TST Issues Brief: Science, Technology and Innovation, Knowledge-sharing and Capacity-building[1]

The pivotal importance of Science, Technology and Innovation (STI), Knowledge-sharing and Capacity-building[2] for eradicating poverty and achieving sustainable development has recently been confirmed at the Rio+20 Conference and the 2013 ECOSOC Annual Ministerial Review. While research and innovation become increasingly open, collaborative and international,[3] access to the benefits of STI and knowledge is unequally distributed within and among countries and people, and the technological gap between developing and developed countries is persistent. STI and knowledge must be harnessed for the benefit of all, including the most vulnerable and marginalized.

1. Stocktaking

STI can be 'the game changer' of the socio-economic situation of developing countries and economies in transition.[4] Development of national STI capacities has been proven to be an important prerequisite for the social and economic transformations that enable sustainable economic growth, human development and poverty eradication.[5] Policies to promote innovation lay the foundation for future growth, productivity improvements, entrepreneurial and employment opportunities. Success in innovation requires a holistic approach with all elements in the innovation eco-system reinforcing one another.

- 2.7% of GDP is devoted to R&D activities in North America, while only 0.4% is devoted to it in Africa.[a]
- Of the world's researchers, only 27% are women.[b]
- Only 0.5% of the world's researchers live in LDCs (European Union: 20.1%, North America: 21.9%).[c]
- An estimated 2.5 million engineers and technicians will be needed in sub-Saharan Africa alone to achieve improved access to clean water and sanitation.[d]
- 74% of inhabitants of developed countries are Internet users, compared with only 26% in developing countries.[e]

(a) Global Investment in R&D, UNESCO Institute for Statistics (UIS), 2012; (b) UIS, 2012; (c) UNESCO Science Report, 2010; (d) *Engineering: Issues, Challenges and Opportunities for Development*, UNESCO, 2010; (e) http://www.un.org/millenniumgoals/global.shtml.

The speed at which we are approaching planetary boundaries[6] is increasing, and in some cases they are already being exceeded.[7] Enhanced scientific knowledge, including geospatial data, about Earth system functioning, has significantly advanced our understanding of the impacts of human actions on vital Earth systems and can provide options for technological solutions as well as management and policy responses aimed at decoupling economic growth from escalating resource use and environmental degradation.[8] The integration of scientific with indigenous and local knowledge is increasingly considered an important element of policies and programmes to manage natural resources in an environmentally and economically sustainable and culturally appropriate manner.[9]

Investment in knowledge systems, including Research & Development (R&D), has expanded globally, including in many developing and emerging countries. The distribution of R&D efforts between North and South has changed with the emergence of new actors in the global economy, creating a more competitive global environment.[10] In parallel, there is a growing emphasis on the relationship between knowledge, innovation and growth, especially in middle-income countries, with increasing focus on STI

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[2] 'Capacity-building' or 'capacity development' is defined as "the process by which individuals, organizations, institutions and societies develop abilities to perform functions, solve problems and set and achieve objectives. It needs to be addressed at three inter-related levels: individual, institutional and societal." UN ECOSOC, *Definition of basic concepts and terminologies in governance and public administration*, E/C.16/2006/4.

[3] See also remarks of the UN Secretary-General at the launch of the *Global innovation Index*, Geneva, 1 July 2013.

[4] Bokova, I., 'An Integrated Policy Approach in STI for Sustainable Development', in INSEAD-WIPO, *The Global Innovation Index 2012*

[5] Report of the UN Secretary-General, *Science, technology and innovation, and the potential of culture, for promoting sustainable development and achieving the MDGs*, 2013 Annual Ministerial Review of ECOSOC (referred to hereunder as 'UN SG Report, AMR ECOSOC 2013').

[6] For a definition of 'planetary boundaries' see for ex., Rockström, J. et al., *Sustainable Development and Planetary Boundaries*, May 2013.

[7] *One Million Voices*: *The World We Want*, UNDG, 2013.

