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Issues Paper on

Science, Technology and Innovation (STI) for the Post-2015 Development Agenda

ADVANCE UNEDITED VERSION

Science, Technology and Innovation (STI) for the Post-2015 Development Agenda

(i) Taking stock: a decade of Commission on Science and Technology for Development contributions to the Millennium Development Goals;

(ii) Looking forward: science, technology and innovation prospects for the post-2015 development agenda.

Paper by the CSTD Secretariat

1. Introduction

At the end of the second Millennium, the development community established a set of ambitious goals to be reached by the year 2015. As that year approaches, and as the community assesses and learns from what has and has not been accomplished under those Millennium Development Goals, the question of new goals for the post-2015 period arises. What is the situation now and what is desired for the future: is a question that looms large for scholars, thinkers and policy makers alike.

There have been important successes over this period of time. At the same time, there have been opportunities to reflect on what cross-cutting factors influence the achievement of overall poverty reduction and sustainable development across countries and how these need to be better factored into such a goal-setting process. One of these cross-cutting issues is the role of science, technology and innovation. Science, technology and innovation (STI) impact upon the process of inclusive and sustainable development in multiple ways. A growing recognition of these multiple channels of impact is paving the way to the global recognition that any discussion on the new global partnership for development in the post-2015 context is incomplete without a consideration of issues of science, technology and innovation. Recent work on the post-2015 agenda has taken a step in the right direction by recognizing the importance of knowledge capacity in the new developmental agenda (United Nations, 2012; ECOSOC, 2013).[1]

The Commission on Science and Technology for Development (CSTD), in its 16th session held in June 2013, selected the following as one of its priority themes for 2013-2014: *Science, technology and innovation for the post-2015 development agenda.* The CSTD further stipulated two important subthemes under this topic, namely, (i) Taking stock: a decade of Commission on Science and Technology for Development contributions to the Millennium Development Goals; (ii) Looking forward: science, technology and innovation prospects for the post-2015 development agenda. This priority theme has been chosen by the CSTD to reflect upon the significant work that has been ongoing for the past decade, not only to take stock of the main findings but also to see how the CSTD can perform its role as the 'torch bearer' on science, technology and innovation issues for the road ahead.

This Issues Paper has been prepared by the UNCTAD Secretariat to facilitate debate and discussion at the Inter-Sessional Panel of the CSTD. The paper is divided into two essential parts. The first part of the issue paper reviews the decade-long work under the auspices of the CSTD on issues of Science and Technology towards the Millennium Development Goals. The second part discusses the key issues in ensuring that STI is firmly placed as a key issue in development within the post-2015 context. Specific recommendations for the way ahead in general, and for the CSTD, are covered at the end of the paper.

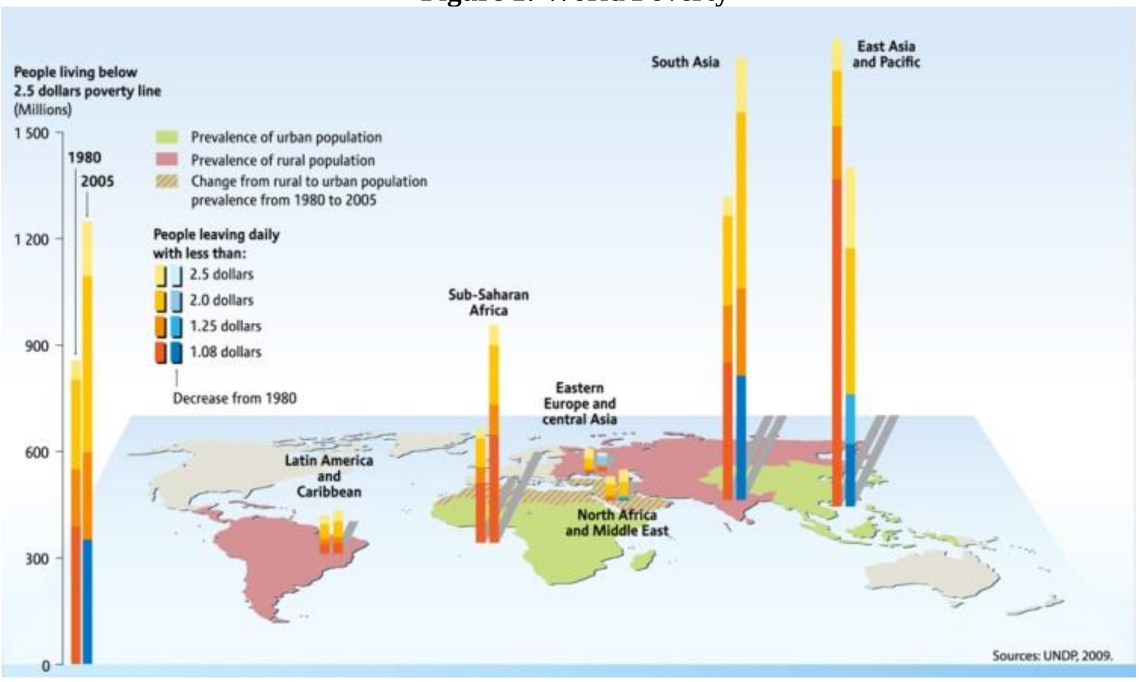
[1] UN System Task Team on the Post-2015 UN Development Agenda: Realizing the Future We Want, A Report to the Secretary General of UNCTAD, New York, 2012.

2. The important role of Science, technology and innovation to development

2.1. Poverty, inequality and the road towards sustainable (environment-friendly) development

Poverty, inequality, and environmental degradation are three great challenges for development. The first of these, poverty is both sign and symptom of the need for development. Where poverty appears around the world, the conditions that development needs to address are apparent.

Figure 1: World Poverty[2]

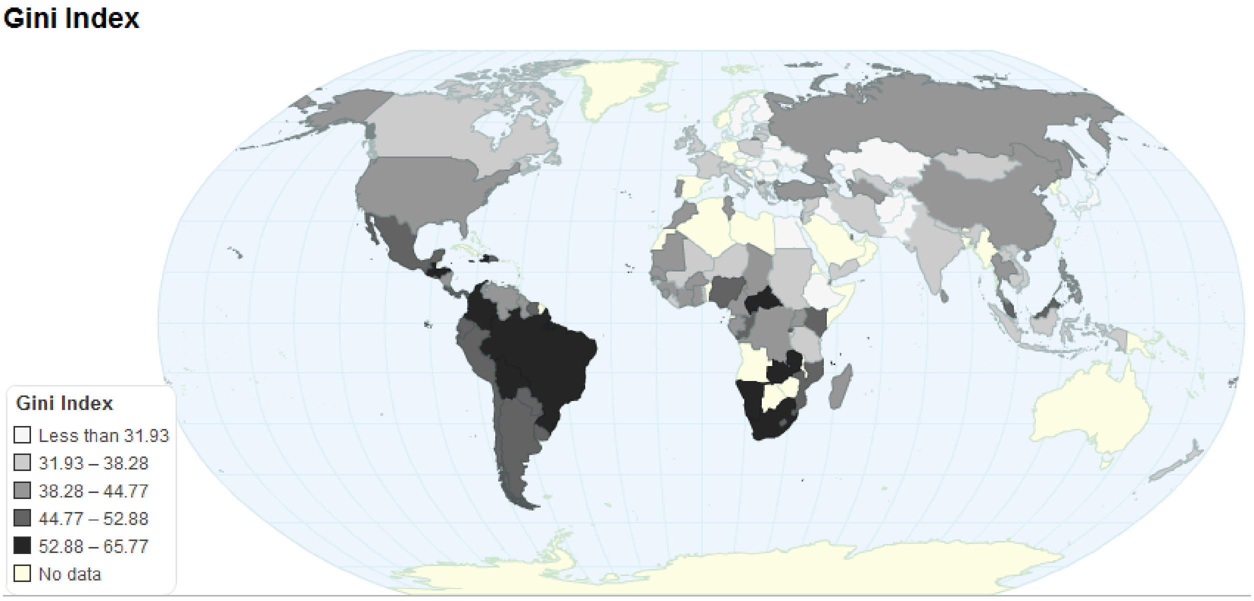


Multidimensional poverty[3] is reflected in many elements of daily life that STI can influence. Education is the soil in which the most powerful kinds of innovation grow, where family and community inventiveness combine with scientific and technical knowledge. The household environment is crucial to well-being, so improvements in cooking fuel, toilets, water, electricity, and housing form a foundation for inclusive development. Finally, nutrition reflects a combination of new knowledge and effective markets, linking food producers with food consumers. Household environment and nutrition are both keys to reducing child mortality and increasing the number of healthy, productive adults and children who grow up as engaged problem-solvers.

Inequality, the second challenge, is an indicator of whether development is inclusive (Sen 1992). In order to meet the development challenge, policymakers need to pay attention to both horizontal and vertical inequalities (Stewart 2002). Vertical inequalities are the distances between rich and poor; while horizontal inequalities are the distances between advantaged and disadvantaged culturally-defined groups, such as genders, races, and religious groups.

[2] http://www.grida.no/graphicslib/detail/world-poverty_6efd, accessed November 25, 2013
[3] http://hdr.undp.org/en/statistics/mpi/, accessed November 25, 2013.

Figure 2: Income inequality within countries



Source: http://chartsbin.com/view/6097, retrieved November 16, 2013.

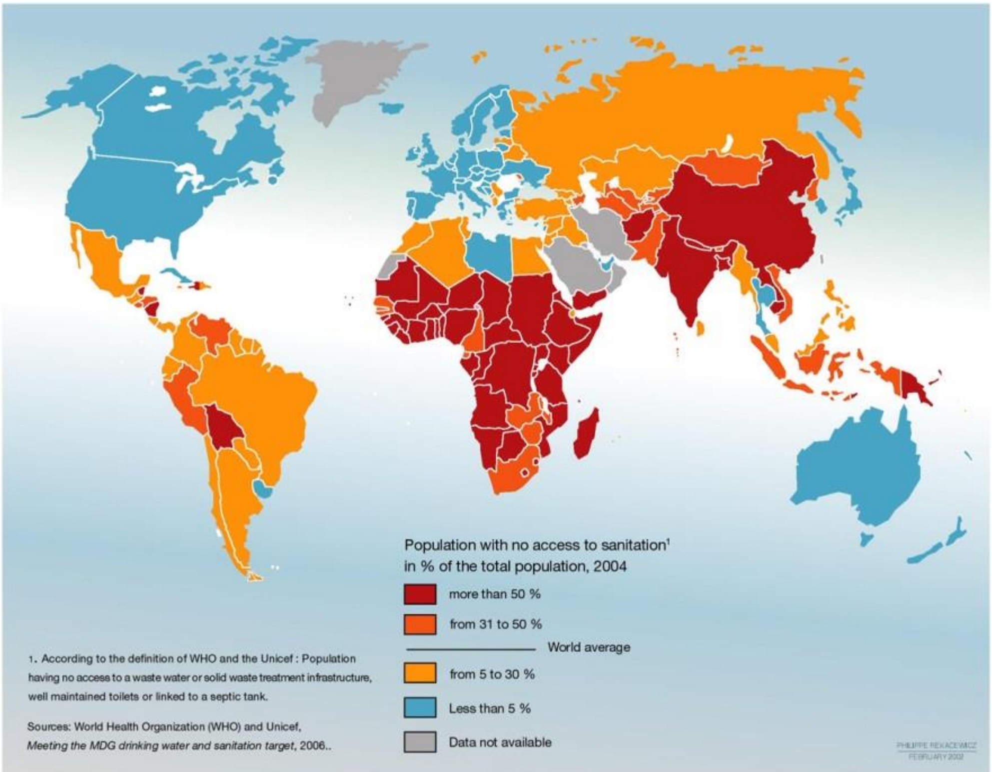
A higher Gini index points to greater inequality.

Unequal distribution of income is one dimension of inequality, but not the only one. Access is often unequal to all the resources just described – education, sanitation, water, electricity, housing, nutritious food, and healthcare. Disadvantage in these basic needs areas contributes to the sense of exclusion and disempowerment. Decreasing income inequality is therefore only one sign of an inclusive development process. What happens in everyday life is even more important. In inclusive development, people in previously marginalized communities build confidence in their own abilities, find ways to use their skills to earn money, learn new capabilities, and contribute to economic growth. In a highly unequal society, science, technology, and innovation are often elite activities, serving a few people and industries. In inclusive development, scientists and engineers become partners of disadvantaged communities as well, contributing their knowledge to address challenges collaboratively. In inclusive development, science, technology, and innovation are not restricted to laboratories and frontier technologies, but contribute to solving day to day challenges.[4]

Environmental degradation, the third challenge, is the symptom of unsustainable socio-environmental systems. Where there is pollution, deforestation, and depletion, the development effort needs to be intensified.

