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BUILDING SCIENCE, TECHNOLOGY AND INNOVATION CAPACITY FOR SUSTAINABLE GROWTH AND POVERTY REDUCTION

The World Bank will convene a Global Forum in Washington, DC on February 13-15 to discuss strategies, programs, and policies for building science, technology and innovation capacity in developing countries for sustainable growth and poverty reduction. This Discussion Paper is a preliminary effort to frame the discussion, raise critical issues, highlight some key topics for possible discussion at the Forum, and, most importantly, to elicit comments, feedback, and suggestions for improvement from a wide range of stakeholders and potential participants. This version of the Discussion Paper deliberately attempts to touch on a wide range of issues and to raise questions rather than to provide definitive answers. The objective is to encourage a discussion rather than foreclose comment, discussion, and dissent.

This Discussion Paper is designed to be a living document, evolving and improving over time as additional comments and suggestions are incorporated into the text. Subsequent drafts, as well as publications produced in the wake of the Forum and in follow up seminars and conferences convened by the Bank, will attempt to provide tentative answers and additional analysis, all grounded in the collective wisdom of the Forum participants.

I. Introduction

With increasing frequency, officials in low and middle income countries are coming to the conclusion that their countries **must** build up their science, technology and innovation (STI) capacity in order to:

- Make demonstrable progress in achieving the Millennium Development Goals (MDGs), tackling acute health and nutrition problems, avoiding and/or mitigating the impacts of natural disasters, embarking on a path of sustainable poverty reduction, safeguarding fragile eco-systems, and improving the quality of daily life for the rural and urban poor.
- Transform their economies from ones based on subsistence agriculture, enclave extractive industries, and simple, low skilled manufacturing into ones based on the production of more knowledge intensive, higher value added goods and services.
- Raise productivity, wealth, and standards of living by developing new, competitive economic activities to serve local, regional, and global markets.
- Develop appropriate R&D capacity to support technology-based economic growth and to address social, economic, and ecological problems specific to each country.

To achieve these goals, a wide array of Governments, ranging from Kazakhstan, to Vietnam, to Uruguay, to South Africa, Mozambique and Rwanda among others, are drafting science, technology and innovation policies, establishing Ministries of Science, and investing more resources into targeted science development programs. In tandem with these national efforts, the African Union and NEPAD recently promulgated a Science and Technology Consolidated Plan of Action that was approved at a recent AU Ministerial Meeting.[1] The African Union is proposing to convene a special summit in early 2007 devoted specifically to the question of STI capacity building. Meanwhile, DFID is devising a strategy for supporting STI capacity building programs and the US National Academies recently issued a report urging AID to do the same.[2] Other bilateral donors such as Canada's International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA) are discussing how, if at all, they should support this renewed interest in STI capacity building.

Helping countries build STI capacity has also become a major item on the G-8 and UN development agendas. The Blair Commission Report and the UN MDG Task Force Report,[3] to name just two of the more prominent recent international calls to action, both argue that building STI capacity should be elevated from a missing or peripheral element of the development agenda to an essential component of every country's strategy for reducing poverty, achieving the MDGs, and producing more knowledge-intensive, higher value added goods and services.

With this in mind, Government officials are searching for policies that will enable them to build STI capability most effectively. As part of their efforts they are reaching out to the Bank and other international organizations for policy and program advice. International organizations, in turn, are seeking to improve their capacity to respond effectively and looking for programs with a proven track record.

This Forum is designed to respond to these calls for action.

II. Forum Objectives, Organization, and Planned Outcomes

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[1] Available at http://www.nepadst.org/doclibrary/pdfs/ast_plan_of_action.pdf

[2] Following publication in 2004 of a UK House of Commons, Science and Technology Policy Committee report that highlighted weaknesses in DFID's S&T capacity building programs, DFID appointed a Science Advisor and is now preparing a new S&T strategy. The House of Commons report is available at http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/133/133.pdf .
For details of the AID S&T strategy paper, see "The Fundamental Role of Science and Technology in International Development: An Imperative for the U.S. Agency for International Development," available at http://fermat.nap.edu/catalog/11583.html

[3] [3] The Blair Commission Report is available at:
http://www.commissionforafrica.org/english/report/thereport/english/11-03-05_cr_report.pdf
and the UN MDG Task Force Report is available at:
http://www.unmillenniumproject.org/documents/Science-complete.pdf

The principal theme of the World Bank Global Forum is that in today's increasingly competitive, global economy, STI capacity building can no longer be seen as a luxury item, suitable primarily for the economic agenda of wealthier, more economically dynamic countries. Rather, STI capacity building is an absolute necessity for poor countries that wish to become richer. The key issue is no longer whether countries should build STI capacity but what type of capacity to build, given their economic constraints, and how best to implement these capacity building action plans.

Therefore the principal objectives of the Forum are to:

- Understand the STI capacity building processes that are already underway in different settings and circumstances
- Share lessons of experience in building STI capacity
- See what STI capacity building programs are working effectively and which are not generating the desired outcomes
- Understand some of the the reasons behind these disparate outcomes
- Glean operational and policy lessons from past and present attempts to use STI capacity as a tool for promoting sustainable development and poverty reduction
- Build Government capacity for STI policy-making and enhance donor capacity to provide STI capacity building advice and to design successful STI capacity building projects
- Discuss how these lessons can be incorporated into future STI capacity building programs and projects designed by governments and supported by the Bank, bilateral donors, NGOs, and IFIs and
- Discuss how donor organizations can work together under the auspices of the Paris Declaration on Aid Effectiveness[4] and other similar international initiatives to improve their STI capacity building programs.

The Forum itself will be organized around case studies of specific STI capacity building initiatives in developing countries. The speakers will, by and large, be "thoughtful doers". Each speaker will be asked to explain what his/her case study accomplished, how it achieved its objectives, why it succeeded or failed, and what lessons of experience can be applied, with suitable modifications to accommodate country and cultural specifics, to future capacity building programs in other countries.

If there is a gap between the lessons of experience generated by successful initiatives and the content of ongoing STI capacity building projects, the Forum will explore ways to bridge this gap. The objective is not to criticize existing initiatives but to improve them by providing compelling alternatives in those cases where lessons of experience indicate they may not be effective and to strengthen successful initiatives where lessons of experience suggest that support for ongoing programs may be warranted.

[4] The complete text is available at:
http://www1.worldbank.org/harmonization/Paris/FINALPARISDECLARATION.pdf

Since this is expected to be a practical, results-oriented event, the principal audience is expected to be government officials, private sector executives, and staff and managers from bilateral, multilateral, and non-governmental organizations and foundations involved in STI capacity building programs. Approximately 300 people would be expected to participate in the Forum.

The Forum will be a two-day event. The first half day will be reserved for keynote addresses and high-level discussions of selected topics. The remaining day and a half will consist of substantive, working-level discussions organized around various lessons of experience described in more detail in the following section of this note and reflected in the attached draft Preliminary Program Description. A third day will be reserved for optional mini-retreats at which participants from individual countries, regions or sectors would discuss potential operational initiatives for implementing some of the innovative ideas discussed at the Forum. These discussions will involve team leaders from the World Bank and other agencies working on STI capacity building projects.

Short to medium term outcomes of the Forum include:

- Specific ideas, strategies and policies for improving the design of STI capacity building programs, based on lessons of experience.
- Partnerships with Governments, NGOs, and bilateral donors to develop STI capacity building programs and projects in countries that have expressed interest in pursuing these programs.
- Publication of Forum proceedings so that officials who were unable to attend the Forum can benefit from the presentations. (In addition, all Forum background documents and presentations will be available on the Bank's STI website.)
- A flagship report on STI capacity building for sustainable growth and poverty reduction. This report will offer analysis and conclusions for STI capacity building programs drawn from the formal presentations and informal comments from Forum participants.
- Follow-up STI Capacity Building forums in various regions that request a follow up event. These regional forums will highlight the specific STI capacity building issues and opportunities facing different regions. Each of these regional forums would build on the work and momentum generated by the Global Forum.
- Improved staff and stakeholder knowledge and awareness of the direct link between STI capacity building on the one hand and a country's capacity to achieve the MDGs, reduce poverty, increase wealth and well-being, and improve competitiveness on the other hand.

III. STI Capacity Building: Issues, Options, and Priorities

There appears to be an emerging consensus that STI capacity building is an essential tool for sustainable development and poverty reduction. But what precisely is meant by STI capacity building? What capacities must be built? How have countries built these capacities? How should policy makers allocate scarce resources to different capacity building objectives and what specific capacities are the highest priorities for any given country at a given stage of development?

