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On

Global Cooperation in Science, Technology and Innovation for Development

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I. Introduction

At its twenty-sixth session held in March 2023, the United Nations Commission on Science and Technology for Development (CSTD) selected "Global Cooperation in Science, Technology and Innovation for Development" as one of its two priority themes for the 2023-2024 inter-sessional period. To contribute to a better understanding of this theme and to assist the Commission in its deliberations at its twenty-seventh session, the Commission secretariat has prepared this issue paper based on relevant literature and case studies contributed by Commission members.

Scientific research increasingly takes place among global teams of researchers, creating networks that extend beyond national institutions and single disciplines (Wagner et al., 2015; UNCTAD, 2018). The growing technological complexity, the fast pace of technological change and the massive transformation brought by recent waves of innovation require a collaborative approach to Science, Technology and Innovation (STI). Choices about today's challenges, from climate change to technological singularity, require an interdisciplinary approach and will have an impact on many aspects of human life at the global level.

Global cooperation in STI is essential more than ever to put the world on an inclusive and sustainable development path and contribute to closing the gap between developed and developing countries. As highlighted by the 17th Sustainable Development Goal (SDG), global partnerships are important vehicles for mobilizing and optimizing resources available among governments, businesses, academia, civil societies and other stakeholders to ensure progress and long-term sustainability in all countries, particularly developing ones (United Nations, 2023). Specifically, SDG 17 stresses the importance of knowledge sharing through North-South and South-South cooperation in STI, the development, transfer, dissemination and diffusion of technology to developing countries on favourable terms, as well as the enhanced use of enabling technology, in particular environmental and information and communication technologies.

Nowadays, the benefits of frontier technologies are not distributed equally among developed and developing countries and the gap is even widening (UNCTAD, 2023a).[2] For example, between 2018 and 2021, the total exports of green technologies of developed countries rose by a factor of 2.6 (from $60 to $156 billion), while those of developing countries grew only by a factor of 1.3 (from $57 to $75 billion). Developed countries are seizing most of the opportunities of the technological revolution unleashed by Industry 4.0, Artificial Intelligence (AI) and green technologies, putting developing countries at risk of being left further behind as happened in previous waves of technological innovation.

Developing countries must act to enhance their STI capabilities and strategically position themselves to take advantage of current and upcoming technological opportunities. However, the success of national policies also depends on global cooperation and the international

[2] The UNCTAD's Technology and Innovation Report 2023 examines 17 frontier technologies, defined as new and rapidly developing technologies that take advantage of digitalization and connectivity, which are divided into three broad categories: (i) Industry 4.0 frontier technologies which include artificial intelligence (AI), Internet of Things (IoT), big data, blockchain, 5G, 3D printing, robotics and drone technology, (ii) green frontier technologies which encompass solar photovoltaics, concentrated solar power, biofuels, biogas and biomass, wind energy, green hydrogen and electric vehicles, and (iii) other frontier technologies which comprehend nanotechnology and gene editing.

community has a crucial role to play in supporting developing countries to strengthen national capacities in STI and to facilitate their participation in global science and technology networks which are currently dominated by few strongly interconnected organizations (Ribeiro et al., 2018). These efforts would help strengthen the national innovation systems of developing countries and guarantee that the global research and innovation agenda meets their interests and needs.

In this regard, this paper explores ways for improving STI cooperation at the global and regional levels to scale up the impact of existing experiences on key development challenges, especially for developing countries.

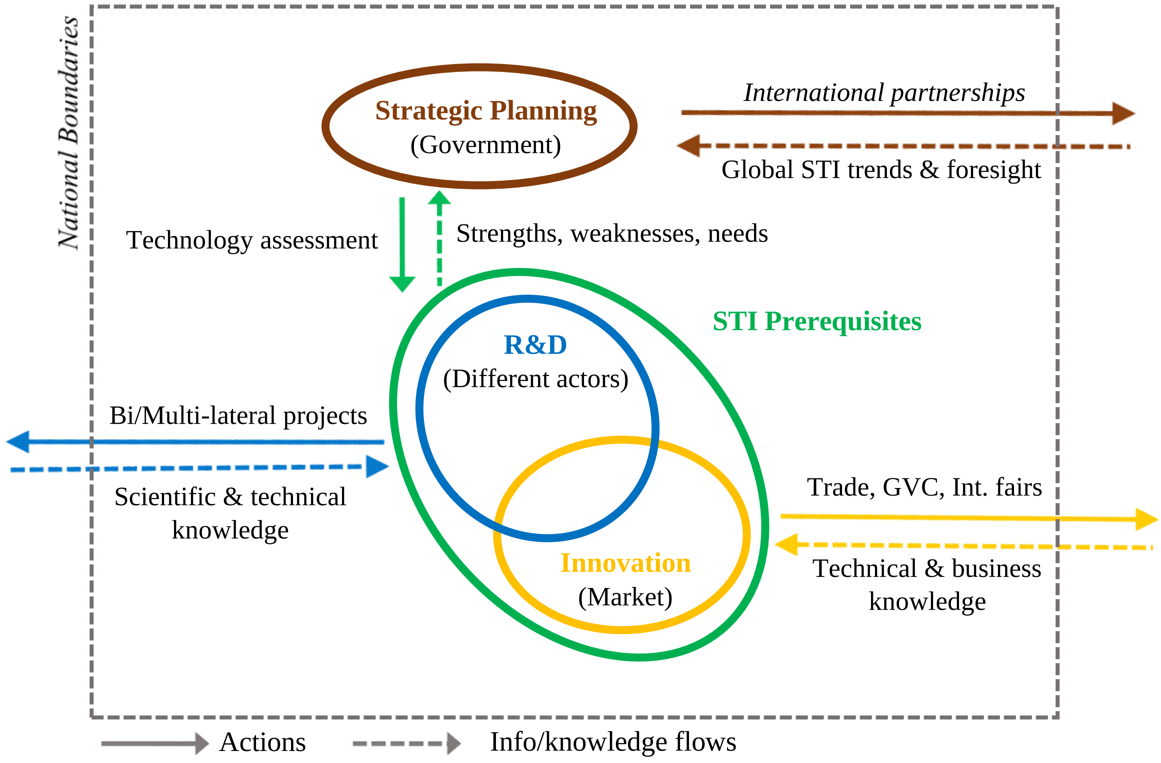
The paper is structured as follows. Section II provides a brief overview of the four key elements for STI development that serves as a framework for a more in-depth analysis of international STI collaboration. Section III examines the status of global STI cooperation under each of the four elements for STI development, focusing on R&D that is crucial for the use, adoption and adaption of technologies and innovations. It discusses collaboration mechanisms, progresses, lessons learned and good practices of different initiatives, as a background to formulate recommendations on strengthening global cooperation in STI for sustainable development. Section IV reviews the contribution of the CSTD in facilitating global STI cooperation and highlighting its role for coordinating and imparting directionality to international STI collaboration. Section V concludes and provides recommendations for the consideration of Member States, the international community and the CSTD. In the annex, the paper includes a list of questions to consider for discussion and facilitate the dialogue at the Intersessional Panel of the Commission on Science and Technology for Development in November 2023.

II. Key elements for STI development

The increasing interconnectedness of STI activities at the global level makes it urgent for countries to rethink their strategies and policies and render more evident than ever the need for approaches that open the focus of STI policy beyond national actors only.

The national innovation system (NIS) approach has long represented a framework to conceptualize and identify the many factors contributing to the determination of the innovative capabilities of a country. Nowadays, the NIS approach does not suffice as a practical framework for STI policy for development, which must be addressed from a global perspective, while still considering the needs, capacities and interconnections that characterize the relevant innovation system. This paper focuses on four key elements characterizing the STI system and its development; these elements allow us to highlight the connections and knowledge flows with respect to actors from outside the national boundaries (Figure 1).

Figure 1: Key elements of a national STI system with international linkages



Note: The figure is not meant to provide exhaustive coverage of all the interactions and actors of a national innovation system but to highlight the main components and their external relationships.
Source: UNCTAD.

The government is part of the wider setting that refers to the institutions contributing to competence building and shaping human interactions in relation to STI (Lundvall, 2016). In particular, the overall direction can be formulated through a *strategic planning* accompanied by the necessary instruments, such as frameworks, policies, guidelines, standards and regulations. For example, the “Ghana STI for SDGs Roadmap” defines vision, targets, strategies, roles and responsibilities, as well as monitoring and evaluation systems to accelerate the achievement of the SDGs prioritized by the Government (Ministry of Environment, Science, Technology and Innovation, Ghana, 2022). A thoughtful consideration of the strengths and weaknesses of the national innovation system with respect to the global trends in STI will contribute to setting the foundations of successful strategic planning. For example, the recent "STIP review of Angola" maps and benchmarks the innovation ecosystem, including entrepreneurship and new digital technologies, by combining data analysis and interviews with representatives of the Government, the private sector, academia and specialized institutions (UNCTAD, 2023b). A solid foundation of strategic planning is based on a comprehensive overview of the state and needs of the *STI prerequisites*, which include both tangible (physical and digital) and intangible (human and knowledge) resources.