[4] http://www.undp.org/content/undp/en/home/ourwork/povertyreduction/focus_areas/focus_inclusive_development.html, accessed November 25, 2013.

Figure 3: Access to sanitation[5]



Access to electricity is very unequally distributed globally. In some parts of the world, less than 10% of households are connected to energy grids. Energy systems must therefore be transformed on a global basis to spread the advantages of electricity without excessive greenhouse emissions; science and engineering have a central role to play in that redesign. Similarly, one out of every six people lack access to clean water, and twice that proportion do not have access to basic sanitation. These problems constitute one of the main global challenges engineers have identified for their profession.[6] To protect water supplies, ecologists and hydrologists need to combine efforts with households, communities, and industries to find sustainable production processes so that economic growth can be sustained over the long term.

The way these three challenges are addressed will be quite different in various national contexts, but in all cases are linked to innovation processes, with contributions from science and technology. For example, at one end of the spectrum, the least developed countries are rich in challenges and poor in STI resources. Political turbulence and sporadic violence undermine efforts to build science institutions and to encourage innovation in the private sector. Targeted efforts to bring technical and local knowledge together, however, can lay the groundwork for inclusive and sustainable development, which must rest on a base of increasing educational attainment for the whole population. At the other end of the spectrum are the newly industrialized economies that have found successful pathways to technology-based economic growth, with varying success on its inclusive elements. Between the two extremes are most developing countries, attempting to build their STI capabilities while attracting foreign investment and building competitive national firms in both services and

[5] http://www.grida.no/graphicslib/detail/total-population-access-to-an-improved-water-source_12f5, accessed November 25, 2013.
[6] http://www.engineeringchallenges.org/cms/8996/9142.aspx, accessed November 25, 2013.

manufacturing. Nevertheless, these strategies do not automatically lead to inclusive and sustainable development. Active efforts must be made to direct STI to those broad goals.

2.2. Linking STI capabilities to the fundamental challenges of development

Developing science, technology, and innovation capacity is a key enabler that promotes the ability of countries to deliver essential public goods, such as greater food security, access to health for all, climate mitigation and adaptation, and access to energy for all. In this context, promoting access to new and appropriate technologies helps to achieve steady improvements in living conditions, which can be lifesaving for the most vulnerable populations, and drive productivity gains which ensure rising incomes.

Secondly, in addition to its role in providing global public goods, STI serves as a crucial driver of rising prosperity and improved national competitiveness. However, a growing technological gap amongst countries implies that different countries have varying ability to make use of existing technologies to promote competitiveness of enterprises and industries. Technological knowledge and skills are cumulative, and depend on the presence of good education (particularly at the secondary and tertiary levels) and research capabilities.
Finally, science, technology and innovation have a critical developmental dimension: they are important prerequisites to ensure an ongoing process of structural change that leads to economic diversification, catch-up growth and rising living standards. Ultimately, such sustainable development alone holds the key to poverty reduction, employment creation and prosperity for all.

A well-functioning STI *ecosystem* needs to include, inter alia, political stability and well-functioning institutions, an educated workforce; sound research and education infrastructure and linkages between public and private innovation actors; enterprises committed to research and development; as well as a balanced intellectual property rights (IPRs) framework. Given that knowledge exhibits several properties of a public good, there is a persistent danger of underinvestment, and policymakers have increasingly sought to improve the incentives to create and transfer knowledge from publicly funded research to enterprises, thereby reinforcing the impact of that research on innovation capacity. But in addition to national strategies, regional and international frameworks including the UN and its agencies, funds and programmes must respond in new ways to ensure that innovation is integrated into national development priorities, particularly in a large number of developing countries and least developed countries (LDCs), where the technological divide is greatest. These varied responses are required because STI *ecosystems* have become more complex and are now built on a mixture of collaboration and competition involving market incentives but also private and public partnerships that cross borders.

In order to understand the connections between inequality, poverty, and STI, the results of science, technology, and innovation must be understood not just as technologies but as sociotechnical systems (Fressoli, Smith et al. 2011). The answers to societal challenges cannot be expected to come from technologies alone, but rather from how technologies are developed and used in the overall development process. A sociotechnical system is the way humans and technologies work together to produce outcomes (Bijker, Hughes et al. 1987). For example, a transportation system is not just vehicles and roadways, but also how people drive, ride, build, and maintain them. A drug designed to save lives, like insulin, can actually kill if it is used in a sociotechnical system that does not support the discipline it requires: reading instructions, timing and control of dosage, equipment disposal, etc. Many poor households might not have the human or physical infrastructure to become part of that system (Gatchair, Bortagaray et al. 2014).

Applying STI to inclusive and sustainable development involves three related approaches: addressing basic needs; grassroots entrepreneurship; and promoting inclusive growth by building STI capabilities. The first approach is to stimulate innovation in the sociotechnical systems that meet the ***basic needs*** of households, such as food, water, sanitation, health, housing, and transportation. As introduced briefly above, all these have technological elements. The systems that meet the needs can be complex combinations of household, community, public, and private action. Some examples from the realm of water illustrate the principle:

- A first example comes from South Africa, from a semi-rural area outside a major city. South African law requires that municipalities provide a certain amount of free water per person each day. (Note the first element of the system, namely, policy.) Households in this area are scattered, so the municipal engineer developed a system that delivers city water at night to holding tanks in each household. (Engineering knowledge comes into play, along with the organizational element of the public utility.) The households participate in the design of the system by asking for a separate tank for each part of the family, and make sure they protect the clean water once they draw it from the tank. The utility provides jobs for several local residents to install and maintain the water tanks and lines (Cozzens and Catalan 2008).

- Costa Rica is the site of a second example. The national water laboratory gets an idea from their colleagues in Spain (cross-national communication appears as an element in the system) for a contest among villages in design and operation of community water systems. They set up the contest, lend their expertise, and the communities organize bottom-up to identify their needs and design systems. (community leadership and cohesion appear as important social elements in the system.) Communities that depend on another organization to do the job or are divided internally between cultural groups have a harder time putting effective water systems in place. (The key variable of organizational and social context appears.) The technology that the communities put to use is largely off-the-shelf, but it did not work to solve local problems until the organizational and technical innovation of the contest came into play (Catalán 2012).

In the best of all possible worlds, the way the basic needs are met should be linked to livelihoods, so that improved living conditions and incomes grow together. ***Community action, public engagement,*** and ***grassroots entrepreneurship***, the second general approach, are important engines of development. Another example from the water sector is illustrated below:

- This example comes from Brazil, where a rural community, with help from a university researcher but contributing much practical and local knowledge, invents a new, simple, and efficient pump to draw water from the underlying aquifer to provide more consistent irrigation. (A combination of different kinds of expertise, the local problem as a stimulus, and the social connection to the university.) The community commercializes its invention and, hopefully, it is sold to many similar communities. (Entrepreneurship becomes an element in the system.)(Soares, Cassiolato et al. 2008)

Grassroots entrepreneurship is also the centerpiece of the HoneyBee Network in India, which focuses on finding local inventions and providing the environment that can turn them into innovations that survive in the market (Gupta 2003). The sociotechnical aspects are illustrated by the fact that the inventor and invention by themselves would be unlikely to succeed, but the organizational complements that HoneyBee provides lead to quite a different outcome.

The HoneyBee approach has been adopted at national policy level in India in the form of the National Innovation Foundation.[7]

The third approach is promoting ***inclusive growth*** by building STI capabilities over time. The Republic of Korea illustrates this, in the earlier stages of its development (Kim 1997). Korea was a very poor country at the end of World War II, although one with a rich cultural heritage of literacy and entrepreneurship. A strong, government-led effort carried out by a few large conglomerate firms and aided by outside expertise first brought Korea into international competitive range, then put it on a footing to be able to innovate, not just imitate. The rapid expansion of manufacturing was possible because the educational level of the population was already high, and the expansion itself brought many women into the labor force (although on a job-segmented basis with a large wage gap) (Seguino 1997). The resulting supplement to family incomes reduced household income inequality dramatically over a relatively short period of time. The case illustrates that the sociotechnical systems that allow firms to be formed, survive, grow, and provide jobs are essential. Governments need to provide the institutional, human, and physical infrastructure for business growth, as well as setting and enforcing the regulatory framework for the kinds of businesses that bring inclusive and sustainable development.

Technologies have not created these accomplishments on their own, nor have policies created them on their own. Neither firms, nor workers, nor households did this by themselves. Instead, the co-evolution of industries, public organizations, governance frameworks, workers, and families together is crucial for inclusive and sustainable development.

3. Taking stock: a decade of work on science and technology issues in the CSTD

Through its priority themes, the CSTD has worked on a range of science and technology issues that are relevant for development over the past decade. The priority theme papers that were presented and deliberated by experts and members in the CSTD Panels and Sessions can be grouped under five significant thematic areas of work. These are:

1. Science, technology and innovation for the MDGs, and bridging the technological divide

2. Science, technology and innovation to meet social goals, such as health, agriculture and energy

3. Science, technology and innovation for capacity building, particularly through education and research

4. ICTs and the digital divide

5. The impact of new technologies on development

3.1. Science, technology and innovation and the MDGs, and bridging the technological divide

As part of the CSTD's reflections on the technology gap between countries and how STI can help promote the MDGs, in 2004, the discussions focused on 'Promoting the Application of Science and Technology to Meet the Development Goals Contained in the Millennium Declaration'. Earnest discussions on the role of science, and technology highlighted the policy challenges related to the application of science and technology in developing countries. The Commission discussed four main issues that were relevant from the point of view of

[7] http://www.nif.org.in/, accessed November 25, 2013

promoting the application of science and technology for development through discussion and sharing of national experiences and best practices:

a. Improving the policy environment for the application of science and technology for development by identifying potential risks and benefits of new and emerging technologies.

- While the advantages and beneficial applications of technological progress have been extensively analyzed, the attention given to risk assessments of new technologies, notably biotechnology and ICTs, has been mixed.
- Potential risks of biotechnology that were identified include its impact on the environment, human health, and livelihoods. Concerns were raised that Governments in developing countries do not have sufficient capacity to regulate and manage those risks.
- Potential risks of new ICTs that were identified consist of breaches of security in communications pose a threat not only to the privacy of individuals, but also to the competitiveness of industries as well as to countries' national security.

b. Strengthening basic and applied research in developing countries and international scientific networking.

- Commercialization of research results is one way of financing research. However, this prospect has presented several difficulties, particularly in developing countries. Some of these difficulties include: issues surrounding intellectual property rights (IPRs); problems in the development stages of getting the product to market; and difficulty in mobilization of funds.
- Another important issue here is the brain drain and the lack of science infrastructure in developing countries. On the other hand, while brain drain is a serious problem, its consequences are not entirely negative. The work experience gained abroad by scientists from developing countries may well prove valuable upon their return to their home countries, hence increasing the prospects for knowledge transfer.
- Various forms of public-private partnerships have emerged, partly in recognition of the fact that developing countries, just like richer ones, are unlikely to meet the challenges of emerging technologies by using strategies that separate the different institutions.

c. Strengthening technology support institutions and science advisory mechanisms; building human capacity; identifying new technologies and applications; and encouraging international collaboration to support research in neglected fields.

- It is desirable to have a science advisory body within Government whose role is to provide accurate, relevant and impartial advice on science and technology. Such an advisory body would help avoid confusion and duplication as well as maintain policy coherence.
- This is important, since science and technology have relevance for all policy areas and hence concern all ministries and agencies for the Government. In some countries, the role and procedures for obtaining science and technology advice are formalized in legislation.

d. Promoting universal Internet access at affordable costs and building strategic partnerships in the field of science and technology for development and capacity building for competitiveness.