[8] Cf. Dobbs, R. et al., *Resource Revolution: Meeting the world's energy, material, food and water needs*, McKinsey & Company, 2011, and Lubin, D.A, Esty, D., *The Sustainability Imperative*, Harvard Business Review, May 2010.

[9] One of the successful examples is the development of prevention and preparedness schemes and early warning systems on weather hazards.

[10] *UNESCO Science Report*, 2010, and World Intellectual Property Report *The Changing Face of Innovation*, 2011

policy frameworks. This is steering countries toward enhancing innovation involving university-industry collaboration and competitive research funding.

The ways in which knowledge is created, processed, diffused and applied have been revolutionized in part through rapid developments in information and communication technologies (ICTs), leading to the creation of dynamic networks and cross-border collaborative processes. The internationalization of research and higher education has increased the mobility of skilled professionals, scientists and academics, and is an important mechanism for knowledge sharing and technology transfer. Even so, lack of a highly skilled workforce and limited investments in STI are preventing middle-income countries from competing with the high-skills and high-innovation products of the advanced economies,[11] while a lack of basic skills prevents large numbers of poor people in middle- and low-income countries from exploiting economic opportunities and technologies potentially available to them.

Disparities in scientific capacity and STI development levels within and between countries and regions remain significant[12] and science and scientific cooperation still need to be globally inclusive:

- **insufficient government commitment and resource base for STI**, including financing, technology and capacity, poorly designed national STI policies and lack of organizational capacities to implement the policies have hampered development of innovation capacities in many countries;
- **unequal access to STI and knowledge as well as to their benefits remains persistent within and among countries**. Developing countries, particularly Least Developed Countries (LDCs), Small Island Developing States and countries in post-conflict and post-disaster situations, continue to lag behind in Gross Domestic Expenditure on Research and Development (GERD) and in international collaboration in science. At the same time, emerging economies are starting to close the STI gap in relation to industrialized countries, which is prompting new avenues for South-South collaboration in STI;
- the **lack of good quality national data and mechanisms to ensure access to and use by decision-makers** needs to be addressed**;**
- in many parts of the world, **women's participation in most fields of science remains low**, with fewer women than men enrolled in science education, working in STI sectors, and participating in decision-making in scientific institutions.[13] In addition, there is insufficient internationally comparable data, gender analysis and gender impact assessment with respect to R&D/STI;
- millions of people, including persons living with disabilities and people living in rural and remote communities, continue to face barriers for accessing the benefits of STI, science education and ICTs; **equitable access to adequate infrastructure, including ICTs, is lacking**.[14]
- the widening economic gap between nations is increasingly linked to corresponding gaps in terms of levels of STI development; low- and middle-income countries vary substantially with regard to the R&D investment and capacity of their public research institutions, science-industry cooperation, infrastructure and policy frameworks for technology transfer, as well as the accountability dimension for public R&D expenditures.[15] A key difference with high-income countries is the **weak linkages between public R&D and national economic development**.[16]
- the **lack of absorptive capacity in firms and their focus on imitative innovation and acquisition of foreign technology** contributes to fragmentation in national innovation systems. The barriers to industry-science collaboration include a lack of communication channels between business and universities, differences in organizational culture, uncertainty of market potential for research results, and high costs for developing and commercializing university research.

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[11] *One Million Voices: The World We Want*, UNDG, 2013.
[12] *UNESCO Science Report*, UNESCO, 2010.
[13] Of the world's researchers, only 27% are women (all fields of science, based on countries providing gender breakdown), UNESCO UIS, 2012.
[14] See for example: CIGI and KDI, *Post-2015 Development Agenda: Goals, Targets and Indicators*, 2012, or *The post-2015 delivery of universal and sustainable access to infrastructure services*, Overseas Development Institute, 2013.
[15] World Intellectual Property Organization, *World IP Report 2011* (see Chapter 1 and Subsection 4.2.1).
[16] This situation is often rooted in a series of factors such as: less developed human capital for S&T activity; low quality research and low relevance of public research to the business sector; limited science-industry linkages, explained by a low absorptive capacity of firms and lack of business demand for S&T; lack of policies and structures to facilitate academic and other start-ups; limited access to financing for innovation.