Within the STI prerequisites, it is useful to distinguish *R&D* (science and technology) from *Innovation*. The former can be mapped into the concept of invention, which is the result of different economic and social processes with respect to innovation (Schumpeter, 1939). An invention can be defined as a unique or novel device, method, composition, idea or process; as such, it is associated with an act of creation. Innovation, instead, is the practical implementation of ideas that result in the introduction of new goods or services in the market or improvements of their offering; as such it is associated to commercialization. R&D includes basic and applied research as well as experimental or incremental development and can be performed by universities, research institutions or firms. Innovation is mainly performed by firms, and it is related to goods and services, production processes, marketing strategies and the overall organization of businesses. Innovation is affected by a country's strength in science and technology, but it depends also on the industrial and organizational context in which firms are inserted (Morrison and Pietrobelli, 2007). The core of the innovation system is represented by firms and knowledge infrastructures, and it is crucial to support the firms' potential for developing, absorbing or using new technologies (Lundvall, 2016).

In the following subsections, the four key elements for STI development will be discussed more in detail to highlight their specificities in terms of processes and interactions internal and external to the NIS. This will set the ground to review and interpret the status of international STI cooperation presented in section III.

A. Strategic Planning

Setting specific and achievable goals is the first step towards success. National strategic goals and development targets can be set through multi-year plans, which include STI.

A well-informed planning for STI requires at least two components: *i)* an understanding of the global STI trends; and *ii)* a clear overview of the country's strengths and weaknesses in STI.

In recent years, there has been a multiplication of technological foresight exercises aiming at looking into the longer-term future of STI. These exercises require resources and knowledge about frontier technologies both from a technological and scientific point of view. Often, small and less developed countries do not have the necessary critical mass to engage in these types of exercises and may find it difficult to understand the implications of the multiple existing assessments. Coordinated efforts at the international level can make sense of the different forecasting and foresight exercises to support the strategic planning of less advanced countries.

Moreover, the accelerated technological change makes it particularly challenging to keep up with the latest and upcoming technological developments. For example, the astonishing pace of development and application of generative AI in creating new content, including text, image, audio and video, raises concerns about the spread of misinformation, intellectual property rights (IPRs) infringement, data privacy violation and amplification of existing bias (UNCTAD, 2023c). The international dimension of these challenges calls for quick but complex responses that may necessitate the development of specific normative and/or institutional frameworks. This requires a shared understanding of the implications of current technological change to build consensus on a common vision that reflects the needs and aspirations of all countries. Global cooperation supporting the sharing of best practices and lessons learned through technological foresight exercises is more important than ever (Box **1**).

Box 1 – Cooperation in technology foresight for assessment

Technology foresight provides a framework to identify and assess challenges and opportunities related to new technologies and support policymakers and stakeholders in the implementation of the 2030 agenda for sustainable development.

During the 19th Annual session of the CSTD (2016), it was highlighted the importance of undertaking systemic research on new trends in science, technology and innovation, and information and communications technologies and their impact on development.

In particular, among other points, it was recommended to:

- undertake strategic foresight initiatives on global and regional challenges at regular intervals and *cooperate towards the establishment of a mapping system to review and share technology foresight outcomes making use of existing regional mechanisms, and in collaboration with relevant stakeholders*;
- use strategic foresight as a process to encourage structured debate among all stakeholders towards *creating a shared understanding of long-term issues and building consensus on future policies*; and
- *conduct (technology) assessments of national innovation systems, drawing from foresight exercises*, at regular intervals, to identify weaknesses of the systems and make effective policy interventions to strengthen their weaker components, and share outcomes with other Member States.

Source: CSTD 19th Annual Session Resolution on Science, technology and innovation for development.

Technology assessment exercises, drawing from international experiences, help policymakers and stakeholders identify specific challenges and opportunities for a country, which are strongly related to the state of its STI prerequisites. A whole-of-government approach is essential to ensure that new STI instruments and targets are tailored to the strengths and weaknesses of the country and aligned with existing actions in other domains, including at least energy, industry and education[3] to leverage complementarities across different policy spheres.

B. STI Prerequisites

Every technological revolution has set higher requirements for the infrastructures supporting the functioning of the economy. Nowadays, it is no longer only about the provision of stable and affordable electricity or functioning transport and mobile networks; the current economic paradigm requires affordable internet connection and high standards of bandwidth and latency (International Telecommunication Union, 2022). The diffusion of digital technologies and AI is blurring even more the boundary between the physical and digital worlds, and their integration into science, technology, and production will strongly depend on supportive infrastructure.

Moreover, intangible (human and knowledge) resources are even more crucial in today's economy (Corrado et al., 2009). Competences and skills are needed at all levels, from those required to use new applications and products to those needed to develop new technologies or adapt imported ones to better fit specific needs and conditions. The digital revolution makes mastering STEM[4] skills (from mathematics and statistics to coding and data analytics) crucial to empower the workforce to adapt to technological advances (UNCTAD, 2018). The competences needed vary across sectors, countries and levels of industrial development, thus educational policies should be calibrated according to countries' readiness to engage and benefit from STI development.[5] In terms of human capital, the skills necessary to adapt to hybrid work environments (e.g., in-site and remote workers and contractors) often require multiple expertises, such as interpersonal communication, collaboration and emotional intelligence (Marr, 2022; WEF, 2016)

Importantly, the lack of appropriate skill sets in government directly results in insufficient representation of technical and analytical expertise in legislative and regulatory framework development processes (UNCTAD, 2021c), which may limit the capability to effectively design and implement STI policy. This further stresses the problem of how to support the development of competences within developing countries and the importance of triggering an upgrading process at all levels of education. The strengthening of the knowledge base will also provide countries with the human resources to participate in and profit from international STI cooperation.[6] Financial and technical assistance are crucial to support the development of an enabling environment for STI and the international community plays an active role in supporting capacity building in developing countries, in particular for disadvantaged groups. Moreover, the set up of formal and informal collaborations strengthening the participation of developing countries in international STI networks would facilitate knowledge flows and could be even more functional for the development of their STI capacities.

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[3] For instance, research shows that the distance in the stringency of environmental policy between countries hinders the intensity of technological collaborations in energy-related technologies (Corrocher and Mancusi, 2021).
[4] STEM stands for Science, Technology, Engineering and Mathematics.
[5] Contribution from the Governments of Brazil and Türkiye and UNWTO.
[6] Contribution from the Government of Cameroon.

C. Research and Development

Research and development (R&D) involves a dynamic interaction among different stakeholders. It comprises creative and systematic work undertaken in order to increase the stock of knowledge and to devise new applications of available knowledge (OECD, 2015). Basic research often creates the foundation for future technical applications. For example, the theory of relativity has led to the development of the Global Positioning System. However, the relationship between science and technology is not univocal and the two co-evolve. For instance, the development of the electron microscope allowed the exploration of the structure of tissues at a level of detail never observed before, contributing to new advancements in biological sciences.

R&D is characterized by a high degree of uncertainty about the results of a given endeavour and by a long-term horizon. Moreover, science and technology typically follow a cumulative process and tend to become increasingly complex and require large investments to stay at the frontier. Undertaking basic research is essential to develop a critical mass of actors with STI skills that enable interactions with STI actors at the international level. These actors can facilitate the identification of existing technologies developed abroad, and their acquisition, adaptation and diffusion at the national level.

Funding and expertise are the two major challenges for R&D,[7] and for this reason, among private actors are large companies and highly specialized firms in high-tech sectors the ones that traditionally invest in R&D. The private sector tends to focus on applied research with the aim of creating profitable products and services relying on specific industry knowledge. Basic research without specific commercial applications is instead largely funded by governments and is conducted mainly by universities and research institutions. In both cases, to compete at the technological frontier, strong expertise and critical mass are required.