- In the efforts to achieve the MDGs, the Commission recognized that the use of ICT plays a crucial role. For example, ICT can be used for distance training of teachers and health workers. ICT can also help broaden the availability of quality educational resources and health-related information. They also allow better monitoring of diseases, famine and environmental degradation.
- Having the physical infrastructure needed for universal access is not by itself sufficient for addressing the problems developing countries face. Accurate and

appropriate information needs to be provided before ICTs can be disseminated. Thus, each country should have a research community in science and technology that can respond to local socio-economic challenges. Without such capacity, it is not possible to realize fully the potential benefits of ICT for development.

- Technical requirements vary depending on the purpose for which ICT use is intended. For providing universal internet access, it is important to have numerous access points as widely as possible. In contrast, research institutions and universities may number few but require high-capacity internet access. Thus, ICTs might be introduced at two levels, one consisting of low-capacity ICT applications (e.g. e-government, e-education. e-health etc) for use by the public at large. The other consisted of high-capacity and state-of-the-art technology (e.g. for networking research institutions and universities).

On the question of bridging the technological gap, the Commission's work concludes that innovative strategies are needed to enable the effective harnessing of existing as well as new and emerging technologies, such as information and communication technologies (ICTs) and biotechnology.[8] These strategies would reduce the costs of, and increase the likelihood of achieving the MDGs. At the same time, existing technologies provide lower-risk, lower-cost opportunities for new businesses to gain footholds by applying such technologies to address specific local needs. For example, agricultural activities can be greatly enhanced through more mature technologies such as small-scale irrigation, quality fertilizers, farm mechanization and enhanced crop seed. Significant strides in health care can be made through existing drinking water systems and generic drug manufacturing.

Key findings on the issue of technological gap include:

(a) In spite of technological achievements made by some developing countries in recent years, the "technology gap" between nations remains wide. For instance, one billion people do not have access to telephones and around 8 million villages or 30 per cent of all villages worldwide are still without any kind of connection. The gap exists not just in the creation and diffusion of technologies, but also in domestic abilities to put available technologies into effective use.

(b) The gap is also evident in education. Mean years of schooling in 2003 was 12.1 years in the USA, 4.2 in Kenya and 0.8 in Guinea Bissau. Similarly, the tertiary science enrolment ratio in 2003 was 27.3 per cent in Finland, 5.5 per cent in Colombia, 2.4 per cent in Albania and only 0.1 per cent in Chad.

(c) Technology achievement indices such as UNCTAD's Innovation Capability Index (ICI) measure the quantitative components of National Innovation Systems (NIS). Within this framework, sub-Saharan Africa has not made any significant gains in its innovative capacity between 1995 and 2001 and continued to have the lowest index values among the regions.

(d) Technology is not just slow in diffusing across the national borders but also within the borders. This gap within nations is a phenomenon that exists in both developing and developed countries. Within the technology gap, special attention should be devoted to the digital divide. The digital divide is defined as a growing asymmetry in the capacity of firms, institutions and individuals in different countries to use ICTs effectively in accessing and applying knowledge, and thus, spurring competitiveness and innovation. The digital divide between the information-rich and the information-poor remains significant – at twice the average levels of income inequality – and is therefore a source of increasing concern.

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[8] See CSTD Issues Paper and discussions on priority theme titled *Bridging the Technology Gap Between and Within Nations*, CSTD Inter-sessional Panel, 10-12 November 2005, Rabat, Morocco.

(e) Comparative Gini coefficients reveal that older technologies such as fixed phone lines are more equally distributed. Yet, also revealed by the Gini coefficients is that relative to other sectors, the mobile phones sector has demonstrated a leapfrogging by achieving much wider and faster technology diffusion, effective usage and the establishment of a dynamic sector.

The policy recommendations of the CSTD on this theme include the following:

(a) It is apparent that the markets alone often do not facilitate the desired rate and level of technological diffusion and upgrading. Policies and capacity building efforts are needed to stimulate the diffusion and the effective usage of technological diffusion in countries. These efforts include both domestic (autonomous) efforts, such as human capital development, improving physical and services infrastructures; and global efforts, such as international technology transfers and internationally coordinated projects.

(b) Most developing countries do not innovate at the technological frontier. Instead, they acquire, adapt, diffuse and use technologies that are developed in industrialized countries. Main channels of technology transfer are capital equipment imports, followed by foreign direct investment (FDI) inflows. Licensing seems to play a much lesser role. Policy efforts should focus on promoting these channels of technological exchange.

(c) The opportunities offered by globalization of technology and international technology transfers are not fully and equally grasped by most developing nations. For example, while East Asian countries such as Thailand, Malaysia and China spend more than 40 per cent of their import expenditures on capital equipment, for sub-Saharan Africa and India, equipment imports constitute only 15 to 23 per cent of their total imports. The policy challenge is thus how governments should build local capabilities to target and facilitate acquisition of technology through FDI. Specific policies need to be formulated to attract FDI with high technology content and increase its potential contribution to the transfer and diffusion of technology, and to the building of local capacity. Therefore, policies on technology transfer through FDI should focus not only on the "physical" aspect of investment, such as imports of machinery and equipment, but also on the acquisition of information and knowledge.

3.2. Science, technology and innovation to meet social goals, such as health, agriculture, and energy

The commission considered the potential of STI to meet three social objectives particularly at length over the past decade: energy, agriculture and technologies to promote sustainable urban growth.

3.2.1. New and Emerging Renewable Energy Technologies for Sustainable Development[9]

Access to electricity and modern energy services can contribute to: *inter alia*, higher yields in agricultural production; increased access to information and telecommunications; improved health and quality of healthcare; and improved an standard of living in general. It also contributes significantly to gender equality and education. Green and renewable energy technologies have been recognized as particularly appropriate for developing countries. In the context of rural areas where transmission and distribution infrastructure is a problem, producing renewable energy locally can offer a viable option.

[9] See CSTD Issues Paper and discussions on priority theme titled *New and Emerging Renewable Energy Technologies for Sustainable Development*, CSTD Inter-sessional Panel, 2009-2010, Geneva, Switzerland.

Discussions on new and emerging renewable energy technologies identified some of the key challenges related to their development and deployment in developing countries, through comparative analysis of selected case studies. The main areas of focus were how to promote the role of Science and Technology Ministries in developing countries in the debate on renewable energy, how to promote inter-ministerial coordination and policy coherence, and what lessons stand out from the policy experiences amongst the developing countries of Asia. The Commission sought to identify key success factors, with a view to stimulating discussion on good practices and policy options for building innovative capabilities, and promoting effective diffusion of these technologies.

The Commission concluded that effective diffusion and development of renewable energy technologies require strong policy initiatives, large investments in infrastructure, long-term commitment in R&D activities, and tailoring innovation to local opportunities, capabilities and needs. Thus, the challenges are of a multidimensional nature. The Commission further identified policy considerations for the effective promotion of renewable energy technologies at the local, national, regional, and international levels.

At the national and local level, the CSTD pointed out policy challenges that call for immediate attention such as (a) private sector development, (b) supporting universities and public research centers, (c) providing incentives for R&D at firm level to support technology deployment in niche markets and (d) Government procurement.

At the regional level, a primary policy issue is to promote collaboration, which can take the form of research centres and networks of excellence for energy technologies, joint-ventures or bilateral projects. These provide venues for exchanges of knowledge and experiences in basic research, technical demonstration, business skill trainings, financial techniques, policy and regulatory advice and support, and market analysis to be adapted to local conditions and challenges.

The Commission's work on renewable energy technologies identified several issues that need to be addressed, strengthened or reviewed at the international level, including:

(a) At the technical front, international organizations should continue to provide support for technical assistance in training, capacity-building, and strategic planning to promote new and renewable energy sources and technologies.
(b) At the financial front, large-scale resource mobilization has been committed by the World Bank, the Global Environment Facility (GEF) Fund, the proposed New Deal Fund, the regional development banks and the international investor groups (REN21) to accelerate investments in technological changes, thereby mitigating climate change impacts and supporting economic diversification and creating employment opportunities.
(c) At the political front, it is necessary to address the unresolved issue of how to balance trade and IP regimes for technology transfer, processes and production methods. Measures such as subsidies, public funding, preferential loans, export credits guarantees, and local content requirements are and will continue to be used to support the transfer and development of these technologies. International efforts should actively support North-South and South-South cooperation in the development of renewable energy technologies (e.g. open source software, Eco-Patent Commons, global technology patent pools).

3.2.2. The Role of Technology and Innovation in Sustainable Agriculture

Improving agricultural productivity in developing countries remains a key challenge even today. Technology and innovation are essential to achieve this aim and promote sustainable agriculture in the developing world. Agricultural innovation systems involve the integration of different sources of knowledge, including local knowledge. For example, women and other marginalised groups often hold local knowledge of low-impact, low-cost methods and coping strategies that can make farming systems more resilient. Conditions that nurture eclectic approaches to innovation must exist and competitors need to work together to continually adapt institutional and policy frameworks for innovation. Coordinated networks relevant to specific challenges, opportunities, or locations are required along with supporting policies. Scientists, policymakers, consumers, and entrepreneurs need to align to mobilise knowledge and continuously innovate.

However, there are opportunities and challenges alike in promoting agricultural innovation. Particular attention needs to be paid to promoting technologies and practices relevant to sustainable agriculture for smallholder farmers in developing countries. A range of promising, existing science and technology applications and farming practices at all stages of agricultural processes can significantly increase agricultural productivity. New genotypes of crops and advances in breeding, biotechnology, remote sensing, integrated pest and nutrient management, and information and communication technologies (ICTs) can make agriculture more resource-efficient and site-specific. Some of these technologies, applications, and sustainable agriculture practices may well be suited for smallholder farmers such as

- Adequate water management,
- Healthy, nutrient-rich soil,
- Improved plants, livestock and fish,
- Available, affordable ICTs,
- Post-harvest enhancements, and
- Sustainable agricultural systems.

The CSTD dealt with this set of issues in order to highlight the importance of new and traditional sustainable production methods and related skills and technologies; an inclusive innovation environment; improved and revitalised agricultural research, education, and extension services; targeted increased investment; financial tools; and to deliberate upon the appropriate forms of policy support.[10]

The main policy considerations that were highlighted in this context are the following:

(a) Sectoral mechanisms are critical for coordinating the interaction needed for innovation.
(b) National innovation coalitions and innovation platforms around particular technologies, policies, or processes can be effective vehicles for innovation. There is also room for increased collaboration among international agricultural research centres and national agricultural research systems (similar to the work of the CGIAR).
(c) Successful agricultural innovation requires attention to all the components of agricultural innovation systems including research, extension, credit and technical support, healthy markets, functioning infrastructure, and a supportive policy and institutional environment.
(d) Local and national governments, as well as international organisations can facilitate and develop R&D capacity by investing in education and promoting new skills and technologies among farming communities. Resources spent on promoting R&D activities should be linked to local demands for specific products, processes, and services in agriculture.
(e) Extension services require sufficient resources to enable technology transfer, both for the government and the farmers. Extension services should ensure that there are effective means of disseminating up-to-date information, and that there is sufficient communication with farmers.

[10] See CSTD Issues Paper and discussions on priority theme titled *Technology and Innovation for Sustainable Agriculture*, CSTD Inter-sessional Panel, 2009-2010, Geneva, Switzerland.

(f) Sufficient financing is one of the key requirements for agricultural science, technology and innovation. Increased investments in agricultural knowledge, science and technology, particularly if complemented by supporting investments in rural development such as infrastructure, telecommunications, and processing facilities, can yield high economic rates of return, reduce poverty, and have positive environmental, social, health and cultural benefits.

(g) An open approach to innovation should be supported by science, technology, and innovation policies. This involves addressing the issues pertaining to intellectual property rights, increasing the intensity of R&D, and actively attracting leading researchers. Intellectual property rights regimes that protect farmers and expand participatory plant breeding and local control over genetic resources and related traditional knowledge can increase equity.

Further areas of work were identified by the Commission that need to be addressed in order to assist smallholder farmers in developing countries. These included:

- Trade policies and tools at the international level;
- Financial incentives to promote the adoption of sustainable agricultural technologies and farming practices;
- Steps needed to revitalise and strengthen extension services;
- Reducing the cost of organic fertiliser, seeds and other inputs;
- Promotion of aid harmonization and alignment with national structures and priorities;
- Making use of new or existing means to share ideas and approaches to fostering agricultural innovation and supporting smallholder farmers.

