrative outlook to the role of science and technology in national affairs but they never really built the necessary programmes to anticipate and respond to emerging scientific and technological developments. Some of these institutions have, over time, lost touch with the reality: it takes more than administrative oversight to promote science and technology development.

2.3 | Low and declining funding to research and development (R&D)

Third, developing countries have devoted considerably low, and in many cases declining, funding to research and development (R&D). Most invest less than 0.5 percent of their Gross Domestic Product (GDP) in this field. In Africa, this is so despite the declaration in the Lagos Plan of Action and in national science and technology policies that each country would allocate at least 1 percent of its GDP to R&D activities. In such economic areas as agriculture, funding to R&D has declined drastically in the last decade to the extent that in many regions the ability to achieve and sustain food security has been impaired. This low and declining expenditure on R&D is a manifestation of the low priority that countries have given to science and technology.

2.4 | Declining quality of science and engineering education at all levels of education system

The teaching of science and technology requires a special form of instructional communication; science teachers are rarely adequately trained in such skills. For example, they are seldom able to show the correlation between science and everyday life. In addition, teachers are often so poorly paid that they cannot devote the necessary amount of attention to the needs of their students. Hence the general public does not become enlightened consumers or 'intelligent users' of their natural environment.

Associated with the above, there is declining quality of science and engineering education at all levels of educational systems in developing countries. Student enrolment in science and engineering subjects at primary, secondary and tertiary levels are falling. These trends typically undermine a country's aspiration to build up its numbers of scientists, engineers and technicians.

There are weaknesses and deficiencies in the science education curricula and their delivery in the education system. First, school enrolments are low, particularly for girls and rural populations. A significant percentage of the young in society thus lack access to science and technology programmes that exist in the curricula. Furthermore, there are very few incentives to draw young people into careers in science and technology.

2.5 | Loss of expertise to other regions of the world

Many economies, both developed and developing, are losing some of their best scientific and technical expertise to other regions of the world. The number of developing country scientists and technicians who are leaving their home for employment abroad is growing. This 'brain drain' is caused by a variety of factors including poor research infrastructure and poor remuneration packages. While some regions such as South and South East Asia have developed and adopted strategies to mobilize and utilize their Diasporas, others, such as Africa lack such measures. Africa in particular can no longer afford to ignore this capital—

scientists and technicians living and working abroad. Economies need to urgently design ways to tap and utilize the enormous scientific and technical talents of this foreign-based Diaspora for its own scientific and technological development.

2.6 | Research and development institutions are in a weak condition
Another challenge faced by developing countries relates to strengthening and/or building institutions dedicated to scientific and technological innovation. As a result of the combination of constraints discussed above, research and development institutions in many countries are becoming institutionally weak. Most countries have not organized and mobilized their institutions in such ways as to efficiently utilize their scarce financial and human resources in specific fields of scientific and technological development. They tend to spread their resources thinly across the institutional terrain, and as a result have been unable to grow 'centres of excellence' in water, public health and related disciplines.

2.7 | Weak links between public research and development institutions and industry
Generally, there are weak links between public research and development institutions and industry. Research results of public research and development activities do not often get accessed and used by local industries, particularly small and medium-scale enterprises (SMEs). In many cases there is mismatch between research and development activities and national industrial development goals and strategies. For example, while industrialization policies of most developing countries have put emphasis on building and strengthening small and medium enterprises (SMEs), scientific research and development institutions have weak links to these enterprises.

2.8 | Cross cutting policies impinge on science, technology and knowledge development
There are a number of other crosscutting policy issues that impinge on a country's scientific and technological development. These include such issues as intellectual property protection, bio-safety, the role of women in research and development, the impact of new technologies on women, and ways and means of ensuring that foreign direct investment facilitates transfer of new technologies.

3 | Framework for actions

The previous section of the baseline paper has outlined a series of generic constraints that impact on the development of science, technology and knowledge in both developed and developing countries. These issues limit the ability of water and sanitation scientists, practitioners and advocates to promote the role and importance of their discipline to policy makers.

By contrast, the following section outlines ways in which these constraints have been addressed, and in selected cases provides a series of recommendations for mitigating their impact.

3.1 | Build reliable and adequate information on, and knowledge of, S&T landscape
While the commentary in section 3 relates to a series of generic concerns as a whole that are indicative of the problems faced by many countries, it is crucial to note that there are significant differences in the way countries handle scientific and technological development.

This is attributable in part to the fact that nation states are invariably at different stages of technological development, or that others are further progressed with institutional and policy reforms that affect science, technology and knowledge development as compared to others. The nature and success of such reforms needs to be assessed and experiences shared among and /or between countries. Wherever practicable, countries should, based on their national priorities and taking into consideration opportunities associated with regional science and technology cooperation, endeavour to review their research and development systems and to share information on the status of science, technology and innovation activities, including the nature and effectiveness of their research and development policies and strategies. A useful tool to support such information exchange would include a synthesis review of national science and technology systems, leading in turn to the establishment of a database on national science and technology systems and regional science and technology programmes.