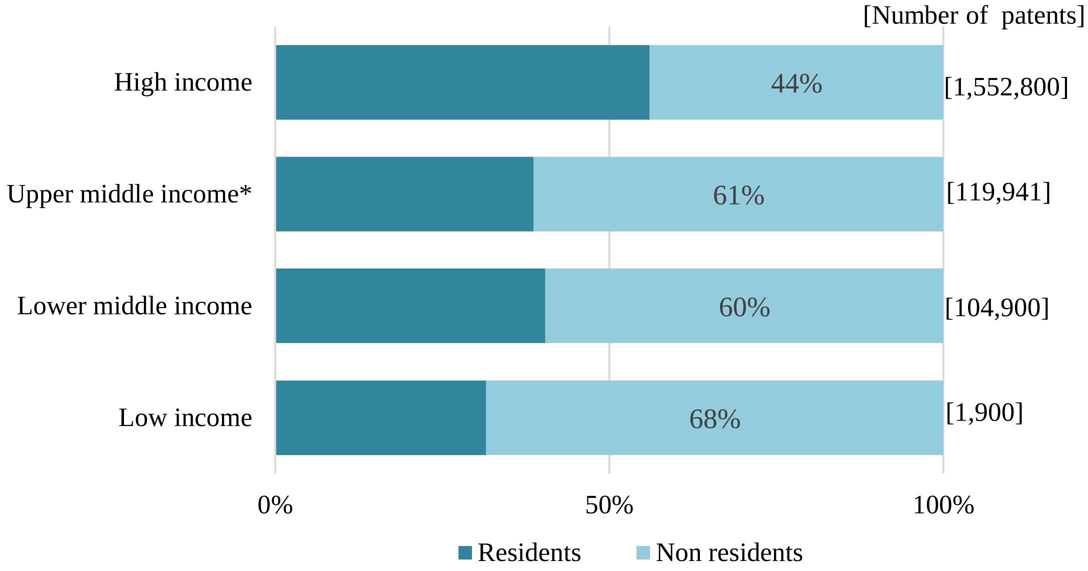
R&D challenges are more evident in developing countries. The average R&D investment of low middle-income countries is about 0.53 per cent of their GDP, a figure much lower than the world average (2.63 per cent) (UNCTAD, 2023a). For many developing countries, it is extremely unlikely that they will be able to close this gap without external support. Therefore, it appears crucial that the international community provides financial and technical support to developing countries for the strengthening of their R&D capacities. The increased support to STI can be coupled with a collaborative design to promote inclusion in the international research network and provide the critical mass that many countries are not able to build internally.

While science is traditionally associated with scientific publications, the result of R&D activities bringing to new technologies with potential industrial applications typically protected with intellectual property rights. Figure 2 reports the number of patents by income country group and the share of patents filed by resident and non-resident actors. Apart from the low number of patent applications, in low and lower-middle-income countries the majority of

[7] Contribution from the Governments ofBrazil, Burundi, China, Cuba, Ecuador, Peru, Türkiye and United Republic of Tanzania. Funding constraint is a particular serious problem in the Global South. Low investment in implementing programs and projects in STI development is due to the fact that investment in STI does not give immediate results and profit and thus less attractive to investors. Also, it was noted that different countries and institutions have different ways to finance and organize research projects, and their budget cycle do not always align, making research collaboration difficult.

patents are actually filled by foreign companies. In low-income countries, more than 2 of every 3 patents are filed by foreign actors, highlighting the weaknesses of national actors in developing patentable inventions.

Figure 2: Patents filed by residents vs. non-residents (%) and total by country income groups



Note: Data refers to the last available year, 2020. Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office. * Excluding China, which has almost 1.5 million patents and a rate of non-resident patents of about 10%.

Source: World Bank Development Indicators (accessed, July 2023).

Large and innovative companies, both national and foreign, can be leveraged for projects aiming at closing the gap between universities and research institutions and the market. For example, Microsoft Research India's Center for Societal Impact through Cloud and Artificial Intelligence (SCAI) is focused on developing technologies with potential large-scale impact on society establishing collaborations with academic groups, startups, NGOs and other organizations. Collaborations can originate from own research projects that are deployed at scale with external collaborators, or with external collaborators to identify and develop solutions for problems.[8] This kind of partnerships can facilitate technological transfer and provide support to accelerate the uptake and development of new technological solutions.

D. Innovation

Many promising R&D projects and new technologies never reach the market because the transition from labs to successful innovation is particularly challenging; this failure is often named the "Valley of Death" (Hudson and Khazragui, 2013). This failure is due to two main reasons: *i)* the role of public versus private investments; and *ii)* skills and the identification of needs.

[8] For more information, see: https://www.microsoft.com/en-us/research/collaboration/scai/

Public funding generally focuses on basic research, while the private sector tends to invest in innovative products and services. On the one hand, stronger public-private partnerships (e.g., university-industry collaborations) could play a key role in overcoming the Valley of Death; connecting the local industry with the international community could further speed up technological uptake.[9] On the other hand, test environments that mimic real-life conditions (e.g., test bed and sandbox) can facilitate product trials and enhance the fit with customer needs. Given the cost and difficulty of setting up test environments and collecting user feedback, the creation of international open testing platforms can represent a valuable alternative for less endowed countries.

Innovation is mainly performed by firms and includes new or improved products and services, as well as business processes covering production, organizational models and sales. Innovation is therefore not only deriving from R&D activities but also requires a set of competences and skills that includes technical and business knowledge. Indeed, only about 31% of innovating firms in developing countries invest in R&D activities (Cirera et al., 2020) and also in developed countries, a large share of innovative firms do not introduce products or services new to the market or invest in R&D activities.

To accumulate knowledge and build a competitive edge, firms largely rely on activities not formalized in terms of R&D, such as using information from clients and suppliers, importing technology or adapting solutions introduced by other firms. Research shows that managerial and entrepreneurial capabilities are an important determinant of both country and firms' differences in productivity (Bloom and Van Reenen, 2010). A fundamental issue is how to link the transfer of technologies (and possibly technical ideas) to the origin of the business ideas for innovation (UNCTAD, 2014).

Technology platforms (or production centres) aims at facilitating the iteration between technology transfer and learning, and business ideas. These platforms involve technology development centres devoted to a specific domain and financed by public development assistance, as well as public–private partnerships. To support innovation they provide: i) technological services for the development of appropriate innovations; ii) support to structure and test initial business ideas and to pinpoint demand for technology from local entrepreneurs to materialize the ideas; and iii) facilitate access to the financing of innovation by local banks, either by supporting a given project or by creating credit lines from developed countries. Essentially, they cover the whole process from technological development to innovation helping to face the different hampering factors stifling innovative entrepreneurship (UNCTAD, 2014). RECPnet, the Global Network for Resource Efficient and Cleaner Production, represents a successful case for the set-up of global-local partnerships for knowledge transfer fostering collaboration among similar centers around the world with the support of UNIDO and UNEP.[10]

Also interactions among firms through trade and participation in global value chains can be leveraged through specific programmes favouring knowledge transfer among the involved players. The benefits of technology and knowledge transfer are manifold and could lead to enhanced competitiveness for both the source and recipient (UNCTAD, 2021a). For example,

[9] Of course, supporting innovation also requires that private financial institutions bear the risk of investing in innovative business projects.
[10] For more information, see: https://www.recpnet.org/

the conception and creation of prototypes with essential functionality and features allow us to test the potential value of new solutions with minimal resources. This helps gather insights on how products can be modified to meet the users' needs and what further investment is needed to scale the innovation in an effective manner. Moreover, incubators and accelerators play an important role in fostering innovation and knowledge sharing by providing the necessary support to speed up the business process from ideation to commercialization. In 2019, the UNDP launched, with the support of Germany and Qatar, the UNDP's Accelerator Labs, a network of 91 accelerators operating in 115 countries, to support local innovation and international learning on what works and what does not work and thus closing the gap between the current practices of international development.

E. Summary

This section has introduced a series of possible areas for global collaboration activities in the field of STI. Table 1 presents the four core elements for STI development together with their main components and some potential areas for global collaboration that will be further discussed in the next section.

Table 1: Summary of key elements for STI development

Key elements	Main components	Potential global collaborations
Strategic Planning	• Agenda setting • Policies, standards and regulations	• International STI agenda • Multilateral STI foresight and assessment system • Supportive international rules
STI Prerequisites	• Physical and digital infrastructure • Human and knowledge resources	• Digital infrastructure • Capacity building activities • ODA for STI
R&D	• Basic and applied research • Experimental development	• Research funding • International research collaboration • Alternative modes of technology creation and distribution
Innovation	• Production and logistic • Marketing and sales	• Technology and knowledge transfer • Test beds • Incubators and accelerators

Source: UNCTAD.

III. Status of global STI cooperation

With reference to the four key elements for STI development discussed above, this section provides a review of the status of global STI cooperation. It examines key examples from the United Nations system, international and regional organizations, research institutions and CSTD member countries, highlighting the collaboration mechanisms, progress, lessons learned and good practices. The analysis emphasizes Industry 4.0 and green frontier technologies that form the basis of the current technological paradigm and offer significant opportunities for developing countries to accelerate sustainable development, provided that timely and decisive action is taken.

The findings illustrate possible approaches to foster international collaboration in STI at different levels. These partnerships should aim both at empowering less technologically advanced countries to catch up with the rapid technological change and at creating an international environment favouring consensus building around different STI-related issues.