3.2.3. Science, technology and innovation for sustainable urbanization

As outlined in the Rio+20 Conference outcome document, cities in the developing world face challenges that cover a wide range from urban sprawl and traffic congestion to inefficient buildings and unplanned informal settlements. In addition to haphazard and unplanned city growth, peri-urbanisation is a process that is closely linked with urban sprawl. It refers to urban growth into zones that lie between the city and rural zones, sometimes also referred to as “spill-over growth”, usually without spatial planning and the provision of basic services. Development of the city fringes that undergo peri-urbanisation is most often triggered by a real-estate boom that accompanies rapid urban growth. Populations that were previously rural benefit from new economic dynamism in manufacturing and services brought by urbanisation, but they do not always enjoy improvements in quality of life.

The CSTD therefore explored potential pathways for more inclusive urbanisation that take into account the needs of peri-urban zones, as enabled by science, technology and innovation.[11] In particular, the Commission's focus was on innovative planning, technology and governance models already in use in several cities across the globe ranging from spatial planning to mobility, from energy to waste management and from the built environment to disaster resilience in order to address these complex challenges.

Against this background, the CSTD's work on the topic draws on current research and cases from around the world to analyse those sectors of urban management where developing countries face the biggest challenges. There are a range of policy initiatives that can impact upon city planning and development in the developing world, promoting quality of life and livelihood to all. Improvements in spatial planning and mobility can play a role in poverty eradication. Energy, waste management and buildings are sectors that can address resource depletion. Increasing resilience in cities is a cornerstone of adaptation to climate change.

[11] See CSTD Issues Paper and discussions on priority theme titled *Science, Technology and Innovation for Sustainable Cities and Peri-Urban Communities*, CSTD Inter-sessional Panel, 2012-2013, Lima, Peru.

Finally, integrating peri-urban zones into urban planning can bring benefits in terms of food security, water and employment opportunities.

The CSTD's work on the topic shows that several innovative planning, technology and governance models exist in the developing world that can be more broadly applied in cities, such as:

a. Density, land use and spatial planning: Increasing density can be beneficial for cities with growing populations and provides alternatives on how to achieve this. Cities can accommodate growing populations in accordance with their land use, spatial design and density plans by combining regulatory instruments that can contribute to sustainable growth in cities. For example, setting up urban growth boundaries and establishing clear limits to any form of building development around cities to limit urban sprawl; creating green corridors that protect existing ecosystems.

b. Mobility: Inadequate transportation infrastructure in cities can be addressed through technologies that can improve urban mobility, such as mass rapid transit – including urban rail systems (metros/subways).

c. Energy for cities: An important sector for sustainability in cities is energy. Emphazising that the future of energy supply for large metropolitan areas increasingly needs to be decentralised, a range of innovative energy solutions that work best in crowded urban environments have been suggested such as kinetic energy generating pavements, district heating systems, and smart electric grids.

d. Solid waste management: Problems surrounding waste management are growing at an even faster rate than urbanisation itself. Integrated waste management, which requires considerable infrastructural investments as well as waste collection initiatives through partnerships with private sector, NGOs and local citizens at large are important ways to resolve the issues.

e. Resource efficient buildings: There is a multitude of available technologies that can improve resource efficiency in buildings. Although start-up costs may be higher, in the long term, buildings that have a smart design generate energy and conserve water to save costs.

f. Resilience against natural risks: A resilient city is one that can predict and react to natural disasters in order to minimise the loss of lives and disruption of city utilities and services. Developing country cities will be those most affected by the increased frequency of natural risks induced by climate change. The possible ways to increase resilience in the face of such risks include the utilization of hazard monitoring and surveillance techniques, geospatial tools which are beneficial for assessing disaster risk, as well as ICTs that can combine data from different departments in order to enable cities to monitor risks in an integrated manner.

The Commission provided several policy options for local government that can stimulate sustainable urbanization, including the following:

(a) Developing spatial plans in early phases of urbanisation based on political consensus of stakeholders, support from private sector and outside assistance or investment can prevent wasting financial resources later on.
(b) Cities can make use of technologies to convert certain types of waste into energy as mentioned in the ISWM approach. Emerging country cities are implementing projects based on ISWM and the 3Rs.
(c) Spatial planning that includes public transport networks from the very beginning is a key factor to help prioritize public transport. Spatial design should plan for integrating the incoming population into the public transport system.

(d) Cities can accompany public transport infrastructure investments with innovative regulatory mechanisms and incentives. Regulation such as public transport incentives and auto disincentives can be introduced.
(e) The use of new technologies in cities can reduce the burden of rapidly increasing energy demand.
(f) Green buildings need not be confined to cities of high-income countries. Local governments in developing countries can address housing shortages through construction initiatives for affordable, sustainable housing and upgrading informal settlements.
(g) Cities can mainstream adaptation into urban planning. Possible measures include building new developments outside of risk areas, upgrading informal settlements, and addressing the lack of infrastructure and the degradation of the environment.
(h) Peri-urban areas can benefit from social inclusion programmes that upgrade existing informal settlements and prevent the formation of new informal settlements through adequate spatial planning.

3.3. Science, technology and innovation for capacity building, particularly through education and research

As part of the CSTD's deliberations on science, technology and innovation (STI) issues, capacity building through education and research was identified as an area of focus. The following three sub-themes were chosen to analyze and discuss STI, transfer of technology, R&D and collaborative development between various actors.

3.3.*1. Deployment of science and technology for development*[12]

Following the 2008 UN Millennium Development Goals Report, which indicated that indigenous technological capabilities have not yet played a very significant role, the Commission highlighted some of the progress that had been registered in a number of MDG areas through scientific and technological innovations. It included the drop in mortality rates caused by diseases such as malaria, HIV/AIDS and measles, and an increase in the number of people with access to safe drinking water. For some targets, progress had depended upon large-scale internationally-funded projects to distribute product-embedded technology directly to the user. Examples include the distribution of anti-retroviral, insecticide-treated bed nets, and measles vaccination programmes.

Key issues in the deployment of science and technology for development as identified by the CSTD in this context include the following:

a. Building indigenous capabilities for science, technology and innovation requires absorptive capacity, but is insufficient by itself, to achieve technological catch-up in developing countries.

b. Building innovative capabilities at the national level in latecomer countries further depends on efforts in three interrelated areas: (1) enterprise development; (2) human capital; and (3) STI policy capacity.

c. From a national innovation system perspective, STI-related policies cross various sectoral/ministerial mandates, including (but not limited to) education, trade, industry, health, agriculture, energy, and environment. Building a successful innovation system will depend on both the prevailing national and global contexts, and these are constantly changing.

[12] See CSTD Issues Paper and discussions on the priority theme titled Science, Technology and Engineering for Innovation and Capacity-Building in Education and Research, Inter-sessional Panel, 12-14 November 2008, Santiago, Chile

d. North-South and South-South cooperation at the national government level in STI policies through sharing experiences is crucial. Due to the lack of understanding of innovations systems, and the associated weak capacity to measure the impact of policy intervention on the performance of an innovation system, there is a case for some sharing of experiences and lessons between international organizations, and involving the national counterparts from the participating countries.

3.3.2. Technology transfer for mutual advantage, entrepreneurship and collaborative development[13]

The CSTD focused directly on the links between the changing ICT landscape and new opportunities for 'learning by collaboration' which have the potential to stimulate initiatives in each of the priority theme areas. The World Summit on the Information Society's Geneva Declaration concludes by subscribing to the concept of an Information Society based upon extended communication and uses both of the terms 'information' and 'knowledge', linking them by indicating that the Information Society provides the basis for a transition to the 'true knowledge society'.

The Commission highlighted the opportunities and challenges related to ICTs for innovation, research, technology transfer, entrepreneurship, and collaborative development in the context of developing countries. Country case studies were used to demonstrate some key developments.

Key findings on technology transfer for mutual advantage and the changing ICT landscape include the following:

a. ICTs generally, and the Internet specifically, are playing a key role in supporting research and innovation aimed at 'catching up' and 'leapfrogging'. Collaborative learning supports information exchange processes and communication that generate mutual advantage and entrepreneurship and underlie collaborative development efforts that extend beyond the private sector to the education, health and environment sectors.

b. It is important to note the need to move beyond 'demonstration' projects and to define sustainable paths for social infrastructure development, the value of more original and critical research concerning the sustainability of capability development projects, and the opportunities for collaborative research, development and innovation offered as a consequence of capacity building.

c. The identification of new opportunities for technology transfer involving knowledge brokering and exchange between higher income and lower income countries is crucial. In doing so, it is also important to consider the role of such transfer activities in stimulating and supporting entrepreneurship, and the implications of these activities for value chain and production network development management.

e. Developments in physical infrastructure over the past decade raise questions about whether parallel and complementary developments in social infrastructure are sufficient to deliver the benefits of the Information Society, particularly in low and middle income countries. Earlier concerns about a broadly inclusive global information infrastructure are increasingly focused on the distribution of capacity *within* countries rather than the extension of the global information infrastructure *to* countries.

[13] See CSTD Issues Paper and discussions on the priority theme titled *Innovation, Research and Technology Transfer for Mutual Advantage, Entrepreneurship and Collaborative Development in the Information Society*, Inter-sessional Panel, 13-15 December 2011, Manila, Philippines

f. The Commission also considered the rapid evolution and variety of access arrangements and institutional forms. These offer important opportunities for public policy and entrepreneurial involvement, but the evidence base for setting private strategy and public policy remains weak and needs further development.

3.3.3. The mutual interaction and dependency of science and technology education with R&D[14]

The CSTD reflected on one of the most critical linkages in the innovation system, that is, the link between education and R&D. Educational institutions, especially those of higher learning, play a critical role not only in education, but also in research and economic development – they provide the pool of indigenous researchers and technicians required to conduct R&D, as well as the platform for conducting R&D. In addition, many universities in developing countries increasingly carry the responsibilities of improving regional or national economic performance.

Key findings on the mutual interaction and dependency of science and technology education in R&D include the following:

a. Improving the educational system, especially S&T education, will result in more domestically trained scientists, provide for the requisite infrastructure to sufficiently challenge talented graduates and attract foreign enterprises interested in making R&D-related investments in developing countries.

b. Moreover, scientists should go beyond their fields of specialization in order to address global challenges and to influence policy-making. Thus, it is important to incorporate social science in science education, and to encourage scientists to focus attention and effort on addressing indigenous issues of importance to their country or region.

c. Within prominent international S&T communities, problems related to developing countries are not viewed as cutting-edge, and thus considered to be of lesser merit. Academics that undertake such studies risk the real possibility of not being able to publish or present their findings in those academic journals or conferences most relevant to improving their standing and enabling them to attract funding. A review of the academic reward system, particularly within developing countries, is therefore necessary. In addition, innovative compensation and reward structures should be created to promote research directed to solving developmental problems aligned to national objectives.

d. By providing jobs and career paths for scientists and technologists, enterprises encourage students to enroll in these fields. As more students matriculate with relevant skills and motivation, this growing pool of human capital will in turn attract more enterprises to the region, thus creating a virtuous, self-reinforcing circle of technological capacity development and R&D activity.

e. For enterprises lacking the scale or capability to internally conduct necessary R&D for the development of a particular product or process, they can resort to the R&D resources of local universities, including trained staff and research infrastructure. These relationships simultaneously benefit the universities, which frequently lack the full capability to commercialize R&D. Working with industry provides them with the necessary capital to develop their infrastructure and support their R&D efforts. Moreover, it also affords the

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[14] See CSTD Issues Paper and discussions on priority theme titled *The mutual interaction and dependency of science and technology education with R&D,* Inter-sessional Panel, 27-29 October 2004, Vienna, Austria

opportunity for students and faculty to conduct research that closely relates to the productive sector.

The policy recommendations of the CSTD in this area include the following:

1. With regard to deploying science and technology to address the Millennium Development Goals, there are short-term and long-term actions needed. In the period up to 2015, efforts will be focused mainly on the deployment of existing technologies (irrespective of their countries of origin), and STI policy should aim to: (1) remove systemic barriers to their deployment; and (2) maximize the potential learning benefits from short-term activities to meet the MDG targets.

2. Beyond 2015, the achievement of sustainable development requires STI policies that build a dynamic enabling environment, and in particular: (1) education and training of an innovative, skilled and adaptable workforce; and (2) support for enterprise development and the improvement of incomes.

3. Building absorptive capabilities within enterprises and social welfare provider organizations will be a major goal for STI policy, as these capabilities are necessary for innovation to take place in a country (irrespective of where new knowledge is produced).