STI capacity building involves building two types of capacity:

- the capacity to acquire and use existing knowledge
- the capacity to produce and use new knowledge

It also involves building capacity at four distinct levels:

- the level of government policy making
- the level of labor force skills and training
- the level of enterprise innovation
- the level of education and training institutions and research institutes

A. Types of STI Capacity

The two types of capacity are:

- **The capacity to acquire existing knowledge that was produced outside the country, to adapt it for local use, to diffuse it throughout the country and to adopt it locally.** Acquiring, adapting, diffusing, and adopting existing knowledge is a major conduit for building STI capacities in every country, irrespective of its level of development. Even if a country dramatically increases the size and quality of its research effort, it is unlikely that the local R&D output will account for more than a small fraction of the global R&D output. Hence, most of the knowledge that any country will have to use if it is to grow and prosper will be produced by others. Thus, developing the capacity to identify, find, acquire, adapt and adopt this existing knowledge must be an indispensable component of STI capacity building. Developing this skill involves much more than building an information infrastructure through investing in ICT and building additional bandwidth, important though this may be. These infrastructure investments provide the physical facilities needed to tap into the existing pool of global knowledge. But developing the capacity to acquire, adapt and adopt this knowledge is more difficult and complex than simply providing additional internet connections and bandwidth, important though these might be. Understanding the challenges involved in tapping into global knowledge and the techniques that other countries employed to achieve these goals will be a major theme of the Global Forum.
- **The capacity to produce and use new knowledge via R&D.** This may entail the capacity to conduct high level basic research, alone or in partnership with leading global R&D institutes. Or it may entail building the capacity to find novel ways of solving local problems – e.g., developing more fuel efficient cook stoves, applying nanotechnology filtration systems to deliver potable water to a local village, or designing biogas energy systems. Not every country has the current capacity (or pressing need) to participate in the global R&D effort to find a cure for AIDS or to develop an anti-malarial vaccine. But every country needs

to develop the R&D capacity needed to find new, innovative ways to apply modern science to solving local problems.

B. Levels of STI Capacity Building

STI capacity building occurs at four levels.

- **The capacity of government to formulate coherent STI policies and link them to discrete development strategies.** These government policies include explicit STI policies (e.g., grant programs to finance R&D, to link R&D more closely to the needs of industry, and to foster technology upgrading in local industry and stimulate enterprise demand for R&D, intellectual property (IP) rules and regulations that encourage enterprise innovation, protect imported knowledge, facilitate technology diffusion, and build skills in technology licensing, etc.) as well as implicit STI policies (i.e., tax policies that encourage or discourage enterprise innovation, trade policies that protect uncompetitive domestic producers from competition thereby discouraging innovation, financing mechanisms that help to generate demand for local research and development activities, administrative barriers and other government rules, regulations, and restrictions that make it excessively difficult to start a new business, etc). The importance of the implicit and explicit policy making dimension cannot be overestimated. For example, many transition economies have a well developed, even world class, scientific infrastructure. But the absence of a suitable enabling environment often prevents them from converting this scientific capacity into knowledge-intensive, value added goods and services. Other countries need to focus their policy making attention on strengthening the knowledge production and acquisition skills of local enterprises or finding ways to help local enterprises train workers to perform more complex tasks and utilize more sophisticated machinery and inputs. The key point is that every country needs to identify those areas where its National Innovation System (NIS) is weakest and then design and implement coherent STI policies that can address these deficiencies.
- **The capacity of the workforce to engage in more knowledge-intensive production.** An educated, trained workforce is *a sine qua non* for STI capacity building. This entails more than simply producing more top-notch scientists. For many countries, a higher priority may be developing technical and vocational skills. One critical question is when education and training should take place in formal educational institutions or when education and skills are best acquired on the job? What is the appropriate balance between these two methods of delivering training? How can formal education institutions be induced to provide vocational and technical training that is more attuned to the needs of local industry? Another question is how various different countries have used education and training to make the transition from a predominantly low wage, unskilled labor force to a higher wage, skilled labor force. This is a question of increasing both the supply of skilled workers, so that enterprises see the country as an appropriate location for skill intensive activities and the demand for skilled

workers so that investments in education and training do not result primarily in brain drain. See Annex 2 for a brief discussion of brain drain issues.

- **The capacity of enterprises to use new and existing knowledge to innovate, and to design, produce, and market more knowledge-intensive, value added goods and services.** Building the capacity to acquire and produce additional knowledge will be of little relevance unless agricultural, manufacturing and service enterprises have the capacity to use this knowledge to produce higher value goods and services. For example, in several countries, world class R&D facilities coexist alongside impoverished rural villages and/or uncompetitive local industries. Additional efforts to build R&D capacity and to train skilled workers will not help industry become more competitive unless these efforts to increase the supply of knowledge are complemented by efforts to increase the private sector's capacity to innovate and its effective demand for knowledge. All too often, public policy focuses on increasing the supply (or even the quality and relevance) of R&D and the supply of skilled workers, on the assumption that the demand already exists for more R&D and for more skilled workers. But is this always the case? If it is, why are so many skilled workers emigrating and why is brain drain such a serious problem for so many countries? Related to this is the question of enterprise innovation. How much and what type of innovation is currently taking place in a country? What are the obstacles to greater innovation? Is it corruption and administrative barriers? The cost of doing business? The lack of skilled workers who can produce more knowledge intensive, value added goods and services and conduct more complex tasks? Or is it the scarcity of enterprises that have the organizational and managerial capabilities needed to produce more sophisticated goods and services? What types of enterprises are most innovative in developing economies – small or large, old or new? The Global Forum will explore these issues and attempt to understand what can be done to spur greater enterprise innovation and the diffusion of technology from outside the country to enterprises inside the country.
- **Education, Vocational Training, and R&D Institutes.** Education, vocational training, and R&D institutes are the main transmission mechanism between the global stock of knowledge, on the one hand, and enterprises and the workforce, on the other hand. Although it is a truism to suggest that a more skilled workforce is a pre-requisite for producing more knowledge-intensive goods and services, in fact, this will only be the case if the supply of skills and knowledge produced by the education and training system broadly matches the demand for skilled workers in the economy. Among other things, this requires an education and vocational training system with the flexibility, autonomy, desire, and technical capacity to respond to market signals and to work in partnership with potential private sector employers. All too often, these administrative and managerial pre-requisites are missing. Spending more on education will not have the desired economic benefit unless the additional resources are accompanied by the necessary organizational and structural changes. R&D institutes are also part of this transmission mechanism. When they operate optimally, R&D institutes serve a dual function – they produce new knowledge and they help to train the next generation of scientists. But all too often, R&D institutes have weak links, at best, to the

innovative needs of enterprises and do not play an active role in training young scientists. The Global Forum will examine how some countries tackled these problems and turned these institutions into resources for economic growth while at the same time, strengthening their role as centers of excellence and transmission mechanisms for global knowledge.

C. Implications for STI Capacity Building Policies

In embarking on an STI capacity building program, policy makers need to decide which dimensions of STI capacity should be highlighted at any given stage of development. They also need to maintain an appropriate balance between different types and levels of STI capacity building. For example, should they give priority to:

- Creating new knowledge or to acquiring existing knowledge, and in which sectors of the economy?
- Increasing the supply of knowledge by increasing R&D and education or to increasing the demand for knowledge in the enterprise sector by improving the climate for innovation, entrepreneurship, and technology upgrading (including upgrading of traditional technologies)?
- Financing hardware (building new laboratories, acquiring new scientific equipment) or software (programs and policies that improve the incentives to innovate)?
- Horizontal policies (level the playing field, reduce administrative barriers and the cost of doing business, improve the quality, governance and relevance of the education system, enhancing Intellectual Property (IP) protection) that establish a good business climate or vertical policies that strengthen the STI capacity in those sectors which the market has identified as probable winners?
- Developing new organizations and institutions or enhancing the capabilities, performance, and linkages of existing STI organizations?

In considering their options, policy makers will need to consider the strengths and weaknesses of the country's current STI capacities as well as the short and long term cost and benefits of emphasizing different dimensions of capacity building. These tradeoffs can only be assessed in the context of a country's individual goals and objectives. Specifically, what problems is the country trying to solve by building STI capacity and what is the best strategy for achieving these objectives?

In some cases, these issues involve difficult tradeoffs. For example, especially in the early stages of development, when financial and human resources are scarce, policy makers will not be able to do everything at one. Under these circumstances, they will need to establish priorities and decide which specific dimension of STI capacity building will generate the greatest development bang for the buck. For example, if a country's industries are all operating far below the technology frontier, should policy focus on creating new knowledge and building R&D facilities or should it focus instead on building the enterprise sector's capacity to acquire and utilize existing knowledge?

In other cases, the issue is one of finding the appropriate balance between different dimensions of STI capacity building. For example, devoting too much attention to building R&D capacity or building the wrong type of R&D capacity may be just as detrimental as focusing too little on R&D. Similarly, improving STI "hardware" is likely to bring results only if it is done in combination with appropriate "software" progress. And to be most effective, horizontal policies probably need to be paired with appropriate vertical policies. Thus, for most countries, it is not a question of selecting one or the other, but maintaining an appropriate balance.