A. Strategic Planning

1. Inclusive international STI agenda

The formulation of the international STI agenda and the evolution of the global innovation system have been historically skewed towards the perspective of developed countries. This is due to their superior technological capabilities and the capacity to manage extensive networks (Lundvall et al., 2002), which reflect a cumulative and path dependence process that has led to strong asymmetries in resources and power. A shift towards a more inclusive and participatory approach requires stakeholder engagement and practical support measures to create a collaborative setting facilitating exchanges of knowledge among different actors and recognizing the needs of less endowed countries.[11]

Collaborative activities may take different forms and be framed within different organizational settings. Highly international settings involve different views resulting both from cultural, and political specificties, as well as the state of development. Participation in these settings involves costs and burdens, especially for less advanced countries, that may limit the ability to collaborate. This can be partly compensated by reducing the cognitive heterogeneity of the topics handled: the more focused the topic, the lower the cognitive distance among participants due to a more homogeneous knowledge base (Nooteboom, 2008; Malerba, 2002). Table 2 connects the geographical level at which STI activities take place with the broadness of the STI topics handled, suggesting that it might be more effective to increase focus when enlarging participation.

[11] Contribution from the Governments of Brazil, Cuba, Peru and Türkiye. Also, it is important to conduct a thorough needs assessment in developing countries to identify their specific development priorities and agendas. Cooperation programs should be tailored to address their most pressing needs to maximize their impact.

Table 2: A framework for the International STI agenda

Geographical level	Main Activities	STI focus
International (Coordination)	• Coordinating experiences • Consolidating agendas • Making sense of topics	Mixing depth and broad
International (Initiatives)	• Specific instruments • Connecting regional actors • Facilitating knowledge sharing	Specific topic in depth
Regional	• Common STI instruments • Best practices and mutual learning • Consensus building	Broad spectrum of topics
National	• See Figure 1	Integration with other national priorities

↑ Increasing Socio Economic Heterogeneity

↑ Increasing Focus of STI topics

Source: UNCTAD.

In general, STI organizations at different levels reflect this principle. Well-functioning national innovation systems are those able to bring together complementary knowledge and foster interactions and spillovers among different actors. While Figure 1 highlights the key elements of an NIS with respect to international linkages, at the national level, strong linkages should be secured by taking a broader perspective. In other words, at the national level, STI should not be seen as a standalone feature but integrated with other socio-economic functions like education, industry, competition or finance.

Effective cooperation under a unified regional approach can address common needs and issues of the region. Some of the key features include a good governance structure, and clear and transparent decision-making and implementation processes. Political commitment, mechanisms to consolidate feedback from different stakeholders and stable funding can offer references for the development of an inclusive STI agenda with supportive incentive systems that take into account the specific needs of different countries.

The ASEAN Plan of Action on Science, Technology and Innovation 2016–2025 (APASTI) represents a well-coordinated regional approach that developed policies and mechanisms to support active cooperation in STI (The ASEAN Secretariat, 2017). Its implementation plan is based on a common vision and shared objectives, and outlines key strategic actions and components with specific timelines, deliverables and key performance indicators. The plan provides guidance to the various Sub-Committees of the ASEAN Committee on Science and Technology to improve the monitoring and evaluating mechanisms of activities and resource mobilization. Among the strategic pillars (thrusts), the plan gives great importance to public and private collaborations and integration through a network of centres of excellence and the mobility of talents (The ASEAN Secretariat, 2017); this is done with an inclusive approach to strengthen engagement and expansion of opportunities in STI for women, youth and the disadvantaged groups.[12] Four new ASEAN Science and Technology networks have been established, including the ASEAN Foresight Alliance, ASEAN Young Scientist Network, ASEAN Network on Metallurgy and Metallic Materials, and ASEAN Network on Sustainable and Environmental Materials, to engage and empower research communities. Meanwhile, the Shared ASEAN High Performance Computing (HPC) Facility initiative provides regional solutions to data intensive problems and can deepen digital access and overcome high entry barriers by cost sharing.[13]

Similarly, the Policy Partnership for Science, Technology and Innovation (PPSTI) of the Asia-Pacific Economic Cooperation (APEC) promotes STI cooperation through common approaches, policy coordination and by prioritizing connectivity. This is done by supporting both digital and people-to-people connectivity through mobility of researchers and science and technology personnel, thus integrating digitalization and innovation.[14] The African Union's STI Strategy for Africa 2024 (STISA-2024) shows how regional STI agenda can be tailored to address specific regional needs and priorities, anchoring on six priority areas that contribute to the achievement of the AU Vision (African Union Commission, 2014). Yet the progress in implementing STISA-2024 is generally slow.[15] These initiatives underscore the importance of setting shared objectives supported by political commitment and cultivating regional collaboration on multiple STI aspects to foster economic development.[16]

While many global STI efforts are governed by developed countries and generally reflect their priorities, there are successful examples of collective research which equitably incorporate the views and priorities of different partners. For instance, the European Organization for Nuclear Research (CERN) is an international mega-science collaboration that adopts a partnership-oriented approach with clear common goals permeated by the scientific spirit embodied in its Convention.[17] Acknowledging the fact that no single national organization can undertake the scope, cost, complexity and associated risks on their own, the CERN community declares and celebrates that their collaborations are not desirable but essential. CERN has been established as an intergovernmental organization to avoid undue influence from any particular country or organization, and its members are elected solely on scientific merits and without reference to nationality. In addition, CERN employs a light leadership approach and exercises consensual governance among member states to effectively manage multi-polarity and avoid gridlocks,

[12] Contribution from the Government of the Philippines.
[13] In addition, the Rising STI Networking for Innovative ASEAN was established to promote collaboration and provide opportunities to develop and improve science and technology usage in ASEAN. The ASEAN Science, Technology, and Innovation Fund has approved over $1 million in science and technology grants covering research in various areas For more information, please refer to https://asean.org/book/mid-term-review-report-of-the-aec-blueprint-2025/
[14] Contribution from the Governments of China and the Philippines.
[15] The slow progress in implementation is manifested in the lack of programmatic initiatives dedicated to the strategy, low levels of investment in STI and relatively slow progress in establishing the African STI Fund, partly due to low levels of knowledge and information on STISA-2023, low levels of policy literacy, insufficient monitoring, evaluation and accountability, as well as inadequate budgets for implementation at national, regional and continental levels. For more information, please refer to https://archive.uneca.org/sites/default/files/uploaded-documents/IDEP/Cours2020/Cours_en_ligne/STISA/brochure_for_the_stisa-2024_web_based_course.pdf
[16] Contribution from the ITU.
[17] The scientific method concerns the practical aspects of how to pursue valid scientific questions according to a relatively well-defined set of rules of investigation using the latest scientific methods. The scientific spirit is a much broader, all-encompassing approach to science based on three elements: enthusiasm, creativity, and integrity (Lefkowitz, 1988).

i.e., breakdowns in cooperation of countries in international institutions to address policy problems that span borders (Robinson, 2019). This secures scientific collaborations from political influences, which may hamper the development of the scientific community.[18]

The Consultative Group on International Agricultural Research (CGIAR) represents a long-lasting experience of global partnership focusing on research related to food security. The CGIAR works with more than 3,000 partners in nearly 90 countries around the world and operates globally through its 15 research centres, consulting with a large number of stakeholders to develop priorities and the development rationale. In 2019, the CGIAR System Council approved the concept of a unified and integrated approach to adapt to the changing global conditions and make the CGIAR system more relevant. Research in agriculture, land and water has become much more interconnected than before, and the fragmented nature of its governance and institutions was recognized as a limiting factor. Therefore, the new approach moved the CGIAR toward a unified governance, an integrated operational structure, and pooled funds to consistently deliver best practices and effectively scale research solutions to counterbalance the increasing interconnectedness of food security issues.

At the international level, the CSTD plays an essential role in facilitating discussions and consensus-building on critical issues related to science and technology (UNCTAD, 2023d).[19] It offers a space for collaborations among key stakeholders and is closely linked to the Technology Facilitation Mechanism (TFM), which champions multi-stakeholder cooperation and partnerships with a key role in collecting and sharing information, experiences, best practices and policy advice. These structures underscore the importance of an inclusive and participatory approach to setting the international STI agenda and consolidating experiences to support initiatives at the national, regional and international levels. They, therefore, represent the natural references to frame the strengthening of international collaboration activities in STI.

2. Multilateral technology foresight and assessment system

Technology foresight and assessment exercises can help countries understand the potential societal, economic, and environmental impacts of emerging technologies.[20] Technological foresight supports strategic planning by looking into the possible longer-term scenarios of science and technology; technology assessment has also an anticipatory approach but focuses more on the specific status of a given national innovation system. Both are key to selecting priorities and shaping the STI agenda and strategy to set the direction of science and technology toward the achievement of the 2030 Agenda for Sustainable Development.