4. As indicated by the national innovation systems approach, there is a need for a clear long-term strategy to coordinate policy development and implementation around a common vision with respect to STI.

5. The difficulties in balancing short-term priorities and long-term goals are compounded at the policy level by: (1) a lack of empirically-based analysis of the time needed for the process or "learning" (in organizations, and at the national level); and (2) a lack of appropriate policy research and analysis methods to evaluate the systemic impacts of different policy options.

6. Governments should create incentives for private enterprises, particularly small and medium-size ones, to hire university graduates. Incentives could include tax breaks or financial aid to support internships or offset initial costs of hiring and training new employees. Governments should facilitate the establishment of research networks or consortia, which provide opportunities for cross-sector information-sharing and collaboration without requiring major investment by individual parties. In addition, Governments should facilitate the establishment of technology offices, technology parks and incubators, which have proven to be effective conduits to pool the scarce resources to stimulate research commercialization and subsequent enterprise growth.

3.4. ICTs and the digital divide

Significant advances have been made in Information Communication Technologies (ICTs) over the last decade, yet there still remains a significant digital divide between and within nations. The CSTD has deliberated at length, in several sessions, upon the issues relating to ICTs and the digital divide. These were dealt with mainly in the following themes: (1) Promoting the building of a people-centred, development-oriented and inclusive information society, with a view to enhancing digital opportunities for all people; (2) Development-oriented policies for a socio-economic inclusive information society that provides access to information and communication infrastructure in an enabling environment; and (3) Measuring the impact of ICTs for development.

3.4.1. Promoting the building of a people-centered, development-oriented and inclusive information society, with a view to enhancing digital opportunities for all people[15]

The CSTD focused on the concept of people-centered, development-oriented and inclusive information society as a framework for development. In doing so, it analyzed the benefits and risks that ICTs may bring, especially to developing countries. The Commission also identified some successful experiences and lessons learned at the national, regional and international levels, in formulating policies and establishing multi-stakeholder partnerships to implement these commitments.

Key findings on enhancing digital opportunities for all include the following:

a. Despite the fact that the digital divide has been shrinking over the past 10 years, in terms of fixed phone lines, mobile subscribers, and internet usage – there remains a substantial gap. ITU estimates that 800,000 villages – representing around one billion people worldwide – still lack connection of any kind of ICTs.

b. It is important to go beyond simply deliberating access *per se*, to the speed of access to the network. Discrepancies in international internet bandwidth – the critical infrastructure that dictates the speed at which websites in other countries can be accessed – are dramatic, and are therefore an important indicator of access to the Internet itself.

c. There are not only economic, but also behavioral, cultural, political and other barriers to the penetration of ICTs, particularly the internet, leading to a significant gap between and within countries. The gap is visible, at various proportions, in all ICT areas, namely the distribution of fixed and mobile telephone subscribers, personal computers and internet users per 100 inhabitants by regional economic groupings.

d. The main obstacles to narrowing the digital divide consist of: (1) the high cost of telecommunications; (2) lack of human resources and the brain drain; and (3) lack of relevant content. The impact of ICT on economic growth is not only the result of the capital deepening effect of ICT investment, but also the spillovers from the greater diffusion of computers, software and telecommunications created by ICT investment. Reaping the benefits from ICT investment is not straightforward and typically requires complementary investments and changes e.g. in human capital, organizational change and innovation. Hence, the economic benefits of ICTs should be considered on a long-term basis.

e. The benefits of ICTs consist of, inter alia, (1) contribution to sustainable economic growth; (2) globalizing production through e-commerce; (3) opportunities for education and research; improvements in healthcare; and (4) improvements in government services to citizens. ICT-related risks entail, inter alia, (a) cyber-crime and cyber-terrorism; (b) erosion of multilingualism and cultural identity; and (c) spam and privacy protection.

The policy recommendations of the CSTD on this theme include the following:

1. The World Summit on the Information Society (WSIS) has outlined a consensus for a global approach to the Information Society common to all UN Member States and based on its four outcome documents (Geneva Declaration of Principles, Geneva Plan of Action, as well as the Tunis Commitment, and Agenda for the Information Society). The Geneva Plan of Action describes the roles of different stakeholders in the information society, including: (1) Governments; (2) Private Sector; (3) Civil Society; and (4) International Organizations. WSIS

[15] See CSTD Issues Paper and discussions on the priority theme titled *Promoting the building of a people-centred, development-oriented and inclusive information society, with a view to enhancing digital opportunities for all people,* Inter-sessional Panel, 6-8 November 2006, Paris, France

set up a framework and roadmap for the building of a global information society. The main measures for building an Information Society include: (1) Awareness Raising; (2) Commitment and Leadership; (3) Vision; (4) Strategy; (5) Partnership and collaboration; and (6) Inclusiveness.

2. ICT is an innovation-driven sector, which develops rapidly, and is made possible due to scientific and technological advances through R&D. National capability in ICT research and development should therefore be enhanced in order to achieve a sustainable development of the Information Society. Partnerships between developing countries in R&D, technology transfer, manufacturing and utilisation of ICT products and services, are crucial for promoting capacity building and global participation in the Information Society.

3. All countries should have a national innovation system (NIS). The NIS system defines domestic capabilities in absorbing international technology and adapting and improving upon it on a local level. The key concept behind the success of any national innovation system is the degree of linkages and interactions among the actors involved in science and technology development, including R&D institutions, science and technology parks, innovation hubs, financial institutions and industry. In developing countries, there is an urgent need to strengthen the relevance of institutions and policies dealing with science, technology and innovation and in particular ICTs.

3.4.2. Development-oriented policies for a socio-economic inclusive information society that provides access to information and communication infrastructure in an enabling environment[16]

Mobile phones have been an important infrastructure for the Internet and communication in a large number of developing countries, leading to increased empowerment and encouraged entrepreneurship, and have enabled users to access information relating to education, health and jobs, carry out banking transactions, and maintain family and social ties. However, internet penetration – particularly broadband – is lagging behind, especially in Africa.

Although a number of middle-income developing countries (led by China and India) are narrowing the gap in fixed-line access with OECD countries, the gap in access with LDCs is widening. For mobile telephony, the gap between the OECD and developing countries has been reduced, with LDCs making considerable gains as well. In 2005, half of all OECD citizens were Internet users, compared with just one in every twelve inhabitants of developing economies and one in every hundred in the LDCs. The debate over the future digital divide is now moving from inequalities in basic "quantity" and "access" to include differences in "quality" and "capacity."

The Commission arrived at several key findings in this regard on development-oriented policies for an inclusive information society, which include the following:

a. At the national level, ICT development requires a multi-thematic perspective and a coherent national policy. Institutional challenges lie in a broader context of policy coordination, which takes into account political, educational, cultural, scientific, legal and financial factors. Examples from Mauritius and Chile illustrate successes in implementing a cohesive ICT development strategy.

[16] See CSTD Issues Paper and discussion on priority theme titled *Development-oriented policies for a socio-economic inclusive society that provides access to information and communication infrastructure in an enabling environment*, CSTD Inter-sessional Panel, 12-14 November, Santiago, Chile.

b. Regional cooperation in deploying ICTs could play an important role in taking advantage of market size, ensuring harmonized investment and regulatory frameworks of policy at regional levels, and avoiding issues of regulatory competition. Furthermore, regional cooperation could provide platforms for information exchange and policy discussion. The protection of intellectual property rights, cyber-security, transparency of regulation, and protection of privacy and personal data are some of the issues that could effectively be addressed at a regional level.

c. Communities that are deficient in ICT infrastructure often lacked access to other critical infrastructure as well. Income divides continued to sustain the digital divide among countries and among individuals within a country. The key issue is how to provide access to ICTs in infrastructure-poor communities.

d. The cost of Internet access and services remains high in developing countries, particularly for broadband access. That is mainly due to limited broadband services, which provide national and international connectivity, and the relatively high cost of personal computers and portable laptops in most developing countries. Shared access and community access offers a potential solution to those existing barriers. There are several existing shared access models, such as telecentres, which are mostly based on a public–private (or NGO) partnership. Other access models are cybercafés. However, for shared access models to be successful, the right range of services has to be found to generate the levels of usage required to make them sustainable. Community involvement is crucial for successful and sustainable community access initiatives.

e. Mobile telephones and broadband could be seen as the two major areas of ICT for development. The CSTD should pay particularly close attention to the issue of access to broadband, which is essential for efficient Internet usage.

Other issues that were identified as potentially important for the CSTD to consider further were:

(a) Shared access and community access arrangements;
(b) Free and open software for e-government projects;
(c) ICT education/training: teaching people how to use ICTs; and
(d) The negative aspects of ICTs, including cybercrime.

The policy recommendations of the CSTD on this theme include the following:

1. The CSTD should encourage regional cooperation with regard to ICT strategies. Some key issues – including cyber security, transparency of regulation, and protection of privacy and personal data – could be effectively addressed at the regional level.

2. The Commission might consider identifying one or more focus areas within the present substantive theme on the information society. Empowerment and education could be priority themes. Other themes could be strengthening democratic processes and election processes through ICTs.

3. Through a development-oriented policy and regulatory framework based on national context, governments could help build a people-centred information society. Governments could also intervene to correct market failures, maintain competition, attract domestic and foreign investment and enhance ICT infrastructure and applications to maximize the socioeconomic benefits of ICTs, especially for underserved communities.

3.4.3. Measuring the impact of ICTs for development[17]

The main objective of the discussions on this theme was to build on ongoing work in the CSTD to highlight the importance of measuring the impacts of ICTs, identify key challenges, and present empirical evidence on impacts of ICTs in areas such as economic performance, health, education, employment, and the environment.

Key findings include the following:

(a) The formulation of internationally comparable ICT statistics is essential for governments to be able to adequately design, implement, monitor and evaluate ICT policies. However, the metrics used to measure ICT impact are possibly the most important but also the most challenging to determine. In particular, there are difficulties in measuring the impact of ICTs due to (a) variety of ICTs with different impacts in different contexts and countries; (b) indirect impacts of ICTs because many are general purpose technologies which facilitate change; (c) difficulty to define impacts; and (d) difficulty of determining causality.

(b) While ICTs can facilitate democratic processes and increase participation by citizens, there are also negative impacts such as Internet-based crime, including fraud and copyright infringement, child exposure to undesirable content and overuse of Internet applications and games, use of the Internet to disseminate pornographic images, and security and privacy concerns.

(c) There are positive and negative links between ICTs and the environment. Positive environmental impacts of ICTs include (a) the potential of ICTs to improve efficiency of energy-consuming processes and equipment; (b) facilitation of dematerialization; (c) climate change monitoring and modeling; (d) dissemination of information; and (e) administration of carbon pollution reduction schemes. Nevertheless, negative impacts arise from energy usage and greenhouse gas emissions due to use, manufacturing and transport of ICT products and pollution from e-waste disposal.

The questions relating to policy making that the CSTD pointed out on this theme include the following:

1. Should the measurement of impact in certain areas be given higher priority than others in the years leading up to 2015 and beyond?

2. Bearing in mind the importance of producing relevant and internationally comparable data needed to undertake impact studies, what can governments, development partners, and international organizations – especially members of the partnership – do to extend ICT impact indicators?

3. From a policy perspective, what types of impact studies are the most useful? (d) What can be done to raise awareness among different stakeholders of the need to measure the impact of ICTs?

3.5. The impact of new technologies on development

The constant proliferation of new technologies bring along opportunities as well as challenges. New technologies embody scientific progress, signaling the advent of newer and often cheaper and more competitive products and processes. Some forms of new technologies, such

[17] See CSTD Issues Paper and discussions on priority theme titled *Measuring the Impact of ICTs for Development*, CSTD Inter-sessional Panel13-15 December 2011, Manila, Philippines

as internet broadband and genomic technologies, have completely revolutionized entire areas of product delivery and customer care. However, at the same time, new technologies are harder for developing countries to access not only because they are less affordable than existing more outdated technologies, but also because learning and innovating in these new technological spheres calls for greater technological capabilities. As a result, such technological breakthroughs often exacerbate the technological divide.

The CSTD has considered the impact of newer technologies on development, emphasizing their benefits as well as cautioning about the risks of exclusion. In doing so, the Commission focused on two sub themes related to new technologies in two separate sessions.

3.5.1. Open access, virtual science libraries, geospatial analysis and other complementary ICT and science, technology, engineering and mathematics assets to address development issues, with particular attention to education.