IV. Global Forum Issues

To help policy makers assess these issues, priorities, and tradeoffs, the Forum will be organized around the following constellations of issues:[5]

The Forum will be organized around four constellations of issues:

- Reducing poverty and achieving the MDGs: the role of STI capacity building
- Adding value to natural resource exports through STI capacity building
- Latecomer strategies for catching up -- linkage, leverage, learning, and STI capacity building
- The role of R&D in the development process.

Although all four sets of issues are related to the notion of "STI Capacity Building," they address different problems and entail the development of different skills and institutions. For example, for many countries without pre-existing, well-developed R&D systems, national priorities for building STI capacity to reduce poverty and achieve the MDGs will most likely entail developing the technical and vocational skills needed to deliver quality health care in rural villages and low income urban neighborhoods, improving public health systems, developing rainwater harvesting systems, and using fairly simple, well-known cultivation techniques to minimize soil erosion. It would also entail developing simple, low cost technologies -- e.g., more efficient wood burning stoves, manual

[5] These four dimensions of STI capacity building should not be seen as mutually exclusive or as either-or options. Countries and policy makers do not have to "choose" one STI capacity building objective to the exclusion of the others. Nor can countries be neatly pigeon-holed into one category or another – e.g., this country needs to focus on the MDGs; that country should emphasize improvements in its R&D capacity. Innovative developing countries with world class R&D capacity may face serious MDG problems. Poor countries may have isolated pockets of research excellence which may need to be nurtured. And middle income countries facing increasing competitive pressures may need to balance the need to build (or rebuild) R&D capacity and also to focus on technology upgrading and generating more value added from its natural resource base. The point is that in a world of scarce financial resources and human capabilities, where it is impossible to do everything at once, policy makers will have to set priorities and determine sequences of STI capacity building initiatives, based on each country's most pressing needs, objectives, and initial endowments. Properly assessing national STI needs, establishing priorities for addressing these needs, and understanding the different dimensions of STI capacity building will be critical to the success of any STI capacity building program.

irrigation pumps and food processing equipment and possibly the selective upgrading of traditional technologies.

Building the STI capacity to address these issues would focus primarily on strengthening applied vocational, technical, and engineering skills to solve local problems and entrepreneurship training to help small businesses produce, market, and distribute products based on these new technologies. It would also involve developing the capacity, know-how, and IP regime to license newly developed technologies to private enterprises that can sell and distribute them inside the country as well as in neighboring countries. Importantly, all of these essential tasks are distinct from building world class R&D capacity.

Put differently, policy makers need to find the right balance between the creation of new knowledge via investments in R&D capacity and building the capacity to absorb, adapt, and adopt existing knowledge. In some cases, the knowledge required to solve many of the most pressing problems already exists and is widely used outside the country. Unfortunately, it is simply not in widespread enough use inside the country. In this case, the main STI capacity building issue is related to technology diffusion which requires building up the skills to find, deploy and utilize more sophisticated technologies. For countries without substantial R&D capacity, therefore, the notion of STI capacity building should refer, at least initially, to developing the technical skills required to find, adapt, and utilize **existing** technology to produce more knowledge intensive goods and services, even if these goods and services are such "low tech" items as roses, coffee, wine, fish farming, and rainwater harvesting systems.

Policy makers need to keep these differences in mind when embarking on STI capacity building programs. They also need to understand what world class R&D capacity can -- and cannot -- contribute to each country's economic development process. The Forum is designed to provoke a thoughtful discussion and debate of these issues.

A. Building STI Capacity to Reduce Poverty and Achieve the MDG's

With an annual per capita income of less than $700, the typical resident of a low income country lives below the $2/day poverty line. Many are engaged in subsistence agriculture or casual, informal urban labor and few have access to electricity and clean drinking water. In many countries, wood is the main source of fuel. As a result, deforestation and soil erosion are serious concerns. In what is clearly a cruel irony, water from heavy rains cascades down hills and mountains, washing away farms and increasing soil erosion. Women and children then spend hours every day hauling drinking water back up to their villages. In another cruel irony, surplus food often rots due to a lack of storage capacity while many of the people who produced the surplus crops do not have the security of a year-round stable food supply.

With this in mind, Government officials are beginning to ask whether targeted efforts to build science, technology and innovation capacity could play a role in alleviating these problems, improving quality of life and well being, and raising standards of living. The Forum will highlight areas where STI capacity building programs can act as catalysts, disrupting the current low level stagnant equilibrium and generating self reinforcing changes that start the village or country down the road to sustainable economic development.

Building STI capacity to reduce poverty and achieve the MDGs would entail boosting STI capacity on a number of related fronts including:

Agricultural productivity. Using new (to the country) cultivation methods and input packages to boost agricultural productivity of subsistence farmers.

- The technical knowledge needed to boost agricultural productivity already exists and is widely known around the world. Unfortunately, subsistence farmers in many countries are simply not using this existing, known technology. To take one example, the Millennium Development Village project in Mayange, Rwanda, shows that substantial increases in crop yields can be generated by fairly simple improvements in cultivation practices, the use of improved seed varieties and fertilizers, and low tech water retention/irrigation/soil erosion prevention mechanisms.[6] In Mayange, most of these practices were introduced by one well-trained, local extension worker. Nearby villages as well as farmers who originally chose not to utilize the new inputs and cultivation techniques are now clamoring to participate during the forthcoming planting season. The main STI capacity building task, at least in Mayange and the surrounding villages, would appear to be one of training and motivating extension agents, providing improved input packages, and diffusing known cultivation techniques to additional villages and farms.

Alternative energy. Many of the world's poorest residents live in urban settlements and rural villages that are not connected to the central power grid.

- Building central generating plants and connecting remote villages to the central grid is neither feasible nor affordable in many countries. Therefore, to serve these people, countries will need to develop alternative, decentralized energy sources including wind, solar, thermal, small scale hydro, and bio fuel. While every home cannot be connected to these alternative energy supplies, at least initially, central locations such as schools and public health clinics can be electrified, at least initially, and can serve as central locations for computer centers, internet cafes, and other public facilities.

Water conservation and rain water harvesting. Water borne diseases, caused by shortages of potable water, are a major source of illness in many countries.

- Rainwater harvesting can provide a relatively low cost effective water supply for use in cooking and drinking water. The techniques and technologies for harvesting rain water are widely known, but not widely used in many countries.

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[6] An excellent discussion of the Millennium Development Village project in Mayange, Rwanda is available in Sarah Tomlin, "Development: Harvest of Hope," **Nature** 442, 22-25 (6 July 2006) http://www.nature.com/nature/journal/v442/n7098/full/442022a.html

Part of the problem is that the local population does not have the technical and vocational skills needed to build rainwater collection systems. A vocational training program to boost the supply of trained technicians along with a program to finance the construction of rainwater harvesting systems might help to address both the supply and demand side of the equation.

Food Processing and Storage. Increasing agricultural yields will not improve food security if food cannot be safely processed and stored.

- New technologies need to be developed and deployed to process and store food without utilizing large amounts of (unavailable) electricity.

Public Health. Health education needs to be widely available to help educate the rural populace in such topics as nutrition, sanitation, hygiene and, as mentioned earlier, the importance of clean drinking water. In addition, public health technicians and nurse practitioners need to be trained to maintain adequate public health records, administer vaccines and medicines, and provide routine health care services. Where possible, rural health clinics need to be connected via the internet to regional health centers where more highly trained personnel are available to provide (via telemedicine) more sophisticated health care services. As this suggests, improvements in public health require social and institutional innovations as much as technological innovations.

The Forum will discuss a number of successful initiatives designed to show how STI capacity building programs have addressed the issues enumerated above. Key questions then become the extent to which the lessons of experience are relevant to other countries and, if they are, what can be done to scale up these initiatives. Will multilateral, bilateral, donor and government resources be sufficient to scale up these programs on a sustainable basis? If not, is the root problem one of inadequate resources or one of inappropriate solutions?

B. Adding Value to Natural Resource Exports through STI Capacity Building

If countries hope to become more prosperous, they must find ways to reduce the ranks of the rural and urban poor and not merely develop technologies that make life more tolerable for them. Reducing the ranks of the poor must entail creating more productive, higher paying jobs outside subsistence agriculture and casual urban labor, developing new higher value added exports[7], attracting FDI, improving the quality of science and technical education at all levels[8], and establishing supply chain linkages between local

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7 Higher value added should not be confused or equated with high tech. For example, electronics is generally regarded as a high tech industry and horticulture as a low tech industry. But horticulture production may, in fact, be more knowledge and skill intensive than assembling imported components into finished computers. The critical economic development issues are the value added generated by a particular activity as well as the labor skills required to produce a particular product, not whether the finished product or industry is classified as high tech or low tech.