UNCTAD conducts pilot projects on technology assessment in selected developing countries in Africa to strengthen the capacities of national policymakers and other stakeholders in designing and implementing policies that support the learning, diffusion and adoption of technologies in the energy and agricultural sectors (UNCTAD, 2021b). In addition, UNCTAD's Science, Technology and Innovation Policy Review programme provides tailored technical support to countries in assessing national STI systems and designing or reframing national STI policies and plans (UNCTAD, 2019). A key feature of the programme is the systematic effort made to involve a broad range of stakeholders towards transformative STI policymaking that

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[18] Contribution from the Government of Russian Federation.
[19] For further discussion of the role of the CSTD in facilitating global STI cooperation, please refer to Section IV of the document.
[20] Contribution from the Government of the United Republic of Tanzania.

advances an inclusive and sustainable development agenda. These supports help countries develop a comprehensive understanding of their relative strengths, weaknesses and needs, as well as the overall trend of technological development and its opportunities, thereby facilitating the formulation of a strategic plan and the necessary instruments, including framework, policy, guideline, standard and regulation.

The national STI policy review programme and assessment exercises could be scaled up to a multilateral system to support a well-informed decision-making and consensus-building process for the formulation of an inclusive international STI agenda and appropriate instruments. The system can be reinforced by the consolidation of technology foresight exercises and the monitoring of emerging technologies at the global level. A multilateral system of technology foresight and assessment could offer a comprehensive analysis of global STI development, thereby providing directionality to technological change, promoting the alignment of national, regional and international STI agendas with the SDGs and fostering international collaboration.

For example, a multilateral system of technology foresight and assessment could help countries understand better the opportunities and challenges brought by the rapid development of Artificial Intelligence (AI) as well as facilitate international cooperation in sharing good practices and lessons learned, thereby ensuring the formulation of consistent policies, standards and regulations. The Ethics Guidelines for Trustworthy AI, released by the High-Level Expert Group on AI set up by the European Commission, is an initiative to ensure the ethical and responsible development of AI. The guidelines emphasize that AI should embody principles such as human agency and oversight, privacy and data governance, as well as societal and environmental well-being. At the international level, the UN multi-stakeholder High-level Advisory Body on AI is expected to advance recommendations for the international governance of AI (United Nations, 2023b). A multilateral system of technology foresight and assessment on AI could complement these initiatives.

Similar guidelines and regulations at the international level are key to guiding the development of AI and other frontier technologies towards the benefit of all countries. The formulation of regional and international instruments should carefully consider the diverse needs and concerns of countries at different stages of technological development, especially for developing countries that require more supportive measures and technical and financial assistance to harness the full potential of STI while minimizing risks and reducing inequalities.

3. Supportive international rules

Apart from consistent international STI policies, the alignment of standards and regulations, international trade rules and intellectual property rights (IPR) systems can support international collaborations and the diffusion and transfer of essential knowledge and technologies to unfold the innovative capacities of developing countries and at the same time facing global issues[21]

WTO has established rules to ensure fair competition in international trade, including those related to tariffs, subsidies and public procurement. These rules have direct effect on STI related issues of countries. In some cases, efforts to align trade and IPR protection with the

[21] Contribution from the Governments of Belize, South Africa and Türkiye.

needs of developing countries have been made, but more can be done, especially when considering issues that have a global reach.

For example, international trade rules should be aligned with the Paris Agreement on climate change. In particular, articles 10 and 11 advocate the importance of fully realizing technology development and transfer in order to improve resilience to climate change and reduce greenhouse gas emissions, as well as the necessary capacity-building. Article 66.2 of the TRIPS agreement provides a sound institutional framework requiring developed countries to provide incentives to enterprises and institutions in their territories for the promotion of technology transfer to least developed countries and enable them to create a sound and viable technological base. To monitor the implementation of the agreement, developed countries are asked to submit annual reports on actions related to Article 66.2. Moreover, to facilitate dialogue, the WTO Secretariat organizes annual workshops with experts from countries and specialized international organizations.[22] The Trade and Environmental Sustainability Structured Discussions (TESSD) set-up at the WTO is expected to have a facilitator function (WTO, 2023a). During the Informal Working Groups Meeting of May 2023, several countries agreed that the green transition is both necessary and beneficial for developing countries; it was also pointed out that weak infrastructure and the lack of access to technology and expertise as barriers to greater adoption of green technologies in developing economies (WTO, 2023b).

Extending more flexibilities to developing countries in the context of the Trade-Related Aspects of Intellectual Property Rights (TRIPS), especially for environmentally sound technologies, would support the implementation of the STI agenda towards sustainable development and help make the multilateral trade regime more consistent with international climate change agreements (UNCTAD, 2021a). Similarly, more flexibilities could be provided to the health sector. In 2022, the Ministerial Decision that allowed eligible WTO members to produce and supply vaccines without the consent of the patent holder to the extent necessary to address the COVID-19 pandemic set a good example of how flexible IPRs could make significant contributions to addressing global challenges (WTO, 2023a).

B. STI Prerequisites

1. Digital infrastructure

Robust digital infrastructure, including interoperable systems, is essential for bridging the digital divide and enabling interconnectivity for inclusive global participation in STI development.[23] International support and public-private partnerships for infrastructure development are key to enhancing access to stable and affordable electricity, mobile networks and the internet[24], particularly in developing nations. While international and regional organizations[25] have actively provided funding and technical assistance to build robust and

[22] Contribution from the WTO. In the last full reporting cycle (2018-2020), nine developed members - namely Australia, Canada, the European Union and its Member States, Japan, New Zealand, Norway, Switzerland, the United Kingdom and the United States of America - submitted reports containing over 754 incentives programmes in various technology fields.
[23] Contribution from the ITU.
[24] The origins of the internet and the World Wide Web are rooted in a small group of scientists. The explosion in popularity and application came along with the development of common protocol which signifies the importance of international cooperation.
[25] Including the World Bank, Asian Infrastructure Investment Bank, African Development Bank, Caribbean Development Bank, Islamic Development Bank, New Development Bank and Asian Development Bank.

sustainable infrastructure systems, the private sector has been investing heavily in digital infrastructure (e.g., Google is building an open subsea cable "Firmina" that runs from the East Coast of the United States to Las Toninas, Argentina to improve connectivity and increase Latin America's access to digital services; Microsoft's Airband initiative has helped more than 51 million people globally gain access to the internet).

In addition, there are different initiatives that aim to facilitate interconnected infrastructure to boost regional integration, such as the Programme for Infrastructure Development in Africa (African Union, 2023) and the Central Asia Regional Economic Cooperation Program (Asian Development Bank, 2021). These multi-sector programmes have played a significant role in improving transportation corridors, energy and ICT connectivity to serve common regional needs and interests by adopting a coordinated approach to infrastructure development.

A notable example is the Asia-Pacific Information Superhighway (AP-IS), spearheaded by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The aim is to bridge the digital divide and accelerate digital transformation by promoting connectivity, digital technology and data use in the Asia-Pacific (The Asia-Pacific Information Superhighway Platform, 2023). With a public-private partnerships funding mechanism that augments traditional financial and technical resources, this region-wide intergovernmental platform has been instrumental in fostering digital collaboration, including the establishment of regional agreements and action plans, knowledge sharing and promoting investments in ICT infrastructure. The main outcome of this initiative is the adoption of the Action Plan 2022-2026 of the AP-IS, which provides Member States with targeted goals towards an inclusive digital society.[26] Through various cooperations, AP-IS has also provided Member States with capacity-building assistance on sharing of policies and practices on ICT.[27]

At the international level, the Broadband Commission for Sustainable Development, established by the ITU and UNESCO, has contributed to promoting universal connectivity. Its major achievement lies in promoting inclusivity in the digital realm, targeting areas with disparities in digital infrastructure and fostering public-private initiatives (Broadband Commission, 2023). Similarly, the Alliance for Affordable Internet (A4AI), hosted by the World Wide Web Foundation, is a global coalition that focuses on creating affordable and accessible internet. Their emphasis on policy and regulatory reforms has driven internet prices down, making the internet more accessible in low- and middle-income countries (A4AI, 2022).

Apart from these dedicated efforts in enhancing digital infrastructure, the aspect of interoperability is central to enabling seamless global connectivity. The International Telecommunication Union (ITU) plays a vital role in this regard. It supports the set-up of international standards and regulations to ensure that various telecommunication systems across the world are compatible. Its effort underscores the importance of homogeneity and coherence in the global digital landscape to facilitate seamless communication and connectivity (ITU Telecommunication Standardization Sector, 2023).