The CSTD considered how three ICT assets – Open Access, virtual science libraries and geospatial analysis – can be harnessed to enhance education for development. The importance of education in development and the growing use of ICTs to support the education sector are highlighted. The Commission also looked at how the related issues of Open Access and virtual science libraries can facilitate knowledge dissemination throughout the world. It examined the growing use of geospatial analysis as an ICT tool, and explored how it might be used to enhance education.

Key findings include the following:

a. Linking education, development and ICTs

The link between education and development is highlighted and traces the growing use of ICTs in education, particularly in science, technology, engineering and mathematics subjects. It focuses on how ICTs can enhance education when combined with efforts to facilitate human development in accompanying areas, such as ICT literacy training, curriculum reviews, maintaining teaching quality.

b. Sharing the wealth of knowledge: Open Access and virtual science libraries

This section focuses on how ICTs can facilitate wider access to knowledge. In academia, the mainstay of scholarly output is the subscription journal, and the main barrier to dissemination of this academic knowledge is access to published research. This is largely due to journal subscription fees, and the location of resources, which can make academic research difficult, time-consuming and costly to find and retrieve. Such challenges affect learners in low-income countries disproportionately due to limited resources and therefore contribute to a de facto bias towards strengthening research capabilities in rich countries. Open Access and virtual science libraries are two ways in which ICTs can be harnessed to overcome barriers to the building and dissemination of the global stock of knowledge, particularly in developing countries.

c. Geographic information systems and geospatial analysis to enhance education

The key challenges related to the use of geographic information systems and geospatial analyses in education are addressed here. ICTs offer novel ways to interpret the world: they can help us to do tasks more quickly, make complex problems more manageable, and use advanced methods of analysis. One such example is *geographic information systems (GIS)*. It became obvious shortly after the introduction of GIS that it would have significant, long-term impacts on society and the policy-making process.

Policy considerations include:

1. Open Access and virtual libraries are two complementary mechanisms to increase and extend knowledge flows, particularly in disadvantaged communities affected by the digital divide. By designing information systems that are simple to use, and housing information that is easy to find and free to access, these ICT assets overcome traditional limitations associated with obtaining data and research.

2. GIS and geospatial analysis are used in many sectors of society and have important uses in addressing development challenges. Meanwhile, GIS can also be used in education to help develop spatial abilities required in a range of different subjects beyond geography classes.

3. However, learning through GIS is not widespread and the transformational potential of GIS in education remains untapped. Some policy options to overcome these challenges include integrating GIS in policy making more fully, building capacity in GIS at all levels, supporting the development of GIS applications for education and building networks of GIS practitioners to share knowledge and best practices.

4. Understanding the local context is imperative to ensuring that education policies and strategies, at national, regional and school level, are tailored to local needs. Technological assistance should only be included in those policies and strategies if it will provide additional benefits and if the capabilities to fully integrate it exist.

4. Looking Ahead: STI and the post-2015 Agenda

Given the relevance of STI to the process of inclusive and sustainable development, STI policies in principle can make a big contribution to each of the three approaches: innovation to meet basic needs, grassroots entrepreneurship, and inclusive growth through building STI capabilities. But conventional STI policies need to be redesigned to have impacts in those areas. The STI policy area matured in industrialized countries with pre-existing significant scientific and technological capabilities. Current STI policy concepts in Europe, parts of Asia, and North America are oriented to turning breakthrough discoveries into a global competitive edge in expensive products. Newly industrialized countries such as Indonesia or the Philippines have had success by adopting these strategies, but at a moment when the world economy was open to newcomers (Chang 2002). The issues faced today by other developing countries are quite different; their baseline resources are different and their strategies must be different as well. The post-2015 STI development community thus faces the task of rethinking STI policies to produce inclusive and sustainable development.

4.1. Framing STI as a core issue for sustainable development

Science, technology, and innovation policies can be seen as falling into four major categories (Cozzens, Bobb et al. 2002). Those categories are introduced briefly here and explored in more depth in the remainder of the section.

- ***Human resource policies*** are aimed at insuring an adequate supply of appropriately trained people for science, technology, and innovation activities. What is needed will vary widely in countries with different development patterns. A least developed country like Senegal may focus on primary education for large numbers while providing support for a few to get excellent postgraduate education abroad. A country with a history of educational disadvantage for a portion of the population, like South Africa, may focus on closing the gap. An emerging economy like China may focus on joining the world research front in selected areas through overseas education for a significant number of university graduates.

- ***Research policies (often referred to as "science policies")*** are those that stimulate the advancement of knowledge, both fundamental and strategic. The first is motivated by curiosity and the second by curiosity about a phenomenon of great practical importance. In either case, the research leads to new understanding of the dynamics of matter or operation of natural or social systems, but strategic knowledge is chosen because of its relationship to a problem-solving goal.

  Research policies often take the form of grant support for research activities or core support for research at government laboratories. Least developed countries, which tend to invest quite small amounts in STI generally, may not spend much in this area, nor provide much encouragement for research activities, whether in universities or public laboratories. (Publications from LDCs are often co-authored with investigators from more affluent countries.) Knowing enough to understand what is happening elsewhere in a few specific areas can be a sufficient goal in these national contexts. In others, only strategic research is likely to be encouraged, since fundamental research without a practical goal in mind may appear to be a luxury. In still other contexts, fundamental research may be seen as the ticket of entry to the world scientific community and a key element of national pride. The Indian investment in particle physics and the South African investment in astronomy illustrate.

- ***Innovation polices (sometimes referred to as "technology policies")*** stimulate the introduction of new products or processes, most often in the private sector but sometimes in the public sector or in local communities. Examples of conventional innovation policies include tax incentives and small business innovation programs. Examples of public sector innovations, which may arise from government agency practices rather than explicit policies or programs, include improvements in police or sanitation services. An example of a program to stimulate community-based innovation is the Social Innovation Program of FINEP in Brazil, or traditional agricultural extension services, which draw on knowledge from the community to improve practice while distributing knowledge to the community about improvements they might want to adopt. These kinds of policies may appear in any developing country context, but will operate on a smaller scale in the least developed countries.

- ***Regulatory policies*** are those that set the ground rules for technological use. Some regulatory policies are directed to new technologies (such as drug safety regulations) and others are heavily science-based (such as environmental regulation of industrial chemicals). Not all regulatory policies are connected to STI activities (for example, the rules surrounding school accreditation). The concept here refers only to those with a strong connection. The general goal of the regulations is to protect public health and safety, including the health of the environment.

  Science-based regulation requires high levels of sophistication and significant investments of time. Least developed economies may lack sufficiently skilled personnel, or may not be able to afford to have those with relevant skills to work on regulation issues on a full time basis. Under such circumstances, the country may choose to follow and adopt the results of international regulatory processes – which in turn are likely to reflect the interests of more developed more STI-capable economies. For example, nanotechnology regulation focuses on industrial chemicals, a major application area in Europe and North America, rather than uses in agriculture, which will be more common in developing countries.

The paper now turns to a more in-depth discussion of what each of these areas can contribute to post-2015 inclusive and sustainable development.

4.1.1. Human resource policies – ensuring enough scientists and engineers for the nation's needs

We envision in the post-2015 world that every country will experience both supply of and demand for technically-trained personnel, at appropriate levels of skill for the current economy and rising availability to meet future needs. Technical careers will be open to all and all technically-trained personnel, including at doctoral level, will have strong ties to community-based innovation.

In least developed countries, the vision may involve rising numbers of secondary school graduates and tertiary education enrollees. Other developing countries may be striving for increases in tertiary education enrollment and master's-level degrees, with increasing success in bringing doctoral students back to the country from overseas. In newly industrializing countries, the goal may be to have the number of PhDs per capita approaching the levels of developed countries.

There are enormous challenges involved in making this vision a reality. Efforts to produce, retain, and utilize high-level science and engineering talent is always pulling against the inertia of general levels of education in the population. The tug of war exists even in developed countries; for example, in the United States, recruitment to science and engineering careers is hampered by the poor quality of public education. Many U.S. students are not prepared by public schools to enter these careers. If one of the world's leading economies face these challenges, the situation in developing countries is easy to picture.

Latin America, Africa, and much of South Asia face particularly steep disparities in educational levels. In the colonial era, colonial administrations either prevented education of the general public in the countries they governed, or educated just a few elite students to serve in the local bureaucracy. Such sharp divisions can have long-lasting repercussions, since education provides a distinct competitive advantage to individuals who want to take up other opportunities. In places where girls are less likely to go to school, they are also not available to become scientists or engineers, thus wasting half the country's talent. Disparities in income reinforce disparities in educational attainment: affluent families can buy better education for their children in private schools and send them overseas for university and postgraduate training. But since these students also have the resources to be globally mobile, they are prone to leave their home economies and in the long run not contribute to economic development there.

Government agencies particularly concerned with science, technology, and innovation are always acutely aware of the problem of the shortage of people with the right levels of education to initiate and support innovation in the economy. However, they almost never have much influence over the supply chain. Ministries of Science and Technology are usually separate from Ministries of Education; they may or may not communicate and work together. Thus the essential flow of numerically literate and scientifically aware students that is crucial to recruitment into scientific and engineering careers is not under the control of those who want it most. Furthermore, for inclusive innovation it is important that community-oriented values and examples of effective science/community engagement appear early in a student's educational experience. Otherwise, the whole system reinforces elite values and aspirations. The monumental effort to train and recruit, however, may direct attention towards how many scientists and engineers are being educated, rather than the value system they are absorbing.

The central agency in human resource policy for STI is typically a research council, such as the National Science and Technology Research Commission (CONICYT) in Chile or the National Council of Science and Technology (CONACYT) in Mexico. These councils may engage in public outreach to get students interested in science and engineering careers. Since university education is typically free in the countries where they operate, they may not spend much on tertiary training, but they often offer fellowship support for domestic postgraduate study in STEM fields (that is, science, technology, engineering, and mathematics). The fellowship support may be oriented to strategic research areas, that is, those that are seen as important for national industrial or social development.

Another common approach is to establish programs to send students overseas for advanced training, with the goal of building local capacity so that advanced training can be done in-country eventually. The challenge such programs face, however, is colloquially known as Brain Drain. Only the best and brightest from the country get the opportunity to do advanced study overseas. After four or five years abroad, they recognize the disparity between conditions for research where they are and conditions in their home countries. Many decide to try to stay where they were trained rather than going home. One way to address this issue is through legal requirements for accepting the fellowship. For example, the Royal Thai fellowships in Thailand require two years of government service in the home country for every year supported abroad. Another is by investing in research resources as an enticement for returnees. Least developed countries have few incentives to offer; the figures on Brain Drain from Africa show how debilitating that situation can be.[18]

Finally, the research councils often maintain registries of scientists and engineers in the country and provide small grants to support curiosity-driven research. The competition for the small grants helps to provide quality control for the system, sometimes reinforced by rating systems for the researchers themselves using international criteria. All these programs help to build and maintain a human resource base for a developing country. The goals of inclusive and sustainable development can be built into those efforts. Community engagement can be a requirement of fellowships. Sustainability and community innovation can be themes in small-grants schemes. The Council for Scientific Research at the University of the Republic in Uruguay, for example, has pioneered in the design of programs that link university researchers effectively with local communities to solve problems (Alzugaray, Mederos et al. forthcoming).

Research councils, or their partners in other parts of government, also sometimes find the resources for larger research centers. These tend to be oriented towards priority industries. Because research centers combine educational with research and outreach functions, however, they also represent opportunities for directing the scientific culture towards inclusive and sustainable goals. Centers and large facilities are typically used for visits from young students, to try to get them interested in science and engineering careers, but the contribution can go beyond that. Industrial foci can be chosen with job generation in mind. Outreach can involve community innovation and support for small business development. Sustainability can be a required theme for every center. In other words, inclusive and sustainable development can be built into the core of any large research effort.

4.1.2. Research policies – those that provide for the advancement of knowledge, both fundamental and strategic

The vision for research for inclusive and sustainable development in the post-2015 era is that many kinds of knowledge are respected in the development process and professional knowledge production places priority on basic needs areas. Professional knowledge will work with local knowledge to solve local problems and create the conditions for inclusive, sustainable development.

The current situation is far from this vision. Several influences compete for attention on the research agendas of developing countries.