8 Improving the supply of skilled workers via education and training programs are absolute pre-requisites for the success of any STI capacity building initiative. But increasing the supply of skilled

firms and foreign investors. STI capacity building is a critical tool for solving these problems.

From a theoretical economic perspective, the solution to these problems is clear and unambiguous. Labor should shift from low productivity subsistence agriculture or casual labor to higher productivity manufacturing and service sector jobs. Fortunately, much of the initial technical knowledge needed to create these new jobs already exists. Unfortunately, although this knowledge exists and is widely used outside many poor countries, it is not widely used by enterprises in poor countries. From this perspective, therefore, STI capacity building needs to focus on finding appropriate technologies, importing them, adapting them to local conditions, and helping firms (both managers and workers) use them to produce and market higher value, more knowledge intensive goods and services.[9] Unfortunately, this is easier said than done.

Developing countries need to establish applied engineering research institutes that focus their R&D efforts on developing such simple, low cost technologies as more efficient wood burning stoves, manual irrigation pumps, food processing and storage equipment, more efficient, low cost construction materials and methods, and non-electrical refrigeration or food cooling equipment. However, it is not enough simply to produce prototypes of better equipment. Designs and blueprints have to be patented and innovative licensing arrangements have to be devised so that the inventions can be transferred (via licensing agreements) to SMEs who would be responsible for producing, marketing and distributing them in local and regional markets. In this way, STI capacity building programs will support and reinforce parallel programs aimed at private sector development, economic diversification, entrepreneurship, and SME development.

Moreover, leveling the playing field, reducing administrative barriers, and reducing the cost of doing business are essential but not sufficient conditions for higher productivity, increased competitiveness, rising standards of living, and economic diversification. Enterprises will not be able to exploit the competitive opportunities generated by a good business climate if their workforce does not have the requisite skills to perform higher value added tasks and if local enterprises do not have the organizational and managerial capacity and technical competence to invest, innovate, enter into strategic supply chain arrangements with other firms, and operate closer to or at the global technology frontier.

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workers may lead to brain drain if it is not accompanied by a corresponding increase in the demand for skilled workers by private enterprises. Building STI capacity to create wealth and diversify the economy is especially necessary to increase the demand for skilled workers. This is especially important for Africa which is more prone to brain drain than most other regions. For additional information about brain drain, see Annex 2.

[9] In a speech at a recent Annual Meeting of the CGIAR, World Bank chief economist Francois Bourgignon asked whether agricultural research should maintain its focus on improving crop yields -- which, by depressing commodity prices, may have the perverse, unintended consequence of increasing rural poverty and stagnation – or begin to focus more on finding ways to add value to crops produced by rural villagers.

Many countries suffer from a shortage of skilled technicians and craftsmen needed to perform such diverse tasks as repair automobiles, repair and maintain electrical appliances and such electronic equipment as printers and copiers, and design and construct such facilities as rainwater harvesting systems and schools. At the moment, there is a shortage of well equipped technical and vocational schools. Annual operating costs for these schools are also much higher than operating costs for traditional academic secondary schools. Thus, donors looking to maximize the number of students benefiting from donor financed education programs often prefer to invest in lower unit cost secondary education, even when this preference does not coincide with the most urgent needs of the economy. At the same time, graduates from the few schools that do exist are having difficulty finding jobs because graduates do not receive enough technical training. Poor countries will have difficulty moving beyond subsistence agriculture without an adequate supply of personnel trained in these mid-level craft skills.

Investment climate improvements, while critically important, will not by themselves generate more competitive domestic enterprises if these firms lack the organizational capability to respond effectively to a better business climate. Building this capacity takes time and should be a major objective of any STI capacity building program.

FDI is frequently seen as an essential ingredient in any STI capacity building program. But FDI is not the automatic development panacea that some suggest. To the extent that a poor country is successful in attracting FDI, it may initially be due to the fact that it offers an abundant supply of natural resources and/or low wage, unskilled labor. These are its current factor endowments and comparative advantage. But numerous empirical studies suggest that FDI does not automatically generate spillovers, clusters, or backward supply chain linkages to domestic suppliers. Nor does the mere presence of FDI generate an automatic evolutionary path leading from low skilled simple activities to higher skilled, activities. So while FDI can help to generate immediate employment and export revenues, host countries need to take a pro-active STI capacity building approach if they wish to use FDI as a stepping stone to producing more sophisticated, knowledge intensive goods and services. This might include such items as skill development programs, technical and vocational education programs, technology upgrading policies, and supplier development programs. By improving the country's capacity to supply more sophisticated products and conduct more complex tasks, foreign (and domestic) investors might be induced to locate more knowledge intensive activities in poor countries. This is largely how Singapore progressed in less than 40 years from a comparative advantage based on an abundant supply of low wage, unskilled labor to a competitive advantage based on its capacity for frontier research, innovation, and high tech, skill intensive production.

Especially during an industry's early stage, when private enterprise capacity is weakest, some form of public-private partnerships may be needed to identify suitable technologies, help to adapt them for local use, and encourage enterprises to adopt them for production.[10] For example, fish farming and horticulture exports are generally thought of as low tech activities. In fact, they require sophisticated inputs, skilled labor, laboratories to ensure that the fish comply with health and safety regulations, and technicians to work in industrial laboratories and quality control centers. In other words, public-private STI capacity building programs need to help countries develop the scientific and technical inputs needed to make these activities globally competitive.

Finally, STI capacity is critical for maintaining the competitiveness of existing, productive industries in the face of changing market demands, business climate, and environmental conditions. The effort to build up an industry to the point where firms can compete for global market share does little for the sustained development of a country if the firms in that industry gradually lose their competitive advantage as new technologies are developed elsewhere which better meet the market need. Similarly, the rapidly changing business and environmental conditions demand innovative responses from firms in order to survive. Examples of this unfortunate growth and collapse cycle abound, including the palm oil industry in Ghana falling victim to changing global demand, the Colombian coffee industry losing ground as the Vietnamese industry incorporated better production technologies, and the Peruvian fishing industry collapsing due to a water pollution related epidemic. As these circumstances may overwhelm even a highly innovative firm's capacity to adapt, more national capacity to support innovation would be necessary to maintain these industries. As developing countries move into even more knowledge-intensive export industries, from aquaculture to tourism to software services, it is the countries with national STI capacities complementing and supporting enterprise-level innovation which will be able to maintain and grow these industries over the long-term in the face of changing business conditions.

Rwanda is an example of a country that is beginning to develop high value added export industries in such diverse fields as coffee, roses, and pyrethrum. They have done so without attracting any appreciable FDI or developing any public-private capacity building partnerships, at least during the initial stages of development. Instead, they have relied on returning members of the Rwandan Diaspora to provide the technological know-how, marketing and organizational savvy, and workforce training.

All of these Rwandan success stories share several features in common, including:

- They have carved out a niche at the high or premium end of the market. This is typically the most lucrative end of the market and the one which is most difficult to access.
- The entrepreneurs who developed these businesses work (or plan to work) in partnership with subsistence farmers. Specifically, local farmers devote a portion of their time and land to growing a cash crop. The rest of their time is devoted to subsistence agriculture. The cash crop is expected to generate an annual income of approximately $300 to $500 per family. (The rose/horticulture operation

[10] For case studies of how new export industries emerged in selected developing countries, see, Vandana Chandra (editor), Technology, Adaptation and Exports: How Some Countries Got it Right, World Bank, forthcoming. Also see Douglas Zeng, xxx

foresees a cash income of $3500 per family in five years.) The subsistence farming activities will provide most of the family's basic food supply. Thus, the cash income can be used to finance such items as school fees, health care, or even an occasional luxury. The additional spending power of the local families has a noticeable impact on the commercial vitality of the local village.

- In the cases of pyrethrum and roses, the primary entrepreneurs are former members of the Rwandan Diaspora. In the case of the coffee enterprise, the initial entrepreneur was a US horticultural expert funded by USAID who has spent the past five years living in Rwanda, working and training local villagers, identifying and linking to foreign buyers, and generally developing the local industry. Subsequently, numerous Rwandan entrepreneurs have also entered the market for producing, processing, and exporting premium coffees.
- In all cases, the entrepreneurs provided the undertaking with an invaluable package of rare skills including: (i) an understanding of the importance of quality control; (ii) a technical understanding of how to achieve quality control; (iii) management and entrepreneurial capacity, and (iv) access to markets or a clear strategy for establishing links to buyers.
- In all three cases, the entrepreneurs started with a basic understanding of what the market required in terms of quantity, quality, and technical specifications. They then reverse engineered the production process to determine the required inputs and the capacity building programs (training, supply chain linkages, logistics, etc.) required to meet the market demand. In other words, these successful capacity building programs responded to market demands. They were not developed and implemented in isolation from market requirements.