[26] Contribution from ESCAP. It was also mentioned that some of the main difficulties encountered include securing a stable budget for the implementation of the AP-IS Action Plan and coordinating efforts across different levels of countries and contexts.

[27] In particular, with the Asian and Pacific Training Centre for Information and Communication Technology for Development and the Asia Pacific Center for Technology Transfer.

Moreover, data governance and cross-border data flows are equally important, especially given the risk of data fragmentation and concerns about privacy (UNCTAD, 2021c). At the regional level, the EU first defined the General Data Protection Regulation (2016), a series of rules to protect and regulate the free movement of personal data[28]. It then passed the Data Governance Act (2022) and the European Data Act (2023) to regulate data sharing between public and private actors, unlock industrial data optimizing its accessibility and use, and foster a competitive and reliable European cloud market. These experiences can provide a base to build consensus on approaches to data that can fuel an international discussion on the issue. The issue paper on data for development and the upcoming Report of the Secretary-General on the progress made in the implementation of and follow-up to the outcomes of the World Summit on the Information Society (WSIS) at the regional and international levels will provide an in-depth analysis of data governance, data interoperability, data security and more.

With the increasing digitalization and automation of production, the adaptation of physical infrastructure and its linkage with digital infrastructure is becoming more important for the deployment of connected devices. The interface between physical and digital infrastructure supports a wide variety of use cases, from digital road infrastructure for traffic management systems to digital power infrastructure that improves the operational efficiency and performance of appliances. Against this backdrop, it is important to build on the successful experiences of regional and international collaboration to foster cooperation in these emerging issues. Meanwhile, the private sector, especially the leading technology companies, should play a more active role in supporting inclusive digital development, especially given the fact that a few companies currently control most of the world's digital infrastructure in the form of cloud storage and computing power.

2. Capacity-building activities

Human capital is the key engine of technological development, and a skilled workforce can drive the transition to a digital and knowledge-based economy. Collaboration with STI organizations could enable knowledge exchange, thereby enhancing the expertise and capabilities of researchers, engineers and other professionals[29].

One example is the partnership between Portuguese universities and R&D institutions and American universities launched by the Foundation for Science and Technology (FCT) in Portugal (A FCT, 2023). Through collaborative research projects and educational programmes, the partnership promoted the internationalization of Portuguese scientific and higher education institutions and the mobility of highly qualified human resources through thematic knowledge networks, involving more than 1,000 teachers and researchers and more than 1,500 masters and doctoral students. The partnership has been expanded to foster the creation of qualified jobs and the attraction of qualified human resources to Portugal via the goPORTUGAL initiative (goPortugal, 2023). Its success is partly attributed to a clear definition of objectives and alignment with the priorities and needs of participating institutions, as well as strong leadership and commitment to coordination.[30]

[28] The GDPR is grounded on the fundamental right to the protection of personal data.
[29] Contribution from the Government of Türkiye.
[30] Contribution from the Government of Portugal and in line with the contribution from the Government of Gambia and ITU.

In terms of regional efforts, the Africa Higher Education Centers of Excellence (ACE) Project, a collaboration between the World Bank and African governments, aims to enhance Science, Technology, Engineering, and Mathematics (STEM) in African higher education institutions. Launched in three phases, the project has established and strengthened 43 Centers of Excellence across the continent. Key takeaways include the promotion of regional specialization to address common development challenges, the strengthening of high-quality training and applied research and the expansion into new areas vital for Africa's economic growth, such as sustainable cities, energy and public health (About The Africa Higher Education Centers of Excellence (ACE) Project, 2022).

In Europe, the Marie Skłodowska-Curie Actions (MSCA) serve as a reference programme for doctoral education and postdoctoral training, aiming to equip researchers at all stages of their careers with new knowledge and skills. It also supports national, regional and international programmes for training and career development through co-funding mechanisms, as well as promotes exchanges of staff members involved in research and innovation activities worldwide. In line with the European Green Deal, the programme targets frontier research that tackles climate and environmental-related challenges. The MSCA inclusive approach supports the strengthening of research capacity in Europe and also the strengthening of international research networks (European Commission, 2023).

Within the UN system, the UN interagency task team on STI for the SDGs (IATT) serves as a crucial collaboration hub to enhance synergy and efficiency, in particular to enhance capacity-building initiatives (United Nations, 2023c). One of the significant undertakings is the work stream 6 on capacity building: it designs and delivers training courses and workshops on STI Policy for SDGs, including a global repository of training materials, guidelines and case studies for policy implementation, particularly for developing countries. It also organizes events at the margin of the multi-stakeholder Forum on STI for the SDGs (STI Forum) to generate awareness, promote advocacy and build partnerships to deliver capacity-building activities (United Nations, 2023d).

Women have a stake in participating in STI to ensure that it does perpetuate gender bias and increase diversity in research. Between 2014 and 2020 the world share of female researchers increased by 2.4 percentage points but still far from parity (from 28.8% to 31.2%).[31] To achieve gender equality and empower women and girls, UNCTAD has partnered with Okayama University and launched the Young Female Scientist Programme (UNCTAD, 2020) and Young Scientist PhD Programme (UNCTAD, 2023e) to build the capacity of women researchers in developing countries working in the STI fields, offering opportunities to engage in cutting-edge research activities. Meanwhile, UNCTAD has collaborated with the Government of Thailand to develop the Bio-Circular-Green Economic Model (BCG Model) that aims to provide a platform for female researchers and entrepreneurs to learn from Thailand's expertise, to share best practices and to network.[32]

[31] Comparing the most updated UNESCO Institute for Statistics (UIS) for 2020 with a previous release of the dataset.

[32] There are also many other capacity-building activities conducted by the UN agencies on specific sector, for example, the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), Access to Space for All, UNWTO's Tourism Online Academy on AI in hospitality, the International Atomic Energy Agency (IAEA) Connect platform, etc. Contribution from IAEA, UNOOSA and UNWTO.

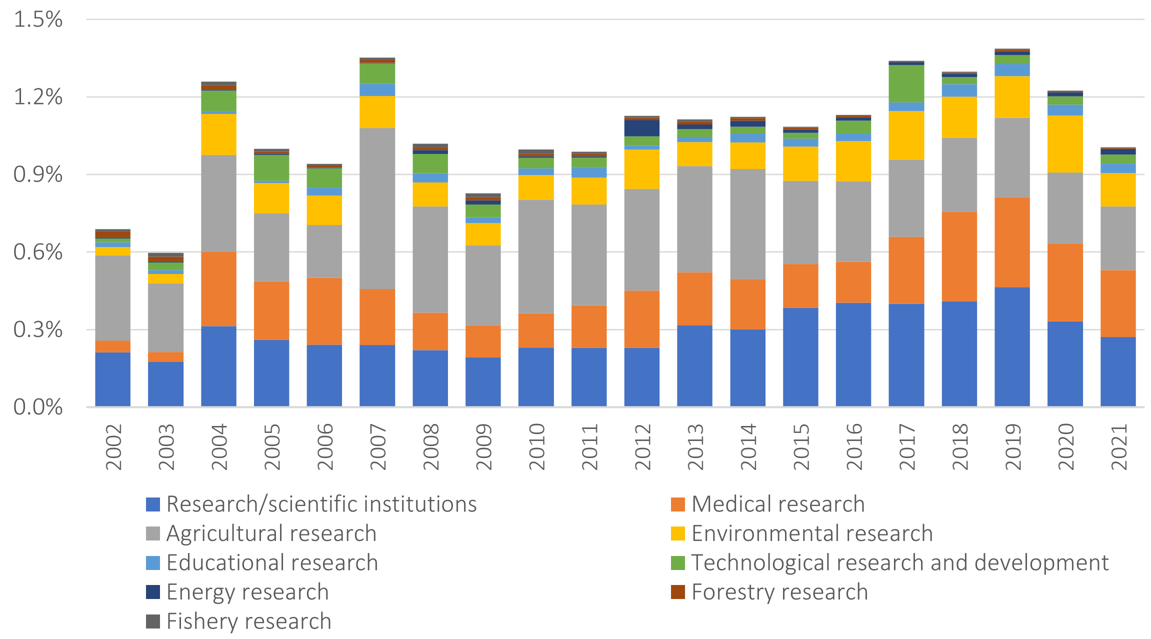
While the examples above cover different actors, including students, researchers, policymakers, etc., one of the common factors contributing to the success of these cooperations is the thorough consideration of the needs of the participants. As the competences and skills required for STI development vary across industries and countries, it is important to design programmes that fit the specific needs and conditions of different actors while emphasizing the empowerment of disadvantaged groups.[33] [34]

3. ODA for STI

The R&D gap between most advanced and developing economies is huge, and financial support from the international community is crucial to strengthen the STI capacities of developing countries.