- The **competitiveness agenda** calls for research to be oriented to the needs of industry in the country, whether the firms are national or multinational. So for example Chilean research gave priority to mining, pulp and paper, and viniculture, and increased attention to aquaculture as the commercial fish industry expanded there.

[18] http://www.universityworldnews.com/article.php?story=20131011121316706, http://www.idrc.ca/EN/Resources/Publications/Pages/ArticleDetails.aspx?PublicationID=704, both accessed November 25, 2013.

This orientation may direct attention to the needs of larger, export-oriented firms rather than small farmers, as for example in research on bananas in Jamaica or coffee in Costa Rica.

- The **international profile** agenda urges researchers to publish in international journals, with the implicit result that topics of interest outside the country, which are most likely to pass peer review, are also most likely to appear in publications. Since there are many more researchers in developed than developing countries, this orientation tends to tilt research attention away from nationally or locally important issues.
- The **development** agenda places priority on the knowledge base for addressing issues that are impeding development, in particular basic needs areas like health, food, energy, and water. It also directs attention to the needs of poor communities, small farms and businesses, and marginalized social groups. It is therefore the most closely related to inclusive and sustainable development, but not a strong contender against the other two influences unless it has strong political backing. Applying new knowledge to development challenges does not produce instant results for the political patrons of science and engineering, however, in contrast to the powerful support that can be provided immediately by industry.

In the developing world, knowledge advancement is often concentrated in academy-type systems. British Commonwealth countries often have public research institutions named "Council for Scientific and Industrial Research," or a variation thereof. As their names imply, their main clientele has traditionally been industry. Other developing countries follow the model of "academies" that are not honorific but rather sets of public research institutions. China and India both follow this model. These systems, on the one hand, are less flexible than the external grant systems that are common in the United States and increasingly in Europe, exercised through grants programs at places like the U.S. National Institutes of Health or the European Research Council. One the other hand, public research institutions are also directly responsible to public goals and thus potential sites for implementing research agendas that are inclusive and sustainable.

The vision for post-2015 research, then, could be internalized and carried forward first and foremost by public research institutions. For this to happen, the political environment would need to place priority on inclusive and sustainable development. These values would then be woven into the strategic plans and operational directions of the public research institutions. Specialized bodies like the Institute for Water Technology in Mexico (IMTA) could become more common.

4.1.3. Innovation policies – stimulating the development of new products and processes

The post-2015 vision: Grassroots, community-based innovation is encouraged by government policies and nurtured with favorable conditions. More creative effort in public and private innovation processes is aimed at making life better for people at the bottom. Substantial innovation-based improvements appear there.

There are narrow and broad definitions of the innovation process, and innovation policies may reflect one, the other, or both. The narrow definition is the traditional one enshrined for decades in STI indicators (Nelson 1993). It focuses on product and process innovations in manufacturing firms, measured through surveys.[19] This definition has been somewhat broadened in recent years by adding service innovation firms to the survey populations and doing surveys in the public sector in some countries. The other major measure of innovation

[19] http://www.oecd.org/innovation/inno/frascatimanualproposedstandardpracticeforsurveysonresearchandexperimentaldevelopment6thedition.htm, accessed November 25, 2013

in conventional STI policy is even narrower – patents – which are known to be the right form of intellectual property protection in some industries. and some others and only under selected circumstances. Both innovation surveys and patents are related to formal research and development processes, another correlate of the narrow definition of innovation.

The broader definition sees innovation as a process that permeates society (Lundvall 1988). Many actors can strive to make improvements in what they are doing. Organizational improvements count as innovations as much as technological ones. Not every innovation needs to be based on research nor captured in a form of intellectual property. It can simply give a business, large or small, a competitive advantage, or make someone's daily life easier. Innovation in this broader sense is closely connected to broad-based learning and capacity building, through small steps over time.

Most conventional innovation policies are designed with the narrow definition of innovation in mind. Intellectual property laws, technology transfer programs, and tax incentives for research and development all fall into this category. Often the lead agency is a ministry of industry or a specialized innovation agency. The pathway to inclusive and sustainable development, however, requires a different set of innovation policies, including extension and public technology development as well as incentives and support for grassroots entrepreneurship. Conventional innovation agencies also tend to be narrowly focused on commercialization, neglecting broader societal benefits of new ideas and businesses, as in the case of the Technology Innovation Agency in South Africa, which seems not to take capacity building or social impacts of technologies into account in its investment decisions.

Even conventional innovation policies face special challenges in developing countries. National governments do not have much leverage in negotiations with multinationals about their investments within their national boundaries, and small economies can become dependent on big investors and vulnerable to decisions outside the country about where to locate production processes. National firms in many developing countries tend to be conservative rather than innovative and often prefer to import new technology rather than invent and commercialize it themselves. Small firms seldom have the incentives or access to knowledge resources to make revolutionary changes.

Innovation to reach low-income markets has its own name these days: "bottom of the pyramid" (BOP). Prahalad (Prahalad 2006) claimed that big multinational firms could make a fortune serving that market, if they were innovative enough to repackage or redesign their products appropriately. Unfortunately, there is no evidence that big business has found this advice useful. The stories of BOP success are inspiring, but isolated. In any event, the kind of innovation that makes changes for rather than with poor households does not build their capacity and scarcely qualifies as "inclusive development" (Cozzens and Sutz 2014).

Small firms and community innovators, on the other hand, seldom have incentives to make big changes, and they are often not linked to the professional knowledge resources that might turn their good ideas and practical experiences into revolutionary changes. Where the innovators are linked to top-down technology systems like public utilities, knowledge from the bottom may not be valued and sent back up the hierarchy. Where the small innovators are part of their own local networks, however, lateral learning may occur so quickly that innovation scarcely gives an advantage. This pattern is reported in the *jua kali* sector in Tanzania, an area of the informal economy that brings hundreds of mechanics and craftspeople into the same market areas (Daniels 2010). In these areas, a new design by one informal entrepreneur is quickly adopted by others, who become the competition.

Small and community businesses can be helped by conventional extension services, which can provide both business and technical advice. National innovation strategies should also include strong champions and programs for social entrepreneurship, that is, successful businesses that change social structures in positive directions. An example is Sulabh Sanitation[20], a company that started to eliminate the need for the Scheduled Caste in India by obviating human cleaning of toilets through new sociotechnical systems. With its innovative toilet designs and forms of marketing, Sulabh has provided jobs to thousands of Indian women as well as safe, clean facilities to tens of thousands of families.

4.1.4. Regulatory policies – setting the ground rules for new technologies

The post-2015 vision in science-based regulation is that sustainability becomes so widely embraced as a concept and practice that regulatory regimes are a matter of consensus, not conflict. Communities protect their own environments and companies relentlessly pursue environmental responsibility as part of business strategy.

Many developed countries might be seen as already on the path to this vision. Sustainability values are strong in Europe, and are woven into aspects of everyday life like good public transportation systems, small cars, and re-usable bags for groceries – all good examples of sociotechnical systems that embody values of a society in both technologies and social practices. Some places in the United States have adopted similar practices, like Portland, Oregon's clear urban/rural boundary, to reduce sprawl and preserve the environment.[21] Oregon's law on "urban growth boundaries" brings citizens, experts, and industry into the process of concentrating development in the centers of cities and thus protecting green spaces at the boundary. Because of the increased population concentration, families have benefitted from better and less expensive public services, and the state's metropolitan areas have earned a reputation as good places to live and work. But seen from the viewpoint of developing countries, the regulatory expectations that underpin these sociotechnical systems can appear to be threatening. The issues debated in climate change agreements illustrate the differences in viewpoint dramatically.[22] The demand from developed countries for developing ones to limit greenhouse emissions sounds like a show-stopper for growth. Prohibitions on genetically-modified foods can be heard as maintaining trade protection. Regulatory regimes raise costs, then prices, and affect the competitive status of products from the developing world. Dynamics like these can be interpreted as increasing inequalities and hampering development.

Sustainable solutions are often innovations in and of themselves, innovations that do not fit with existing sociotechnical systems. Distributed power generation, for example, has the potential to preserve environments, use local skills and knowledge, and spread accessibility of electrical power more quickly and thoroughly than big dam projects (Soumonni 2013). Distributed power is thus both inclusive and sustainable. But the big dam projects have powerful actors behind them, in industry and government. The social movement for sustainable solutions is relatively small in developing countries; while it provides a critique of current practices, it seldom wields much political power.

Where are the actors in government that could build sustainability into national agendas in developing countries? Health and environmental ministries must take the lead, but a range of regulatory bodies should join the effort. The education system needs to incorporate sustainability ideas across the curriculum, bringing in local knowledge in order to teach respect for its essential contributions. Multinationals can be a positive influence on these national dynamics, carrying information on best practices from around the world, lending technical expertise, and setting high environmental goals for themselves.

[20] http://sulabhinternational.org/, accessed November 25, 2013.
[21] http://www.oregonmetro.gov/index.cfm/go/by.web/id=277, accessed November 25, 2013.
[22] http://thediplomat.com/2013/11/the-us-and-china-play-chicken-over-climate-change/, accessed November 25, 2013.

4.2. Partners in the effort

The previous section has identified some of the main STI policy actors in national governments and the roles they might play in moving towards inclusive and sustainable development in the post-2015 era. This section points to the various partner institutions that might join them in that effort, identifying win-win collaborations that both build STI capacity and link STI policies to development goals.

4.2.1. Public institutions

Since people are at the center of STI capacity, partnerships between STI policy institutions and educational authorities, particularly those responsible for higher education, are particularly important. A strong national STI workforce begins with high participation in primary and secondary schooling and good preparation in mathematics and science. For inclusive development, both girls and boys must go to school, as well as children from all cultural groups and both urban and rural communities. Research councils and institutions of higher education can partner with primary and secondary educators to provide engaging and challenging curricula at all levels of the system. A rising tide of individual capabilities is needed to lift the boats of research and innovation in any society.

Another crucial set of partners are government "mission" or "sectoral" agencies, in areas like health, agriculture, energy, and transportation, or in different ways of mining or defense. These agencies can be partners for the core STI agencies in any of the four areas identified in the last section. They have a strong stake in developing the human resource base, and may provide scholarships to engage students with their particular mission areas. They are often the home base for public research institutions, where the goals of inclusive and sustainable development can find leadership, as described above. The mission agencies create strong demand for innovation, in particular the "frugal" innovations that increase access by decreasing cost without loss of quality. [23] This kind of innovation can increase the effectiveness of government services without increasing cost. Government can also create a market for certain innovations that will benefit the poor but would be out of their reach based on income alone; this often happens, for example, through public health services. And finally, the mission agencies are often deeply enmeshed with the new technologies that are subject to health and safety regulations, and thus stakeholders in making sustainability a core value and guiding principle.

4.2.2. Supranational and subnational policy actors

National actors are not the only important ones shaping inclusive and sustainable development, although they have historically been the central ones. Overall, development is going to depend more in the post-2015 era on subnational policy actors such as cities, municipalities, states, or departments, since it is at local level that bottom-up development happens. In developed countries, local-level STI policies have been directly related to economic development, to attracting new companies to the area and nurturing small firms that might start there. Universities based in the region have been considered key resources, and strong partnerships with particular companies and industries have been formed. The challenge for developing countries is often that there is very little expertise at local level to undertake such activities. If human resources are thin at national level, as the last section has described, then it follows that the local level will be even more challenged. Recent developments in Colombia illustrate. A new national law allocated significant sums to the regions for science and technology, to be spent through projects reviewed by a central agency.[24] But very few projects were proposed and large parts of the money remained unspent at the end of the first

[23] http://www.frugal-innovation.com/, accessed November 25, 2013.
[24] http://colombiareports.co/oil-royalties-bill-passed-by-house-of-representatives/, accessed November 25, 2013.

year of the program. The capacity to envision STI-intensive projects and carry them out takes time to develop, so the influx of funds, which is likely to be transformative over the long run, was not effectively absorbed in the short term. The post-2015 era should be a time when local STI capabilities get special attention.

For some countries, supra-national groupings will be increasingly important in the post-2015 era. African nations, for example, have worked together through NEPAD to develop strategy. Higher education institutions are working together to bootstrap their capacity and an STI indicators volume has been produced for the continent, with help and funding from the International Development Research Center in Canada.[25] Latin America, despite its history of national rivalries, has built some strong regional STI institutions, including its STI indicators network that includes Spain and Portugal. The network, formed in 1994, has brought together the official STI agencies of all the American countries, to participate in capacity-building workshops and conferences as well as contributing to a common data set that compares STI indicators across the continent.[26] Such regional groupings can play an important role in the post-2015 era, creating shared capabilities where they make sense. In a time of globalization, even developed countries are turning to cross-national institutions to address global challenges; how much more appropriate this approach is for developing countries.