3.2 | Identify and institute measures to increase financial investment in research and development

Developing countries are unlikely to attain scientific and technological development and improve their economies and livelihoods for the majority of the population if, individually and collectively, countries to do not increase financial allocation to research and development. Regional political structures such as the New Partnership for Africa's Development (NEPAD) in Africa need to develop a strategic framework on science and technology which identifies and articulates specific ways and means of leveraging and allocating more financial resources to research and development activities. Emphasis should be placed on how to mobilize national and international public and private funding for national and regional science and technology programmes.

3.3 | Improve public understanding and utilization of science

Initiatives in public understanding of science would consist largely of finding the means to deliver scientific information to lay people, and training scientists on how to communicate more effectively. Instruments that capture the interest and imagination of the general public are usually effective in popularizing science and simple application of technology. These programmes should seek to:

? Encourage creativity and innovation in everyday scientific and technological activities, and provide incentives for participation.
? Provide opportunities for the general public (especially the youth) to appreciate science and technology and participate in its development.
? Demonstrate the linkages between basic and applied science and technology, and showcase their role in development.
? Give visibility to successful projects and research results that impact on society's progress and development.
? Honour and recognize scientists and technologists who make significant contributions in their fields.

A strong programme for the popularization of science needs to be located in a similarly strong institution that carries a clear mandate for this purpose. Such a focal point institution has to be both regulatory and advisory, under an oversight arrangement that is as close as possible to the highest levels of government. The institution needs to be invested with

enough authority to be able to command the respect and cooperation of other institutions and organizations, both public and private that are relevant to the popularization of science. Government can play an important role in demonstrating its political will towards such a programme through appropriate funding and political patronage.

3.4 | Develop and/or establish networks of centres of excellence in water and sanitation
To consolidate and effectively utilize human, technical and financial resources to address specific developmental challenges (in particular poverty related ones), developing countries should strengthen existing centres and where necessary create new ones at both national and regional levels. Such centres should be networked to achieve intra- and inter-regional institutional synergy, and maximize sharing of resources. NEPAD, for instance, in collaboration with regional and international organizations such as the European Commission could promote this by (a) developing a conceptual framework for identifying and networking centres of excellence; and (b) supporting countries to map national and regional networks of excellence in scientific research and technological innovation. Similar initiatives, such as Streams of Knowledge (an alliance of resource centres working in water, sanitation and hygiene) have proven their value in supporting processes of policy and practice improvement at national and sub-regional levels.

3.5 | Mainstream science, technology and innovation considerations into wider policies & programmes
Science, technology and innovation underpin all facets of sustainable development and should thus be treated as crosscutting elements throughout programmes for societal development. It is important to ensure that science and technology are mainstreamed in all government programmes, a priority that will require reviewing existing initiatives and where necessary strengthening their scientific and technical content. The development of guidelines for mainstreaming science and technology in this manner are fundamental.

3.6 | Promote or strengthen regional and international science and technology cooperation
Regional and international collaboration are important avenues of strengthening a country's scientific and technological development. Such regional and sub-regional bodies have a major role to play in promoting science and technology cooperation. South-South and South-North forms of cooperation although given much lip service in international agreements are still required and remain crucial. Organizations such as NEPAD in Africa or the SAARC Secretariat in South Asia should play a major role in promoting these forms of cooperation. A review of the nature of regional and international science and technology cooperation in order to identify and promote 'best practices' is of critical importance.

3.7 | Develop and implement flagship programmes
In addition to those activities and processes that are aimed at improving conditions for scientific and technological development, there is a need to encourage countries and facilitate their efforts to develop and implement concrete regional scientific research and innovation programmes in the field of water, sanitation and health. For example, organizations such as NEPAD may wish to develop regional programmes on the application of modern biotechnology to improve drought resistance abilities of selected crops; such programmes would be implemented through or by designated NEPAD centres of excellence.

4 | Concluding remarks and next steps

Science and technology for sustainable development must be global in its reach, yet local and regional in its implementation. It is not possible, however, for science and technology to effectively contribute to sustainable development if countries do not have basic scientific capacity. The responsibility for building and maintaining this capacity lies squarely on the shoulders of national governments but requires significantly enhanced collaboration and partnerships with the global development assistance community and the science and technological community.

The same community has a responsibility to inform and participate in decision-making processes in order to increase the impact of science in policy discussions and decisions. In an international arena increasingly defined by knowledge, in a global economy depending more and more on science and technology for its success, and in a world challenged by environmental and problems that spill across political and cultural boundaries, scientists and engineers have an obligation to become more and more involved in sustainable development policy issues and implementation.