In 2022, official development assistance (ODA) by member countries of the Development Assistance Committee (DAC) amounted to $204 billion, about 0.36% of their combined GNI and far below the UN target of 0.7% (OECD, 2023a). Moreover, the share of ODA dedicated to STI-related projects is rather marginal. Over the last two decades, the share of ODA in STI has been fluctuating around 1%, and it has been declining both in 2020 and 2021 after a peak of 1.4% in 2019 (Figure 3). The decline has affected all the purpose categories, including medical research (from 0.35% to 0.26%), despite its high ranking in the policy agenda due to the COVID pandemic (OECD Statistics, 2023).

Figure 3: Share of ODA in STI by main purpose category



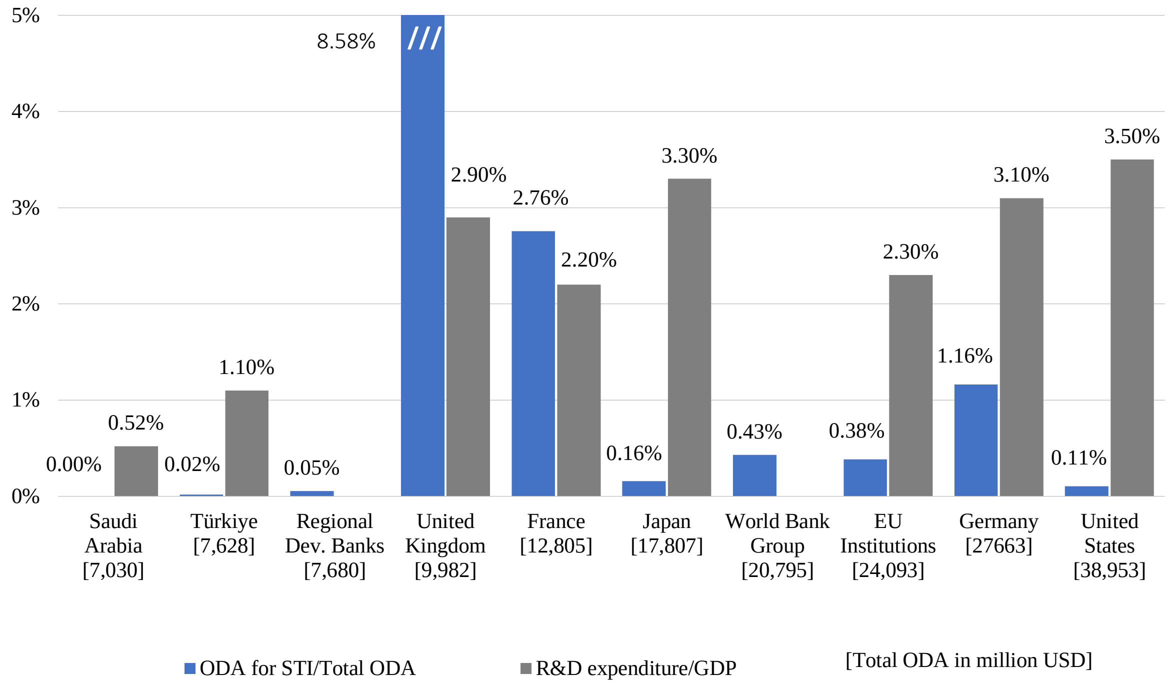
Source: UNCTAD based on OECD development finance data.

[33] Contribution from the Government of Türkiye. The emphasis is on the potential impact of STI cooperation on women's empowerment, both direct and indirect.

[34] In line with the contribution from UNESCO. Also, more awareness and advocacy are required to build robust, inclusive and human-centred STI ecosystems that engage the beneficiaries of STI from the outset in the design of policies and empower marginalised and vulnerable groups through knowledge.

The low budgetary relevance of STI among ODA does not reflect the increasing importance that R&D and innovation have in determining countries' competitiveness in today's economy. Moreover, it does not reflect the increasing R&D investments among advanced economies. Figure 4 compares the share of ODA in STI with the share of R&D with respect to GDP for the top ten official DAC donors in 2021. The share of ODA in STI of most countries is dwarfed by their R&D intensity. In particular, the share ODA in STI for the US and Japan is below 0.2% compared to an R&D intensity of over 3%. Also institutional donors like the World Bank and the various Regional Development Banks invest a very marginal share of their budget in STI projects. On the contrary, the UK and France show a strong engagement in supporting STI activities.

Figure 4: Share of ODA in STI versus share of R&D over GDP, top 10 official donors in 2021



Note: R&D over GDP cannot be computed for the World Bank Group and Regional Development banks.
Source: UNCTAD based on OECD development finance data.

The main takeaway is the presence of a remarkable gap in ODA for STI. Relatively small relocations of ODA budgets can make a big difference in the overall assistance toward the strengthening of the STI capacities in developing countries. If channelled toward collaborative projects, it would also strengthen the inclusion of developing countries in international research and innovation networks.

C. R&D

1. Research funding

Research funding is key to supporting the unfolding of STI in developing countries. A collaborative research funding mechanism should take into account both specificities of and synergies between different research areas, as well as mechanisms to ensure stakeholders' commitment.

Horizon Europe is the 9th EU framework programme to fund research and innovation with a budget allocation of about EUR 95 billion for the 2021-2027 period. Since the onset, EU framework programs have an explicit collaborative design aiming at the creation of an integrated European Research Area: a large share of their budget has been dedicated to projects with at least 3 partners from 3 different EU countries. The creation of an integrated research area complements policies aiming at integration and convergence among EU countries from a market and economic point of view (Archibugi et al., 2022).

One of the key features of Horizon Europe is the coverage of the full spectrum of research and innovation activities, from curiosity-driven research to partnerships with industry for advanced demonstrators (Bogers et al., 2018). Moreover, it facilitates interdisciplinary research to enable solutions for more complex issues, as the most transformative breakthroughs often occur at the crossroads of different sectors and disciplines (Bogers et al., 2018).

In the last editions, a focus on global challenges was added to favour non-EU countries accessing resources, expertise and the collaborative network.[35] The program is based on the principle of co-financing to ensure shared financial responsibility among member states and other stakeholders.[36] To widen participation, Horizon Europe includes coordination and support actions such as the European Cooperation in Science and Technology (COST). The core activity of COST is the networking of researchers and stakeholders from public and private institutions, NGOs, industry, and small and medium enterprises (SMEs). Its model is the funding of bottom-up, open and inclusive networks that bring together researchers, innovators and other professionals to collaborate on research topics for 4 years, thus providing a reasonable time horizon for research activities (COST, 2023).

At the international level, the Green Climate Fund (GCF) aims at assisting developing countries in adaptation and mitigation practices to promote low-emission and climate-resilient development pathways and can represent crucial research funding for green frontier technologies. The GCF operates on the principle of "country ownership" (Asfaw Solomon et al., 2019), ensuring that projects are aligned with the recipient country's priorities and plans for addressing climate change. Acknowledging that public funding alone is not sufficient to address the climate challenge, the GCF also catalyzes private sector investment in climate initiatives (Asfaw Solomon et al., 2019). The GCF is the largest international public climate fund, but its budget is rather small compared to the world climate-related finance, and it

[35] Contribution from the Government of Latvia. Also, by participating in the program, developing countries could shape the research agenda and ensure that it aligns with their own development priorities. Yet it is noted that small private innovative companies have limited capacity to come up with new initiatives and implement several projects at the same time.

[36] For more informations on the complementary funding mechanisms in third countries and territories, please refer to: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/complementary-funding-mechanisms-in-third-countries_he_en.pdf

struggles to attract funding from donor countries, which often prefer bilateral agencies (Kumar, 2015). Better coordinating STI support on climate change issues at the international level could help rationalize resources, guarantee stable funding over a horizon reasonable to scale up financed activities toward self-sustainability, and give more voice to developing countries in pinpointing those areas of intervention closer to their more pressing needs.

One of the possible solutions proposed to reduce the variability and subjectivity of pledges is a burden-sharing scheme for allocating responsibilities among donors (Cui and Huang, 2018) (Dellink et al., 2009). In line with the "Polluters Pay Principle" first proposed by the OECD in the 1970s (OECD, 2022) (Cui and Huang, 2018), contributions could be determined by the historical emissions of donor countries; alternatively, the ability-to-pay principle first proposed by Adam Smith, would use GDP as a benchmark. This example remarks the importance of establishing a clear and equitable allocation of funding responsibility for the success of international research funding mechanisms.