- there is a **disconnect between policy-makers, technical experts (scientists, engineers, etc.) and users/citizens** in generating, sharing and utilizing scientific knowledge, as well as between scientific knowledge production systems and other knowledge systems, including in terms of content/issues, context-responsiveness and adaptation, values, and sectoral involvement.
- **there is a lack of consistent life cycle thinking and long-term perspective in the STI frameworks and policies of countries**, especially in those of developing countries and the emerging economies.

A) Lessons learnt from the MDGs

The MDGs did not include any goal explicitly related to STI, despite the critical role in development. The MDG target 'Making the benefits of technologies, particularly ICTs, available to all'[17] may be considered achievable by 2015 when it comes to the evolution of the ICTs sector and access to mobile services.[18] However, the potential of ICTs has yet to be fully realized. Access to and use of information and knowledge facilitate the achievement of the MDGs. A substantial reorientation of development policies that draws upon new and established S&T knowledge was recognized by the MDG review process to be key for meeting the MDGs. Improving the policy environment, redesigning infrastructure investment, fostering enterprise development, investing in higher education in science and engineering, are some of the areas identified for policy action to achieve the MDGs.[19] While several of them have been addressed in a number of countries, much remains to be done.

B) Emerging challenges and opportunities

a) The full potential of STI, knowledge-sharing and capacity-building for poverty eradication and sustainable development will be best harnessed by **building coherent enabling legal, policy, financial and institutional frameworks at the national, regional and international levels.** These should fully take into account the needs and aspirations of all, in particular women and youth. **National STI policies and systems need to be designed within the context of national strategies and action plans for sustainable development; they must be strategically linked to education policy, intellectual property and trade policies, macroeconomic and industrial policies** as well as other efforts to increase productive capacities, particularly green technology development.[20] The sustainability of STI initiatives in developing countries is key.

b) **STI efforts should be more effectively targeted to address environmental, economic and social challenges and to provide sustainable and effective tools for strengthening sectors with the greatest poverty-reduction potential and/or involvement of people living in poverty.** The UN TST Issues Briefs on Poverty Eradication, Employment and Decent Work, Sustainable Agriculture, Food Security and Nutrition, Health and Nutrition, Water and Sanitation, and Desertification, Land Degradation and Drought, Climate Change and Disaster Risk Reduction, Oceans and Seas, and Biodiversity all highlight the explicit linkages between each of these priority areas and STI, including the importance of the generation and sharing of scientific knowledge, the strengthening of the science-policy-society interface as well as the contribution of local and indigenous knowledge systems. Other areas such as equitable delivery of public services, especially for the most vulnerable populations, and the promotion of good governance, depend on targeted STI and particularly on ICTs.

a) A strengthened science-policy-society interface is needed for ensuring that scientific research, technology development and policy both address the needs of society and respond to current and future sustainability challenges.[21] The widespread integration of science into policy-making will

[17] Target 8.F: In cooperation with the private sector, make available benefits of new technologies, especially information and communications.
[18] The number of mobile cellular subscriptions worldwide by the end of 2011 reached 6 billion http://www.un.org/millenniumgoals/global.shtml
[19] UN Millennium Project 2005. *Innovation: Applying Knowledge in Development*. Task Force on Science, Technology, and Innovation.
[20] UN SG Report, AMR ECOSOC 2013.
[21] On the importance of the science-policy interface, see the Outcome Document of the Regional Consultations on the Post-2015 Development Agenda, Dakar, Senegal (10-11 December 2012), UNECA, AUC, AfDB, UNDP and the recommendations of the UN Secretary-General's High-Level Panel on Global Sustainability Report *Resilient People, Resilient Planet: A Future Worth Choosing*, 2012.