A very practical and concrete next step action is the establishment of a science and technology Forum. Such a platform would be comprised of a high-level committee of ministers and presidential science advisors, a panel of eminent persons/experts, and an electronic platform of all other stakeholders. It would mobilize developing country scientists, policy-makers, civil society, industrialists and other stakeholders to develop a science and technology strategic framework and action plan at the international level.

The advisors to the Forum would:

(a) Critically examine and dialogue on emerging science and technology questions and their implications for developing country's sustainable development;
(b) Provide political guidance to formulate and cause the adoption of a developing countries blueprint on science and technology; and
(c) Recommend to Heads of State specific actions to taken to enhance a country's scientific and technological development.

The panel of eminent experts/persons would provide technical advice to the committee of ministers and presidential advisors. It will be instrumental in building awareness of global scientific and technological developments that are important for fostering a country's development. The panel would conduct its work through task forces on specific themes and may commission existing regional and international institutions to prepare background papers on some of the identified issues. Both the ministerial committee and panel would interactively determine priorities and substantive themes to be addressed.

5 | Annexes

5.1 | Water Research Commission

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Water Research Commission (WRC), South Africa
The Water Research Commission (WRC) is a dynamic hub for water-centred knowledge, innovation and intellectual capital. The organisation provides leadership for research and development through the support of knowledge creation, transfer and application. The WRC engages stakeholders and partners in solving water-related problems that are critical to South Africa's sustainable development and economic growth, and is committed to promoting a better quality of life for all.

The WRC is a unique public entity that has been in operation for about 35 years, providing South Africa with appropriate knowledge required for the development and management of the country's scarce water resources and its uses.

The WRC was established through an Act of Parliament (Act 34 of 1971, last amended in 1996). The Water Research Act also provides for the establishment of a Water Research Fund in order 'to provide for the promotion of research in connection with water affairs' and stipulates that the function of the WRC is to 'obtain information, accumulate, assimilate and disseminate knowledge'.

In short, the mandate of the WRC is:

- ? Promoting co-ordination, co-operation and communication in the area of water research and development
- ? Establishing water research needs and priorities
- ? Stimulating and funding water research according to priority
- ? Promoting effective transfer of information and technology
- ? Enhancing knowledge and capacity-building within the water sector
- ? Cooperating internationally (accumulation and dissemination of knowledge)

The WRC has public entity status and autonomous standing and reports via a governing board to the Minister of Water Affairs and Forestry. It is currently governed (as are all other public entities) by the Public Finance Management Act of 1999. The public entity status allows the WRC to widely serve the water sector as well as other related sectors of the economy while being appropriately regulated as it actively handles public funds. The Water Research Fund originates from levying charges on water supplied or made available and from the levying of rates on land irrigated by water supplied or made available. The WRC income is about R90 million (about US$14 million) per annum, 87 per cent of which is derived from the levying of water research rates and charges.

The WRC's main function is to invest in knowledge creation through the funding of research projects using a clear contracting process. Research is carried out within four key strategic areas (KSAs). The actual research and development are carried out by universities and research organisations, water utilities, major sewage works, local government and specialised consultants. The WRC is providing leadership for the creation of new knowledge and its dissemination and transfer. Funds also cater for development of new capacity by supporting both M.Sc. and Ph.D. students. During 2004/05 the WRC supported about 450 research projects and 465 students. Research proposals are subject to extensive peer review evaluation and each research project has a reference group that meets annually, providing

scientific and technical direction and serving as a focal point for knowledge sharing and transfer as end-users often form an active part of such groups.

The KSAs address both the resource and its uses:

? Water Resource Management
? Water Linked Ecosystems
? Water Use and Waste Management
? Water Utilisation in Agriculture

Cutting across these key areas are four key impact areas comprising water and health, the environment, society and the economy. These impact areas often address issues concerning both developed and developing countries or, as referred to in South Africa, the first and second economy.

Knowledge dissemination is another key activity of the WRC. The organisation organises many workshops and a number of open days, annually. In addition to publishing technical reports, producing guide documents, and disseminating research results via other interactive routes, the WRC also publishes a scientific journal namely *Water SA* and *The Water Wheel*, a public understanding of science magazine that brings water science to the wider South African population. Annually, the WRC also produces the *Knowledge Review* that provides a comprehensive review of all research activities for any given year, in terms of the KSAs and key impact areas.

The impact of research and development is often indirect and difficult to measure. However, it is quite clear that South Africa has benefited immensely from the existence of a unique entity such as the WRC. Through it various activities along the 'knowledge cycle' the WRC has provided South Africa with a strong cadre of internationally known water researchers with close links to both the developed and the developing world. In addition, the WRC has provided South Africa with a good basis for its current water legislation and related practices, form the introduction of Integrated Water Resource Management and providing the tools for measuring the Ecological Reserve, and more recently, by giving strategic advice on the impact of climate change on the country's scarce water resources.