It is important to stress that the enterprises provide much more than markets for local farmers. They help the farmers organize themselves into local producer coops. They train farmers in modern production techniques and quality control mechanisms. They also provide training in such "ancillary" activities as public health and sanitation and modern cultivation techniques for subsistence crops. Thus, in addition to boosting the production of high value added crops and boosting the cash income of participating farm families, the enterprises provide a major impetus to local economic development, education, and technology upgrading. In effect, entrepreneurs become agents of STI capacity building as well as employers of the STI capacity that they help to create.

As part of its STI capacity building strategy, the Government wants to identify market-friendly, pro-business ways in which public-private partnerships could help private sector entrepreneurs in these and other promising value added export and import substitution sectors. Thus, it proposes to consult with entrepreneurs to identify areas where government policy reforms or critical infrastructure investments could ease bottlenecks and reduce the cost of doing business in Rwanda. In addition, it wants to explore options for (i) placing R&D labs (a horticulture or botany laboratory) directly in private enterprises. This would help to ensure that the R&D conducted in these labs is directly related to the needs of private enterprises in that sector; and (ii) creating policies to encourage private entrepreneurs to organize or provide vocational and technical training directly related to the needs of that sector. This would supplement the training provided by the existing vocational and technical training institutions.

C. Latecomer Strategies for Catching Up: The Role of STI Capacity Building

How do countries and especially enterprises "catch up" to the technological leaders? How do they learn? More importantly, how do they learn to learn? And what can they learn from the historical lessons of experience of countries, sectors, and enterprises that have managed to catch up?

The Global Forum will attempt to provide some answers to these questions, based on lessons of experience from developing countries that have recently been successful at catching up to the leaders in various high tech and low tech sectors. It will look at how countries have employed innovative public-private partnerships to support the technology catch-up process and foster local innovation.

The Global Forum will also explore the role that FDI can – and cannot – play in this process. For example, empirical evidence suggests that FDI does not automatically generate spillovers that help local enterprises become more innovative and more technologically adept. Some countries have attracted FDI, but then found that it does not lead to much technological modernization over and above the direct employment benefits generated by the FDI itself. When lower wage locations become available, the flow of new FDI slows dramatically and, just as troubling, foreign firms that operated in the host country are quick to move elsewhere. Growth slows dramatically and the country finds itself facing an economic crisis.

Other countries, by comparison, have been adept at using FDI as a learning or technology upgrading opportunity. These countries may start with an abundance of low wage, unskilled labor. But they quickly embark on a deliberate process of technology and skills upgrading, so that foreign investors who were attracted to the host country by the low wage labor are gradually induced to locate more knowledge and skill intensive activities in the host country. At the same time, these countries help local firms provide value added goods and services to foreign investors and build other supply chain linkages between local firms and global firms operating in the country and region. The Global Forum will discuss how these countries used FDI as a tool to promote technology upgrading.

Finally, the Global Forum will explore the role of R&D in the technology upgrading process. Anecdotal and survey evidence suggests that enterprises innovate primarily by importing new, more modern capital equipment. There seems to be little domestic enterprise demand for local R&D capacity. This is not necessarily surprising. Since most domestic enterprises operate far below the technological frontier, they do not need to finance R&D or conduct R&D in order to improve their productivity and competitiveness. However, it does suggest that grant programs to increase the domestic private sector's demand for R&D may be less effective than their proponents would wish.

A more in-depth discussion of R&D, not only for technology upgrading but also in the context of the overall development process, is in the following section of this paper and will be an important focus of the Forum.

This remainder of this section will briefly discuss two important strands of research related to the catching-up process: (i) the process of technology diffusion, linkage, leverage and learning that successful latecomers have used to find new, high value added niches in the global division of labor and (ii) the array of skills and capabilities that individual enterprises must develop during the catching-up process.

A. Technology Diffusion, Linkage, Leverage and Learning

Catching up means finding a niche in the global division of labor and using that initial niche to move from lower value added, less knowledge intensive activities to higher value added, more knowledge intensive activities. Getting an initial foothold and devising a strategy for moving up are not simple or straight-forward tasks. According to Mathews (2004), the most critical aspect of the catching up process is the absorption, adoption and adaptation of products, processes and technologies that are already in use elsewhere. This is the so-called process of technology diffusion and it is easier said than done, which is why it is so rarely done well and successfully. As Mathews observes, diffusion is not a passive process. It is not something that simply happens to an enterprise or an economy. It requires an active, conscious policy of linkage, leverage and learning.

According to Mathews, "the strategic goal of the latecomer is clear: it is to catch up with the advanced firms, and to move as quickly as possible from imitation to innovation." A latecomer firm (Mathews: 2002, p. 471) is "condemned to be follower by history, and it has to make the best of its resource-poor initial situation. It starts not from the powerful position of an IBM but from the resource-meager position of an isolated firm seeking some connection with the technological and business mainstream."

Latecomer firms and latecomer countries have a distinct advantage – if they are skillful enough to recognize it and develop tools and strategies for exploiting it. That advantage is the ability to tap into advanced technologies rather than devoting time, resources and effort to develop new technologies or industries from scratch. Mathews identifies three essential tools for the catch-up effort:

- Linkage. Latecomer firms must link themselves to dynamic firms that already have a successful foothold in the global economy. Linkage provides the latecomer firm with a window to the global market place and to global technology trends.
- Leverage. Latecomer firms must devise strategies and develop the capacity to exploit the knowledge and opportunities generated by linkages to more successful firms.

- Learning. Latecomer firms must develop the capacity to absorb and adapt the knowledge generated via linkage and leverage and convert it into new, more profitable economic opportunities.

This entire process, according to Mathews (2002: p. 479) must be "buttressed, supported and disciplined by an institutional framework…. Public agencies and various forms of inter-organizational superstructures create the conditions in which the process of learning and leverage can be applied, over and over again, each time at higher levels of technological and organizational capability."

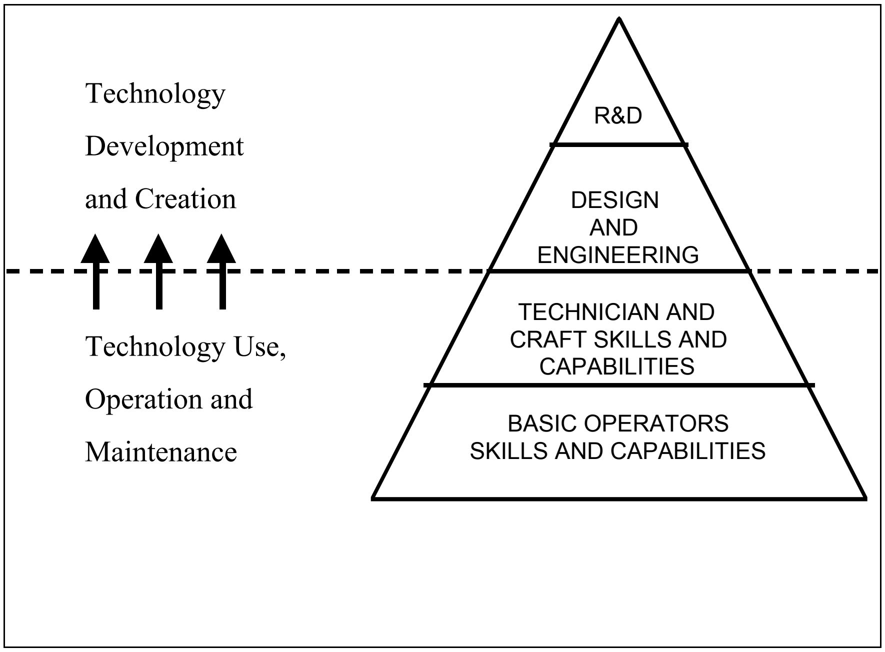
B. Enterprise Capability

Latecomer firms need to develop certain skills and capabilities if they wish to convert their latecomer status into a strategic advantage. At least two distinct types of skills are required: (i) practical technology absorption, adoption and adaptation skills; and (ii) strategic technology acquisition skills.

Absorption, Adaptation and Adoption Skills. R&D is only the tip of the technology development and innovation process (Figure 1) which, in addition to R&D includes such non-R&D activities as: (i) skills for acquiring, using and operating technologies at rising levels of complexity, productivity and quality and (ii) design, engineering, and associated managerial capabilities to acquire technologies, develop a continuous stream of improvements and generate innovations. Different skills are most relevant at different stages of technological development. For example, R&D is most relevant for firms that are closing in on the technological frontier or already at the frontier. Technology acquisition and utilization skills, on the other hand, are most relevant for firms that are at the technology acquisition, assimilation or deepening stages.[11]

[11] This analysis draws extensively from the discussion in Martin Bell, Knowledge Resources, Innovation Capabilities and Sustained Competitiveness in Thailand: Transforming the Policy Process, Report Prepared for the National Science and Technology Development Agency of Thailand, (Funded by the World Bank via IDF Grant No.TF050237), January 2003.