greatly depend on science being 'useful, useable and used'[22]. Priority should be put on sharing and disseminating scientific information and on translating it into practical methods and policy options that can readily be integrated into policies, regulations and implementation plans. Enhanced mechanisms for science-policy dialogue and exchanges on all levels[23] are needed together with the promotion of Open Access to scientific information and research.[24] Science also has to interact with civil society to ensure an inclusive user-driven approach to knowledge, research and technology. **It is also critical that research, development and deployment in all fields take into account existing gaps and gender perspectives, and that national and international research priorities benefit both women and men.** Participatory methods can ensure that women's needs, preferences and constraints are not neglected; more generally, they are key to bringing knowledge inputs and feedback from technology and knowledge users back into the STI production loop.

b) Strategic investments need to be made in education, capacity development in STI and engineering, and innovation ecosystems. Strengthening science education at all levels, including technical and vocational education and training, entrepreneurship education and teacher training, with special attention to making them attractive to both women and men, is essential to catalyze innovation. Higher education and research institutions should be strengthened to produce the knowledge that informs policy and facilitates the adaptation of appropriate technology solutions to local contexts. The links between university and industry, technology and enterprise need to be created, expanded and supported. These efforts need to be complemented by provision of venture capital and facilitating competiveness of technology-driven businesses including those established by youth and women.[25]

c) **Multidisciplinary and integrated as well as culture-sensitive approaches, bringing together natural and social and human sciences as well as local and indigenous knowledge, are key to build the necessary knowledge for sustainable development at all levels**, with the participation of the scientific community, civil society and the different components of the private sector in the scientific process.[26] Problem-solving approaches to research integrating multiple challenges and disciplines and ensuring openness in their dissemination, can lead to useful and usable knowledge generation. For example, considering the full life cycle of technology options for long-term provision of human needs, from raw material acquisition to waste disposal/recycling, is essential to ensure sustainable consumption and production. Participatory and flexible problem-solving approaches are also critical in sectors where challenges are very context-specific and evolve rapidly and, to varying extents, unpredictably such as the agriculture sector.

d) Open access to knowledge and the free flow of information need to be expanded in order to maximize the potential of scientists to bridge the knowledge gaps within and among societies, facilitate economic growth and social cohesion, and promote good governance. ICTs, including open solutions, can significantly advance science in many fields, by, inter alia, promoting Open Access by scientists to each other's findings and data at no or low cost, harnessing multidisciplinary collaborations, scaling-up innovative ideas and supporting innovation and the diffusion and transfer of technology. Open access to patent information and patent analytical tools also offers a rich body of technological information that can support R&D and innovation. Tools that enable co-creation and and exchange, including digital platforms following the Free Open Source Software model, enable increased competition, access, and diversity of choice. Inclusive and affordable broadband and ICT policy and the empowerment of all men and women to tap into and leverage the rich reservoirs of

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[22] Boaz, A., Hayden, C., *Pro-active evaluators: Enabling Research to be useful, Usable and Used*, Evaluation, 2002; vol. 8(4):44053.
[23] UNESCO-UNEP-SCOPE Policy Brief 3, *How to improve the dialogue between science and society: the case of global environmental change,* 2006.
[24] For ex., the integration of geospatial data and information into decision support systems would allow for more accurate environmental impact assessment and more informed decision-making.
[25] See for ex., *Training Strategy for Strong, Sustainable and Balanced Growth,* ILO, 2010; Skills for Green Jobs: A Global Review, ILO, 2012; *Set of policy recommendations to meet skills needs for green jobs*, Inter-Agency Working Group on Greening TVET and Skills Development, ILO, 2013.
[26] UN SG Report, AMR ECOSOC 2013.

creativity and ingenuity are required. Mobile technologies, especially when easily accessible, can open new innovation channels,[27] including through improving service delivery and providing support for social movements. ICT solutions need to be accompanied by change management approaches to increase institutional acceptance. Partnerships with the private sector are also crucial to fully benefit from big data.

e) **Unintended consequences of STI need to be addressed and the precautionary principle applied.** While the potential return on investment in STI is usually high, the increasing pace of technological innovation raises ethical questions about the development and use of STI. The quick advances in the life sciences, such as in biotechnology, have raised public concern and require serious reflection about the benefits and risks involved. Also, privacy issues have to be taken into full consideration when deploying open data and making use of big data.