4.2.3. Cross-national partnerships for development

(a) Development agencies

National STI policy agencies, particularly in the least developed countries, may also find partnerships in the development agencies of various countries and in global non-governmental organizations (global NGOs). National development agencies have provided a significant portion of Gross Domestic Product in many least developed countries. For many years, these agencies focused on providing funding for specific projects in the countries where their money was spent. In the 1960s and 1970s, for example, they funded the establishment of funding councils in Latin America. A more recent example in Africa is the support that IDRC provided for the development of STI indicators under NEPAD. These agencies have gradually been moving towards sectoral funding strategies, under which they delegate significant responsibility to national agencies for developing plans to spend donor money in the sector. This strategy has the potential to build capacity in the recipient countries. The approach is most likely to intersect with STI policies in specific mission areas or sectors, as described above. No international donor agency has adopted a similar strategy towards STI as a policy area in and of itself. Either the project approach or the sector approach can thus help build overall STI capacity, but the problem of coordination between agencies within the country remains.

(b) Global non-governmental organizations

Global NGOs also tend to focus their efforts in least developed countries and aim to affect one sector at a time. They thus also miss the possibilities of building general STI capability. There are many examples of emerging institutional arrangements to use research and development to address development needs, with both inclusive and sustainable profiles. For example, public-private partnerships in health are developing vaccines and treatments for diseases that would not be addressed under standard market conditions. New mechanisms like advanced purchase commitments have been envisioned, and used in some limited cases. These mechanisms bring the technical expertise of developed countries together with the needs and institutions of developing ones. For example, Mozambique has been a major site of testing for malaria vaccines, through collaboration between Gates-funded researchers and

[25] http://www.africasti.com/headlines/nepad-to-build-africas-sti-capacity, accessed November 25, 2013.
[26] http://www.ricyt.org/homeenglish, accessed November 25, 2013.

local health institutions.[27] Everyone who participates in a clinical trial is assured access to any successful vaccines that are discovered. But there is nonetheless serious concern about the domination of these partnerships by institutions in developed countries. Whose agenda is being pursued? Is local capability being built? The efforts are inclusive in the sense of targeting serious health problems that poor countries and communities face. But they may not be inclusive if the requirement is that the research be both for and by marginalized groups. Some capacity in the local health sector is built through these projects, through contacts and collaboration with partners from outside the country and the provision of equipment for rural health facilities. However, for inclusive and sustainable development to happen in the post-2015 era, these efforts must have stronger accountability to the groups they are trying to help.

(c) Multilateral development banks

Finally, multilateral development banks have a role to play in bringing STI to bear on inclusive and sustainable development. In general they have moved beyond a focus on growth and growth alone and have begun to pay attention to distribution. The World Bank for example, has been producing analysis of the relationship between growth and inequality for a decade, and has a serious effort devoted to gender analysis. The translation of this concern into practical action in the STI arena, however, has focused almost entirely on entrepreneurship. The formation of new businesses is part of the overall movement that is needed in the post-2015 era, but not the only part. The previous section of this paper analyzed the variety of approaches that must work together to produce inclusive and sustainable development. The support for entrepreneurship, like other STI policy mechanisms, must be designed specifically for low-income and informal economy entrepreneurs. Those that provide goods or services that reflect sustainability or increase the well-being of marginalized groups must receive specific encouragement and support, or the overall effort will not lead in the desired direction.

4.1.4. Policy coordination and collaboration

To achieve inclusive and sustainable development in the post-2015 period, there must be coordination among disconnected efforts and a cross-cutting view of what science, technology, and innovation are and how they could contribute. In some cases, supranational bodies may be the appropriate ones to take the lead in that effort, but in most cases, national authorities will be responsible. Coordination within countries is not easy, as previous sections have pointed out. In relatively new democratic governments, and even in better established ones, ministers compete for position and agencies defend their own territories. National leaders often feel that their countries have more important issues than science, technology, and innovation to deal with. The extent to which the future depends on building STI capabilities is not always clear. The post-2015 era calls for compelling statements of the extent to which STI capabilities are the future, and leaders in the STI policy arena who can articulate that importance.

National development plans need to embed STI policy and give it priority. Least developed nations need to bootstrap from their current capabilities, building steadily through the educational system and using their diaspora and collaborators as much as possible. Other developing countries need to steadily expand investment and devote specialized offices to analyzing what works in using STI for inclusive and sustainable development. Most importantly, in the developing country context, STI leaders need to work together with sectoral leaders to build capability strategically and give maximum support to the development process.

[27] http://www.gatesfoundation.org/What-We-Do/Global-Health/Malaria, http://www.economist.com/node/2084799, both accessed November 25, 2013.

There is a great deal of work to be done to build cultures in developing countries that understand and value science, technology, and innovation. The current global STI regime does not produce much for most of the population in most developing countries. This situation does not lead to political support for the investments that need to be made. Promoting an STI-supporting culture requires a two-way process: both increasing understanding of STI among students and young people in particular, and increasing the actual benefits that STI produces for those who live near to and below the poverty line in developing countries. The most effective motivator of young people from poor communities to master the mathematics and science they need to move into STEM careers is to see that people in those careers make a difference in their lives. An STI culture is a relationship. It needs to be built through partnerships.

Ultimately, international cooperation mechanisms will be useful primarily to support the national transformations that this vision implies. The contribution of STI to inclusive and sustainable development depends in the end on encouraging the right values among scientists and engineers and forging the right practical partnerships within developing countries.

4.3. Articulating the role of the CSTD

How can the CSTD contribute to this effort? In the area of human resource policy, the CSTD could encourage sharing of experiences and best practices among governments with regard to cooperation within the educational system and strengthening of capacities and skills at each level. How have both least developed and other developing countries incorporated the values of inclusion and sustainability in the educational process? For example, the CSTD could encourage governments to:

1) Strengthen collaboration between primary and secondary education leadership and tertiary education institutions in raising the educational levels of the general population, including strengthening basic skills in mathematics and science.
2) Include the involvement of students at all levels in using their technical skills to help marginalized communities solve their problems.
3) Incorporate sustainability into scientific education at all levels.
4) Invest in opportunities for talented students to continue their education in science, technology, engineering, and mathematics, through tertiary education and into postgraduate studies, at home or abroad.
5) Focus on stimulating attractive conditions for the return of students who earn postgraduate degrees abroad, including opportunities in private industry, government, and universities.

The CSTD could also organize dialogue among national STI policymakers on the most effective pathways for incorporating poverty reduction in research and innovation policies and programs. As earlier sections have explained, public laboratories are particularly well suited to providing leadership in this area. The CSTD might encourage national government to

6) Adopt both impact on poverty reduction and sustainability as criteria in choosing projects undertaken by public laboratories.
7) Make collaboration with marginalized communities a central feature of the mission of public laboratories.
8) Encourage cooperation among sectoral research laboratories and agencies and transversal ones on collaboration with marginalized communities for local problem solving.
9) Study and draw lessons from the experience of both domestic and foreign researchers in contributing to problem solving by marginalized communities.

The CSTD can help national governments create environments that nurture grassroots entrepreneurs and reward innovation processes that make life better for families at the bottom of the income scale. The innovation studies research community is beginning to study these experiences but the results of those studies are too often confined to one continent rather than being share across them. The CSTD could help spread knowledge by convening workshops that bring together innovation researchers and innovation policy practitioners to discuss the most effective pathways to bottom-up, community-centered entrepreneurship. The CSTD might encourage national or local governments to do the following:

10) Encourage grassroots innovation and facilitate commercialization of promising grassroots inventions from marginalized communities.
11) Create strong, long-term programs for collaboration between knowledge institutions and marginalized communities to bring together local and scientific knowledge in solving local problems.
12) Encourage social entrepreneurship, eliminating any roadblocks to its operation;
13) Use open IP protection for inventions from public laboratories, and provide incentives for a diversity of applications of public intellectual property.
14) Encourage local innovation for efficiency and effectiveness rather than imports in all sectors of the economy.
15) Encourage collaboration between local and national programs in setting the conditions for indigenous innovation.

Finally, the CSTD can increase communication and cooperation among countries on sustainability. In this area, STI policymakers are often partners with other government agencies, so a particular focus for shared learning might be how to work together on sustainability goals. Actions the CSTD might encourage include:

16) Embracing sustainability as a general value in public action, including innovation;.
17) Welcoming the efforts of large and small companies to adopt sustainable practices, and encouraging them to innovate in this direction.
18) Participating in cross-national projects for inclusive and sustainable development, insisting that such efforts produce tangible results commensurate with the effort invested.

The CSTD has the opportunity to play a leading role with regard to inclusive and sustainable development. It could consider:

19) Helping to stimulate the development of an international community of practice in inclusive and sustainable development to bring researchers, development practitioners, and policymakers together to accumulate lessons learned and improve practice.

In short, inclusive and sustainable development is centrally important issues for the post-2015 era. Science, technology, and innovation can contribute to addressing them. But a great deal of work remains to bring the power of STI to bear on the problems of development. The CSTD can play a central role in making that happen.

References

Alzugaray, S., L. Mederos and J. Sutz (forthcoming). "Building Bridges: Social inclusion problems as research and innovation issues." Review of Policy Research.

Bijker, W. E., T. P. Hughes and T. Pinch (1987). The Social Construction of Technological Systems. Cambridge, MA, MIT Press.

Catalán, P. (2012). Community-Based Innovation Dynamics in the Water Supply and Sanitation (WSS) Sector, Georgia Institute of Technology.

Chang, H. J. (2002). Kicking Away the Ladder: Development Strategy in Historical Perspective. London, Anthem Press.

Cozzens, S. E., K. Bobb and I. Bortagaray (2002). "Evaluating the Distributional Consequences of Science and Technology Policies and Programs." Research Evaluation **11**(August): 101-107.

Cozzens, S. E. and P. Catalan (2008). "Global Systems of Innovation: Water Supply and Sanitation in Developing Countries". Globelics. Mexico City.

Cozzens, S. E. and J. Sutz (2014). "Innovation in Informal Settings: Reflections and Proposals for a Research Agenda." Innovation and Development **Forthcoming**.

Daniels, S. (2010). Making Do: Innovation in Kenya's Informal Economy Analogue Digital.

Fressoli, M., A. Smith and H. Thomas (2011). From Appropriate to Social technologies: some enduring dilemmas in grassroots innovation movements for socially just futures. Globelics 2011. Buenos Aires.

Gatchair, S., I. Bortagaray, L. Brito and R. Brouwer (2014). Uneven Publics: Life, Death, and Recombinant Insulin. Innovation and Inequality: Emerging Technologies in an Unequal World. S. C. a. D. Thakur, Edward Elgar.

Gupta, A. K. (2003). "Mobilizing grassroots' technological innovations and traditional knowledge, values and institutions." articulating social and ethical capital **35**(9): 975-987.

Kim, L. (1997). Imitation to innovation : the dynamics of Korea's technological learning. Harvard Business School Press, Boston.

Lundvall, B. A. (1988). Innovation as an interactive process: from user-producern interactions to the national system of innovation. Technical Change and Economic Theory. G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete. London, Pinter.

Nelson, R. R. (1993). National innovation systems: a comparative analysis, Oxford University Press, USA.

Prahalad, C. K. (2006). The Fortune at the Bottom of the Pyramid, Pearson Education India.

Seguino, S. (1997). "Gender wage inequality and export-led growth in South Korea." Journal of Development Studies **34**(2): 102-132.

Sen, A. (1992). Inequality Reexamined. Cambridge, MA, Harvard University Press.

Soares, M. C. C., J. E. Cassiolato and H. M. M. Lastres (2008). Innovation in Unequal Societies: How can it contribute to improve equality? International Seminar Science, Technology, Innovation and Social Inclusion.

Soumonni, O. (2013). Electrification in West Africa: Which Way Forward? An Adaptive Management Perspective on Energy Policy, Georgia Institute of Technology.

Stewart, F. (2002). Horizontal Inequalities: A Neglected Dimension of Development. Oxford, UK, Centre for Research on Inequality, Human Security and Ethnicity, CRISE.