Figure 1: Hierarchy of the Structure of Industrial Technology



Thus, as the diagram above suggests, innovation and capacity building policy should not be limited to promoting R&D. A much broader focus is needed, with a stress on technology **creation**, including both R&D and design and engineering skills, technology **acquisition** skills, and technology **use** skills. These are all vital dimensions of technology development. Indeed, the non-R&D dimensions of technology development may be especially important for the vast majority of enterprises in developing countries which are not engaged in R&D, are far from the technological frontier, and do not require cutting edge R&D to improve their competitive standing. For these firms, assistance in honing skills related to technology acquisition and use may be much more relevant than additional public R&D funding.

Technology Acquisition Skills. Acquiring knowledge is not simply a question of going out and purchasing it from outside vendors. Firms need to have the capacity to search for different technologies, to evaluate different technological options, to modify off-the-shelf technologies for use by a particular enterprise and, last but by no means to least, to integrate new technologies into their production processes. These are not simple or easy tasks. They require a great deal of organizational, managerial, and technological sophistication. Simply put, enterprises need to acquire the skills which they need to acquire and use technology.

The Forum will help participants address these issues by looking at the policies of countries which have successfully benefited from technology upgrading strategies in the past. The Forum will discuss how these strategies can be appropriately adapted to other country contexts rather than merely imitating the policies and programs of these past successes.

D. The Role of R&D in the Development Process

When should countries focus on building their R&D capacity and what sort of R&D capacity should they strive to build – one that is focused on applied research or one that tends to emphasize basic research? How can the growing R&D capacity in the developing world be harnessed for solving the development problems in the developing world? How can R&D organizations in developed countries support this process? This section of the Global Forum will attempt to address this set of issues.

It is important to stress at the outset that R&D capacity should not be equated **only** with the sort of frontier R&D done by scientists and engineers at MIT or in Silicon Valley. Nor should it be equated only with nanotechnology, biotech, and other assorted "high tech" activities.[12] R&D capacity building in developing countries might include frontier R&D and the production of new knowledge for those countries which currently have the capacity to engage in these cutting edge research activities. For other developing countries, the existing or newly created R&D capacity might be better deployed solving the problems of developing biogas generators and more efficient water pumps, providing clean drinking water, or developing more value added products from locally grown crops and local natural resources.

Why should developing countries build R&D capacity? What is the purpose? One objective is to enable research institutes in developing countries to participate in global R&D projects aimed at developing country issues, such as developing new vaccines for tropical diseases or new drought resistant crop varieties. Another objective is to develop the indigenous capacity to solve local problems. And still another objective is to build the capacity of developing country research institutes to collaborate on a more equal footing with research institutes and industrial laboratories in all parts of the world, irrespective of whether they are investigating problems of special relevance to developing countries. India, China, Brazil, and South Africa are frequently cited as examples of developing countries that have recently succeeded in achieving world class status in building R&D capacity. Korea and Singapore are cited as examples of earlier success stories. The NEPAD S&T Action Plan provides a compelling rationale for emphasizing this aspect of S&T capacity building in Africa, but the arguments can easily be generalized to apply to other regions as well.[13]

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[12] Although not necessarily able nationally (or regionally) to undertake full R&D/innovation process to address health (and agricultural) problems, local research institutes often have contributions to make to the process, based on local knowledge and access to patient cohorts, biological diversity, and indigenous knowledge related to therapeutic proerties of plants. Development of skills to protect, market and license inventions will enable contributions to global product development processes (either through partnership with non-conventional development partners such as Product Development Partnerships – PDPs – or more conventional partners in the private sector). Such skills can also generate recognition of, and value for, locally developed research to spur greater industrial interest and greater investment.

[13] The NEPAD Science and Technology Consolidated Plan of Action is available at http://www.nepadst.org/doclibrary/pdfs/ast_plan_of_action.pdf

Progress along this dimension of S&T capacity building is commonly measured by such indicators as the share of GDP devoted to R&D, the number of patents registered in the US and European patent offices, the number of articles published in prestigious, refereed journals, the number of grants obtained from such international science funding sources as the NSF and EU Framework Program, and the number and value of research projects conducted in partnership with local and international research institutes. A country would be seen to be making progress toward developing its NIS, building STI capacity, and becoming more "competitive" when its scores on the variables listed above begin to increase and eventually approach levels found in innovative OECD countries. Government policy is frequently oriented toward moving these indicators in the desired direction.

This dimension of STI capacity building draws most of its inspiration from the challenges facing OECD countries and ongoing efforts to benchmark those countries against each other. The salience of these measures for many developing countries is less clear. In fact, attempts of smaller, poorer countries to use this OECD experience as a guide for their own policies may even be seriously counterproductive. Unless policy makers take explicit pains to distinguish and adapt what is relevant, imitation of OECD country experience may lead to inappropriate and ineffective policies.

The problems facing many poorer countries are different from those confronting OECD economies. Examples of significant differences include:

- The size of the economy and of the non-subsistence agricultural sectors in many of the poorest countries is comparatively small.
- The baseline levels of technology used in the economy -- except for occasional extractive industry activities -- are typically quite low.
- Many countries have only modest resources to invest in S&T. Even if they spent 1% of GDP on science and technology, this would amount to only $50 million. These amounts pale in comparison to the amounts spent in scientifically-advanced countries or even to the amounts spent each week by a single innovative private enterprise on R&D activities. (See Annex 2 for a further discussion of scale issues.)

Scale effects will have a major impact on how countries assess the trade-offs between building the capacity to create new knowledge via investment in cutting edge R&D vs. investments designed to build the economy's capacity to import and adapt existing technology. Small countries, with limited existing R&D capacity will need to decide whether to focus their limited STI capacity building budgets on boosting R&D capacity or on boosting the economy's ability to acquire, adapt and adopt existing technology.

Also see Romain Murenzi, "Physics Has a Key Role in Development," SciDev.Net, January 16, 2006, http://www.scidev.net/Opinions/index.cfm?fuseaction=readOpinions&itemid=458&language=1

However, some developing countries, occasionally dubbed Innovative Developing Countries (IDCs) [14] have sophisticated, well developed R&D systems. As a result, they have the potential to make significant contributions to the global stock of knowledge. But most IDCs also face many of the same problems that confront non-IDCs. Large portions of the population live below the poverty line, large swathes of domestic industry are not globally competitive and all too often, the R&D system is an overhead expense rather than a resource for economic development, innovation, and national competitiveness. Even when the R&D system serves as a resource for economic development, it is important to ask "whose development?" Is the R&D system geared to solving the research and technology problems of multinational corporations (MNCs), or is it designed to address the domestic problems of reducing poverty and enhancing economic competitiveness?

In many countries, converting the R&D systems into a resource for economic growth will entail numerous structural reforms in the way R&D is performed and also in the way it is linked to the needs of industry and to markets. For example, experience suggests that modern science functions best when (i) research is linked to teaching; (ii) scientists and engineers from different disciplines collaborate in multi-disciplinary problem-solving teams, rather than working alone; (iii) the supposed distinctions between basic and applied research are minimized or eliminated; and (iv) there are close links between research scientists and business enterprises.

The current organization of science in many developing countries frequently violates these precepts. For example, (i) at a time when the boundaries between applied and basic research are becoming increasingly blurred, different ministries may be responsible for basic research and applied research; (ii) teaching and research take place in separate institutions, with little interaction between the two. The higher education sector is primarily responsible for training scientists, engineers, and researchers, whereas the bulk of research activities is performed in separate research institutes; and (iii) research is organized vertically, with physicists in one institute, mathematicians in another, and chemists in yet another institute, rather than in broader, multi-disciplinary problem solving teams.

In addition, research organizations frequently operate in isolation from each other and, more importantly, from domestic and foreign markets. Institutes and universities do not collaborate with each other or work closely with local or foreign industry. Research is performed primarily in independent laboratories and institutes which frequently set priorities without regard to market demand, the technology upgrading and competitiveness needs of local enterprises, or the Government's own scientific priorities.

Even worse, many scientists mistakenly believe that their institutes have a large stock of inventions that can be easily commercialized, especially if venture capitalists can be

[14] There is no universally accepted definition of IDCs. The term generally includes Brazil, Russia, India, China, and South Africa. However, countries such as Ukraine, Kazakhstan, Mexico, Chile, Argentina, Malaysia, and Thailand, among others have the potential to join the club in the foreseeable future.

induced to provide the necessary financing. Unfortunately, many scientists do not know how to commercialize their inventions nor do they have the connections to global markets which would be needed to mount a successful commercialization effort. Simply put, they do not know how to access markets or how to assess the needs of these markets. Nor do they have a clear idea of what they are trying to sell. Are they marketing an off-the-shelf technology or are they selling their problem solving, research capacity.