f) There remains an uneven global landscape in terms of innovation capacity reflecting a certain divide between innovation leaders and followers. In addition, connecting local technological needs to international technological opportunities is a challenge for many developing countries. A well-functioning STI ecosystem needs to include: 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 R&D; as well as proper framework conditions and incentives for innovators, including a balanced intellectual property rights (IPRs) framework. There is a **need to prioritize national capacity-building for innovation focusing on the establishment of a conducive policy framework for innovation, especially in developing countries**.

g) 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 sustainable innovation is integrated into national development priorities**, particularly in LDCs, where the technological divide is greatest. Intellectual property (IP) is an important way of rewarding R&D investments and the commercialization of innovation, as well as promoting the disclosure and dissemination of technological information. Although a key element of the ecosystem, IP is not an end in itself. Commitment to the protection of IP through cooperation among States should be coupled with a commitment to ensuring that all countries are able to benefit from the use of IPRs for economic, social and cultural development. Finding the right balance between accessibility of technology and reward for creativity and innovation remains a fundamental challenge. Given that appropriate IP policies are context specific, there is also a need to ensure that, for those countries that request it, appropriate technical assistance and capacity-building are available to make most effective use of the IP system.

h) New global multi-stakeholder partnerships need to be designed, emphasizing the role of scientists and academics as essential for the post-2015 development agenda and promoting the development and sharing of innovations for the benefit of all.[28] These partnerships should embrace the principles of open access to data and knowledge, as well as looking at STI streams that contribute to enhancing the life of people at all social levels. This includes partnerships with economic actors at different scales, including small- and medium-sized enterprises in rural and urban area, South-South and triangular collaboration. Partnerships with local and marginalized communities, including indigenous people, women and youth, should also be pursued. Strengthening science diplomacy provides further opportunities to build scientific cooperation on issues that no single country can address alone.

i) A data revolution for sustainable development is necessary, and a Global Partnership on Development Data should be established.[29] A post-2015 development agenda needs to be grounded on a strong monitoring and evaluation framework. Science can support establishing baselines and

[27] UNDP, *Mobile Technologies and Empowerment: Enhancing Human Development through Participation and Innovation, 2012.*
[28] *Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda*, 2013.
[29] Ibid.

development of goals, targets and metrics based on evidence, and can help in assessing progress. Strong statistical capacity at country level and sound data-sharing policies at international level are needed for monitoring progress.

2. Overview of proposals

Several proposals for integrating STI-related targets into the SDGs framework have been made so far. Proposals either put stand-alone goals on S&T forward or propose science- and technology-related targets under other development goals.

A) **One or several SDG(s) on science, technology and innovation** has(ve) been put forward by:

- Rio+20 Issues Brief 12 **(UNCSD Secretariat).** Three potential areas for goals were identified: 1. Global technology performance improvement by a factor 4 (i.e. decoupling growth from resource use and environmental degradation); 2. Universal access to sustainable technology; 3. Global green innovation systems for sustainable development, including institutional and input targets such as: global R&D cooperation system; global IPR system; combined public and private investment of at least 2 per cent of GDP in R&D in all countries, and at least 3 per cent in technologically advanced economies; publicly-funded technology, scientific discoveries and creative works made freely available for sustainable development.

B) **Inclusion of science and technology aspects under other SDGs.** This approach has been proposed by:

- **The UN Secretary-General's High-Level Panel of Eminent Persons on the Post-2015 Development Agenda.** To include under the illustrative goal 'Create a Global Enabling Environment and Catalyse Long-Term Finance' the following target: 'Promote collaboration on and access to STI and development data'; under the goal 'Create Jobs, Sustainable Livelihoods, and Equitable Growth', a target: 'Strengthen productive capacity by providing universal access to financial services and infrastructure'.
- **UN Global Compact.** Under the goal 'Modernize infrastructure and technology', the following targets are proposed: 'Deploy investment sufficient to meet requirements for "green" transport, energy and water systems in the developing world, and for upgrading or replacing old and "brown" infrastructure in the developed world'; 'Universal and affordable access to the Internet and computing technology' and 'Step up R&D in both public and private sectors.'
- **The UN Broadband Commission** proposed the target 'gender equality in broadband access by 2020'.
- The **55th Session of the Commission on the Status of Women** recommended to 'set concrete goals, targets and benchmarks […] to achieve equal participation of women and men in decision-making at all levels, especially in S&T institutions […] as well as in the design of S&T policies and research and development agenda setting.'
- **The Brookings Institution.** Under a goal on 'gender equality', the development of targets for political, scientific, and corporate leadership is suggested and, under a goal on 'global partnership and good governance', the development of ambitious targets for data quality and availability as well as targets for civil society efforts, including scientific "citizen goals".
- **The Campaign for People's Goals for Sustainable Development.** Under a 'Climate justice and environmental sustainability' goal, a target 'Ensure sharing of safe, appropriate and ecologically sound technologies' is suggested.
- **The Center for Global Development.** Under an education goal, the need to accelerate progress in math and science skills 'for a productive role in national and global societies' is mentioned.

In addition, many other SDG proposals depend on increased capacities in STI, and on knowledge generation and sharing to achieve the targets set, such as 'monitoring of ocean acidification', as suggested under an ocean SDG[30], or 'improving integrated water resources management and water-use efficiency', as suggested under a stand-alone goal on water.[31]

3. Way forward

The benefit of a stand-alone SDG on 'Harnessing STI for Sustainable Development' is that it would enhance the adoption and operationalization of integrated national STI strategies and action plans for sustainable development and would increase innovation capacities, green technology transfer and scientific capacity-building in developing countries. Mainstreaming STI into other SDGs appears to be a necessary complementary requirement for promoting knowledge-sharing and for building capacity to face the multiple challenges posed by sustainable development. Many statistics and indicators on STI-related issues are available, but they rarely connect or measure the input of STI in achieving development goals. In the light of the complexity of STI, knowledge-sharing and capacity-building and their multiple impacts on and contribution to sustainable development and poverty eradication, a series of goals, targets and indicators could usefully be considered.

On the basis of the proposals made so far and in the light of the challenges and opportunities outlined in this brief, **specific goals, targets and indicators[32] could be developed around the following priority areas**:

- Investment in science, technology and innovation, including investment in R&D, as a percentage of GDP and as a percentage of Official Development Assistance;
- STI policies as holistic frameworks and integral part of national sustainable development policies addressing inter alia the following:
  - Increased multi-stakeholder collaboration across the policy-science-industry-society spectrum;
  - Human, institutional and societal STI capacity-building, with a strong focus on training and science education at all levels;
  - Measurement of innovation capacity across a range of metrics which combine to create national innovation eco-systems;[33]
  - Achieving gender parity in STI systems;
- Level of openness achieved in accessing, sharing, processing and using scientific research and knowledge;
- Inclusive Internet connectivity and use; scaling up of ICTs to spur local innovation;
- Data revolution including solid STI statistics and indicators systems, and adequate capacities for data collection and analysis;
- Regional and international STI cooperation and multi-stakeholder partnerships, in particular South-South and North-South-South;
- New and stronger financing mechanisms at all levels for STI, knowledge and data-sharing, capacity development and green technology transfer;
- Achieving specific resource efficiency/decoupling factors via STI.

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[30] See for example, Civil Society Organizations at 64th Annual UN Department of Public Information NGO Conference (2011).
[31] See for example, the UN Secretary-General's Advisory Board on Water and Sanitation (UNSGAB).
[32] Indicators tracking goals and targets 'should be disaggregated to ensure no one is left behind and targets should only be considered 'achieved' if they are met for all relevant income and social groups.' See HLP Report.
[33] UN Secretary-General's Press Release at ECOSOC 2013 at the launch of the WIPO-INSEAD-Cornell *Global Innovation Index 2013*.