R&D capacity building programs need to overcome these structural impediments. The Global Forum will address this issue. The Forum will also explore how R&D institutions in OECD countries can help to build R&D capacity in developing countries and, equally importantly, how the research capacity in developed countries be mobilized to address problems in developing countries.

V. Highlighted Issues and Discussion Topics

The Forum will focus primarily on drawing from lessons of experience to inform the capacity building objectives discussed above. In doing so, the Forum presentations will inevitably call attention to a series of strategic and tactical questions related to the implementation of STI capacity building programs. In general, these can be summarized by the question: "What should Governments and the donor community do to help build appropriate STI capacity in different countries, with different needs, different initial levels of development, different existing capacities and initial factor endowments, and different development strategies?" This section will enumerate a number of these important strategic and tactical questions. Not all of these questions will be discussed explicitly and directly during the Forum. But in listening to the presentations and participating in the discussions, and reflecting on the implications for STI capacity building programs, Forum participants may want to keep the following questions in mind:

Strategic Operational, Organizational and Implementation Issues

- What do we mean by STI capacity building? Although there is widespread agreement that STI capacity building is important, it is not at all clear that policy makers are always all referring to the same thing when they refer to "STI capacity building." Eliminating this conceptual or terminological confusion is important, not merely for the sake of semantic clarity, but because different aspects of STI capacity building serve different purposes, have different objectives, and entail developing different skills and institutions. A productive dialogue on STI capacity building policy will be difficult unless individual countries have a clear idea of what they hope to achieve by building STI capacity and what type of STI capacity they wish to build.

- Sequencing and Priorities in STI Capacity Building. What is the appropriate sequencing and set of priorities for STI capacity building? What specific STI capacities should be built at different stages of development? Should countries focus initially on building research capacity or, alternatively, should they focus on building the national capacity to absorb, adapt and adopt existing knowledge that is widely available outside the country but that is not widely used inside the country? Put differently, should countries focus initially on creating new knowledge or absorbing existing knowledge? If the initial focus is on absorbing existing knowledge, at what stage in the development process should countries begin to focus on R&D capacity?

- Skills. The skills needed to conduct world class R&D are fairly well known; albeit difficult to acquire. But what skills are needed to build knowledge absorption capacity? And what can countries do to ensure that the private sector's demand for skilled workers and managers roughly matches the increase in the supply of skilled workers and managers? Put differently, is it sufficient for countries to boost training and education programs – the supply side of the equation -- or do they also need to place some emphasis on boosting private sector demand via technology upgrading and innovation policies?

- Choice of appropriate priorities for technological development. Many Government officials emphasize frontier research and high tech activities -- biotech, nanotech, new materials, IT, etc. They are less interested in (and less knowledgeable about) using S&T to improve the competitiveness and productivity of more "mundane" industries like food processing, machine building, horticulture, etc. However, these non-high tech industries may be precisely the ones that generate the greatest social and economic returns to S&T capacity building. How can the Bank and donors help alert policy makers to this important issue?

- Rationale for regional initiatives. Especially in those parts of the world with large numbers of smaller (neighboring) countries, it may not be feasible in a short term or desirable to establish similar S&T institutions in each and every neighboring country. Instead, a more coordinated regional approach may be preferable. Is it, in fact, preferable? If it is, how can the Bank and donors support regional approaches to S&T capacity building? Is this more feasible with IDA resources than with IBRD resources? Do such precedents as the Aral Sea project and the Africa Trade Facility provide useful or relevant lessons of experience?

- Development of STI institutions and programs. Should the Bank and donors support the establishment of new world class S&T institutions (e.g., Africa Institute of Science and Technology or AIST) that can serve as beacons of excellence for other institutions in the country or region or should it strive instead to convert selected existing institutions into world class centers of excellence and models for others to emulate?

- Adapting STI programs from advanced economies. How can successful STI programs from more advanced economies (e.g., MSI, STTR, SBIR, etc.) be adapted to address the needs of poor and middle income countries?[15] For example, would it be feasible and desirable to organize and finance a "Pan-Africa" MSI or STTR program? Should participation in such a program be open only to African universities and research institutes or could research institutes from IDCs outside of Africa participate as well? Should research priorities be driven by a purely scientific agenda or should there be clear, specific links between scientific research and a country's social and economic development priorities? What is the appropriate mechanism to balance these potentially competing priorities? If this research is financed in whole or in part with public funds, what sort of licensing and intellectual property

[15] A description of these programs is available in Annex X (not yet available).

arrangements would be needed to balance the public interest in ensuring equitable access to the newly created technology with the private sector's interest in clear ownership rights and strong financial incentives to market and disseminate these new technologies?

- Appropriate donor support arrangements. Many Bank and donor financed projects, especially in the context of PRSPs, provide assistance primarily in the form of budget support. Is budget support an appropriate *modus operandi* for STI capacity building, or should the Bank and donors foster a more hands-on approach? Budget support projects tend to be relatively less staff-intensive and are less expensive to prepare, implement and supervise than a series of smaller, more focused capacity building projects. Yet a review of previous selected Bank S&T capacity building projects suggests that a dense network of overlapping, smaller, capacity building projects may be more effective than a smaller number of larger, more intermittent projects. Will the staff and budget resources be available to support the detailed capacity building efforts that lessons of experience suggest may be most effective?

- Establishment of Cross-Sectoral Efforts. Should STI capacity building projects be organized around specific sectors – e.g., health, agriculture, infrastructure, etc. – or should they be organized around an integrated, multi-sectoral, problem solving approach – e.g., improving well being in rural villages where the vast majority of the population is engaged in subsistence agriculture or promoting technology upgrading? If the latter is preferable, what organizational, budgeting, staffing and managerial changes would be needed to implement this new approach?

- Operational implications. How can the Bank and donors ensure that STI capacity building figures more prominently in strategic policy documents? What can be done to convince Country Directors, country economists, managers, and Government officials that STI capacity building is not a "diversion" from the Bank's poverty alleviation and EFA/primary education agenda but rather an essential tool for combating poverty and establishing a vibrant private sector?

Tactical STI Capacity Building Issues

In addition to these broad, strategic questions, individual countries will address a series of specific tactical questions related to the design and implementation of their STI capacity building programs. These include:

- What are the key developmental challenges facing each country in specific sectors and industries -- agriculture, mining, newly emerging export industries, building supply chain linkages to foreign investors -- and how can STI capacity help to meet these challenges?

- How much innovation and technology upgrading is taking place today in each country? More importantly, what are the specific barriers to increased innovation and technology upgrading in each country? What institutional building efforts and high priority policy reforms – e.g., in scientific and engineering institutions, in the financial sector, in customs reform, in trade reform and openness to competition, in reducing administrative barriers and making it easier to establish new business -- would be required to eliminate or reduce these obstacles to innovation?

- Do individual firms or farmers have the capacity to identify new (for them), potentially useful technologies and to adapt them for local use? If they don't, where in the economy does this capacity exist? And if the capacity doesn't exist or if it exists in latent form but is not being effectively mobilized, what can be done to build the necessary capacity? How have other countries addressed these issues when they were at a similar, early stage of development?

- In what economic sectors does each country have a competitive advantage? In what new sectors might poor countries realistically strive to achieve a competitive advantage? What is inhibiting the development of these new sectors? What can be done to eliminate the constraints? What is the proper ratio of scientists, engineers, skilled workers, and business managers needed for the development of a particular nascent industry or sector?

- Should each country's limited STI capacity focus on serving the global market (by attracting FDI, building supply chain linkages with foreign firms, and developing such new globally competitive export sectors as fish farming, food processing, etc.) or should it be harnessed to addressing pressing regional, local, and domestic needs? How should each country establish these priorities? Are these competing claims? Is this an either-or situation? Or can countries attempt to do both simultaneously?

  What skills are needed to address these problems -- theoretical physicists? Engineers? Basic vocational skills? Basic literacy only? Elementary school teachers? Science teachers for secondary schools? Science teachers for universities? What is the critical mass of skills needed to make an impact?

- In many countries, 50% or more of GDP is produced by micro and small enterprises. These enterprises often employ indigenous knowledge and traditional technologies and have only a modest capacity to innovate and absorb knowledge. These firms also employ very few technologically savvy workers and conduct almost no R&D. Should STI capacity building programs bypass these technologically inert SMEs and focus attention on larger enterprises with more in-house capacity and potential to innovate? Or should capacity building programs attempt to build up the innovative potential of these smaller enterprises? Which strategy – helping the strongest become stronger or strengthening the weakest – will be most effective?

- Are the adverse impacts of implicit S&T policies – e.g., the impacts on STI capacity building of such non-STI policies as tax, trade policies, cost of doing business, etc. – offsetting the expected benefits of the country's explicit STI capacity building initiatives? If yes, what reforms would be required to align implicit and explicit STI capacity building policies?

- How can STI capacity building help to reverse the brain drain? What strategies and policies would help each country to engage more effectively with its Diaspora and encourage members of this community to return to the country?

- How do you disturb the low level equilibrium with catalysts that generate the cultural and social change often needed for technological advance? Is there a cultural impediment to fostering innovation? How can pervasive everyday items such as cell phones and cows serve STI capacity building by spreading technical knowledge and creating cultural change?

ANNEX 1
SCALE EFFECTS

[NOTE: THIS ANALYSIS WILL BE EXPANDED TO INCLUDE COUNTRIES FROM A WIDER RANGE OF CONTINENTS]

Scale effects will have a major impact on how countries assess the trade-offs between building the capacity to create new knowledge via investment in cutting edge R&D vs. investments designed to build the economy's capacity to import and adapt existing technology. These are very different tasks, with very different skill requirements. Technology adaptation may not have the allure or "sex appeal" of prestige world class R&D, even though the economic returns and impacts on growth and poverty reduction may be much higher. A productive dialogue on regional cooperation cannot take place unless individual countries have a clear idea of what they hope to achieve by building STI capacity, what type of STI capacity they wish to build, and how regional cooperation can complement and reinforce national efforts.

Differences of several orders of magnitude separate most Eastern and Southern African countries from more advanced countries with respect to resources available for investment in S&T, numbers of researchers available, private sector investment in technology, graduates in science and engineering, patents, journal articles published and other related variables.[16] The aggregate economic output of the seven countries listed in Table 1 below is smaller than the budgets of the three top research funding agencies in the United States.[17] Johns Hopkins University spent 50% more on research activities than aggregate manufactured exports for these seven countries (US $1.2 billion versus US$ 879 million) and the revenues from technology licensing and equity in spin-off companies in 25 US universities is greater than total FDI. Policy advice must take these differences into account and provide concrete, specific recommendations about how these countries should best harness their STI capacity building efforts to the achievement of national development goals.

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16 Differences in these S&T indicators are typically much wider than differences in per capita income. Sagasti

17 The US National Institutes of Health (NIH), National Science Foundation (NSF), and Office of Science of the Department of Energy (DOE) had a combined budget of US$ 38.75 billion in 2004.

Table 1: Indicators for Selection Southern and Eastern African Countries

Country	Pop	GDP US$ billions	GDP/ Capita	FDI (US$ m)	FDI as % of GDP	Export US$ m	Man. Exp. (US $m)	Man. As % of all Exp.
Kenya	31.3	11.2	360	45	0.4	2,094	503	24
Tanzania	35.2	9.7	290	252	2.6	875	149	17
Uganda	24.6	5.9	240	153	2.6	442	35	8
Rwanda	8.2	1.8	230	4	0.2	56	1.7	3
Mozambique	18.4	3.6	200	40	11.3	684	55	8
Zambia	10.2	3.5	340	185	5.3	970	135	14
Burundi	7.1	0.7	100	0	0.0	30	-	-
Total	135	36.4		679		5,151	879	
Burundi	7.1	0.7	100	0	0.0	30	-	-
Total	135	36.4		679		5,151	879	

Source?/Year?

Thus, even if African countries boost R&D spending (as a share of GDP) to the EU average, they will still be minor players in the global R&D arena. Like it or not, therefore, most of the economically relevant knowledge that African firms will need to use if they are to boost productivity and compete internationally will be produced elsewhere. Each country's success in the global economy will depend as much on the ability and willingness of local enterprises (both foreign-owned and domestic) to adapt and utilize knowledge produced outside the region as it will be for African scientists to produce knowledge inside Africa. Policy makers and business executives, therefore, need to devote attention to enhancing the economy's ability to scour the world for knowledge, import it, adapt it for local use, and integrate it into local production processes.

ANNEX 2
BRAIN DRAIN IN AFRICA[18]
Prepared by Tatyana Soubbotina

[NOTE: THIS ANALYSIS WILL BE EXPANDED TO INCLUDE A WIDER RANGE OF COUNTRIES.]

Sub-Saharan Africa has the lowest share of skilled workers among residents in the world. But in terms of the share of skilled workers born in the country who have emigrated from the country, Sub-Saharan Africa has one of the highest rates of skilled emigration,[19] trailing only the Caribbean and Central America (see Table 1).

Table 1. Rates of skilled emigration by world regions, 2000

	Share of skilled workers among residents, %	Rate of emigration, %	
		Total	Skilled
North America	51.3	0.8	0.9
Australia & New Zealand	32.7	3.7	5.4
Europe	17.9	4.1	7.0
South America	12.3	1.6	5.1
Central America	11.1	11.9	16.9
Caribbean	9.3	15.3	42.8
Asia	6.3	0.8	5.5
Africa:	4.0	1.5	10.4
- Northern Africa	7.5	2.9	7.3
- Southern Africa	8.7	1.0	6.8
- Western Africa	2.4	1.0	14.8
- Eastern Africa	1.8	1.0	18.6
- Central Africa	1.6	1.0	16.1
Sub-Saharan Africa	**2.8**	**0.9**	**12.9**

Within SSA, small countries have the highest emigration rates of skilled workers: Cape Verde (67.5%), Gambia (63.3%), Seychelles (55.9) and Mauritius (56.2%).

This can be partially explained by the difficulty of achieving agglomeration and other scale effects particularly important for establishing successful knowledge-intensive industries. But in many SSA countries with populations over 5 million, the rates of

18 This discussion draws from Frédéric Docquiera and Abdeslam Marfouk, "Measuring the international mobility of skilled workers (1990-2000) - Release 1.0." Available for download at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=625258

19 Skilled emigration is defined as number of emigrants with at least tertiary education in proportion to the total labor force with the same level of education born in the source country.

skilled emigration are also extremely high: Sierra-Leone (52.2%), Ghana (69%), Mozambique (45.1%), Kenya (38.4%), Uganda (35.6%), Angola (33%), Somalia (32.7%), Rwanda (26%), Malawi (18.7%), Cameroon (17.2%), and Zambia (16.8%).

At the other extreme are several SSA countries with very low rates of skilled emigration: Swaziland (0.5%, same number for the USA), Chad (2.4%), Burkina Faso (2.6%).

Among SSA countries, only South Africa probably benefits from skilled immigration, mostly from neighboring countries. There were 1.3 million immigrants to South Africa in 2000 and about 19% of adult immigrants were recorded as having tertiary education.

Overall, Africa is the continent most affected by the brain drain. As anywhere else, it reflects the oversupply of educated workers relative to economic demand for them. For example, according to the World Economic Forum global survey, enterprise managers in Ghana and Kenya tend to consider scientists and engineers in their countries "widely available" (WEF, 2005, p.508) even though the rates of skilled emigration in these countries are very high (see above). However the lack of economic demand for scientists and engineers does not mean that their services are not needed at home. Most SSA economies suffer from low availability of educated personnel (in government service, in various enterprises, in R&D, and in education itself, see Fig. 1), but fail to create sufficient economic and/or institutional incentives for 'brain retention'. If nothing changes, the recent growth of tertiary enrolment rates in many SSA countries will run the risk of leading to further brain drain. Moreover, increased foreign aid to tertiary education in Africa can itself lead to higher skilled emigration rates rather than to higher shares of people with tertiary education in African countries' labor force. Linking education policies directly to economic and technological policies is essential to reduce the imbalance between the supply of and the demand for workers with tertiary education in SSA.

Some researchers argue that brain drain should not be interpreted as a sheer loss to a source country, because in the longer term this country might still benefit from return migration of its former residents bringing in foreign knowledge and skills, and because having extensive foreign diasporas can be instrumental for building business relationships between the sending and the receiving countries (networking effects). However, with respect to sub-Saharan Africa these arguments are undermined by recently published data on the extent of the so-called 'brain waste' suffered by many African countries. According to the US Census Bureau, only about 40% of Ethiopian, Ghanaian, and Nigerian males with bachelor's degrees who arrived in the USA during the 1990s managed to obtain skilled jobs as of 2000 (compared to 76% of skilled immigrants from India, 70% from Hong Kong (China), and 69% from Ireland). The problem of 'brain waste' appears to be somewhat less acute for Kenya (52% of it's emigrants to USA found skilled jobs by 2000) and South Africa (62%). But for most SSA countries skilled emigration does represent considerable economic loss even in the longer term – economic loss associated not only with the loss of embodied education costs, but also with the economic damage from reduced skill-intensity and competitiveness of domestic production processes. The risk of losing best-trained workers due to high probability of emigration can even motivate domestic managers to abstain from personnel training and make production and technology decisions matched to lower skill levels (Commander, Simon, et al., 2003, p.25).