Public-private cooperation and coordination are fundamental for the success of STI cooperation mechanisms,[37] especially when considering global challenges. The Bill and Melinda Gates Foundation, the world's largest private grant-making foundation and leading philanthropic organisation offers useful references about how to facilitate co-funding schemes and cooperation involving the public and private sectors. By allowing for flexibility in their projects, especially with regard to intellectual property rights and research contracts, the Gates Foundation has been able to make collaborative initiatives attractive to the private sector. For instance, IPR arrangements allow pharmaceutical companies to profit from drugs developed within their research projects. In particular, the arrangements allow them to keep exclusive licenses and sell drugs at market price in developed countries if they commit to selling drugs at marginal prices in developing countries.[38] Another element that characterizes the Bill and Melinda Gates Foundation is the emphasis on thorough preparatory work and priority-setting when selecting projects. Instead of relying on annual result reports, the foundation has always followed a milestone-driven approach to oversee various stages of a project and directed its efforts to achieve tangible outcomes (OECD, 2012).

The above examples offer valuable lessons that can inform the design and implementation of collaborative international research funding mechanisms. For instance, supporting not only basic research but also more applied one through partnerships with the private sector could increase the likelihood of research breakthroughs becoming a reality. This can be done by designing co-financing mechanisms that ensure shared financial responsibility among stakeholders and by offering incentives to mobilize financial and technical support from the private sector. This approach can be particularly fruitful for developing countries that have limited R&D investment from the private sector. Having said that, each funding mechanism has unique strengths and shortcomings but continuous monitoring and evaluation, as well as flexibility to adapt to the shifting landscape of research needs, challenges and opportunities are common ingredients leading to success.

[37] Contribution from the Government of Brazil.

[38] Another example is the setup of the Advance Market Commitment which is intended to create a market stimulus for the development of a new pneumococcal vaccine that protects against more strains of the disease by guaranteeing to buy the vaccine at a set price when it is developed, and thereby creating a market where none existed before. For more information, please refer to https://www.oecd-ilibrary.org/science-and-technology/meeting-global-challenges-through-better-governance_9789264178700-en

2. International research collaboration

International research collaborations play an important role in promoting the share of scientific and technological resources, improving efficiency and achieving breakthroughs (Zu et al., 2011) (Wagner, 2006). Collaborations should focus on building the capacity of participating countries to effectively address their development priorities.[39] Technology dissemination and innovation networks are key to fostering STI and tackling global challenges addressing the SDGs, especially in emerging economies.[40] From the exchange of ideas and data sharing to a close partnership on a specific project, global research collaborations could be arranged in different formats based on the goal and commitment of stakeholders.

The Asia-Pacific Research and Training Network on STI Policy (ARTNET on STI Policy) is a knowledge platform initiated by the ESCAP to promote the sharing of knowledge and ideas. It has contributed to dialogues on STI policy and academic research, as well as capacity-building projects, thereby fostering an environment of shared knowledge and collaborative growth in the region. The partnership with the public sector, including policy council, university networks, and the private sector (e.g., Google), helps in bringing the perspectives of different stakeholders to support research and policy formulation for sustainable development in Asia-Pacific.

The Ibero-American Science and Technology for Development Program (CYTED), created in 1984 through an Inter-Institutional Framework Agreement signed by 21 Spanish-Portuguese-speaking countries, aims to foster Ibero-American STI cooperation. This is done by promoting the integration of the science and technology communities, facilitating joint research and transfer of knowledge, as well as engaging the business sector in the innovation processes.[41] The program is organized in a decentralized model through specialized committees in different thematic areas to address the regional needs. Various strategic projects and thematic networks have involved more than 25,000 researchers and 1,000 private firms, financing about 500 networks in different areas of knowledge (CYTED, 2023).

At the international level, EUREKA is the world's biggest public network for international cooperation in R&D.[42] It promotes collaboration among enterprises and research institutes and contributes to the growth of market-led R&D through a network present in 45 countries. Eureka's programmes are tailored to the needs of different actors with a strong focus on ICT but also biotech and industrial research, facilitating linkages between research groups and prominent large companies.[43] Various programmes deal specifically with: funding for industry-led mid- to long-term R&D projects; supporting innovative SMEs on international collaborative R&D; assisting research and business ventures in new markets; and promoting international partnerships (EUREKA, 2022). The bottom-up approach enables stakeholders to achieve market-oriented outcomes through strategically targeted projects, which are reflected in the improved return of assets of participating firms (Bayona-Sáez and García-Marco, 2010).

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[39] Contribution from the Government of Türkiye. Meanwhile, regular monitoring and evaluation are essential to track progress and collect feedback to improve the relevance and effectiveness of the collaboration.
[40] Contribution from the Governments of Brazil and Türkiye.
[41] Contribution from the Governments of Peru and Portugal.
[42] EUREKA offers researchers and innovators the widest geographic scope to access funding to date. In 2022, public-private investments of EUREKA amounted to over 560 million euros. For more information, please refer to: https://www.eurekanetwork.org/about-us/Annual%20report%202022.pdf
[43] Contribution from the Government of Hungary.

However, the co-funding scheme could be improved to avoid that eventual late contributions from member states jeopardize the projects' kick-off.[44]

The International Science Council (ISC) stands as an example of the power of cooperative scientific research. With a vision rooted in advancing science as a global public good, its success lies in the ability to bring varied scientific communities under the same umbrella, promoting knowledge exchange and co-designing future scientific agendas. ISC stands out for its emphasis on bridging the science-policy interface at the international level, also working with the United Nations (Our work at the UN and global policy processes, 2023). ISC is being recognized as one of the initiatives that successfully foster the mobilization of the academic community towards the SDGs (Dibbern and Serafim, 2021), with a particular emphasis on promoting data stewardship and dissemination (de Sherbinin et al., 2021).

Data sharing is a crucial aspect in the context of research collaboration. Despite the challenges such as accessibility across borders, lack of specific standards, coordination and data quality, as well as the fact that most data are not sufficiently findable, accessible, interoperable and reusable (OECD, 2023b), global data repositories have the potential to progressively assume a critical role in R&D, as they have demonstrated in the healthcare sector.

Two examples are the Coalition for Epidemic Preparedness Innovations (CEPI) and Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV), which represent an unprecedented level of global collaboration that leverages STI to combat emerging infectious diseases (ACTIV, 2023; CEPI, 2022). They play a leading role in fostering public-private partnerships to optimize the allocation of resources and effectiveness of crisis response (Katz et al., 2018). Their success could be attributed to the efforts in coordinating and streamlining processes to make the best use of biomedical research resources, enabling access to data and information for continuous generation and review of knowledge, as well as promoting collaboration among stakeholders via rapid response platforms.

The conservation of biodiversity is another field where data sharing and open access are developing significantly (Lacher et al., 2012). For example, the Global Biodiversity Information Facility (GBIF) provides a standardized biodiversity data-sharing platform, which is instrumental for R&D in the context of biodiversity protection and green technologies. GBIF's objective is to ensure critical data for human and environmental welfare are open access and fully shared without restriction. Researchers making substantial contributions to research products are acknowledged as authors to ensure accountability and recognition of their efforts.

Lessons drawn from the examples above underscore the importance of equitable partnerships, commitment to knowledge-sharing, as well as open and inclusive collaboration mechanisms.[45] In particular, the efficiency and efficacy of governance modes are key elements of successful international STI collaboration that foster quality outputs and ensure the continued involvement of actors and new contributors (OECD, 2012). Enhancing trust, transparency and inclusivity among parties coupled with monitoring and accountability mechanisms increase the chances of collaborations to be effective.[46]

[44] Contribution from the Government of Hungary.
[45] In line with the contribution from the Government of Gambia.
[46] Contribution from the Government of Türkiye.

3. Alternative modes of technology creation and distribution

Apart from the traditional model of research collaboration, the value of open innovation has received strong interest in recent years. Open innovation encompasses a paradigm shift in how companies and institutions approach R&D: instead of relying solely on internal resources, open innovation posits that organizations could leverage external R&D and market solutions that, in some cases, can take place in a non-proprietary manner (Chesbrough, 2003) (Chesbrough et al., 2008). This new approach to technology creation and distribution is in essence a model of cooperation that helps facilitate collaborations between institutions, companies and independent innovators around the world by allowing a richer pool of ideas and faster time-to-market solutions, thereby accelerating the R&D process and increasing internationalization potential[47].

One of the pioneering models is the open-source paradigm that promotes the free and open sharing of software source code to encourage collective improvement and distribution by users (Fitzgerald, 2006). Successful cases in the open software paradigm are Linux, MySql, Firefox and WordPress. Beyond software, the concept has found applicability in diverse arenas such as hardware (Open Source Hardware Association, 2023) and scientific research. The Human Genome Project, for instance, adopted an open-source approach to generate the first sequence of the human genome. The landmark agreement of rapid pre-publication data release (i.e., release of all DNA sequence data in publicly accessible databases within a day after generation) has been credited with establishing a greater awareness and openness to the sharing of data in biomedical research, revolutionizing global collaboration (The Human Genome Project, 2023).

Parallel to open-source is the approach of crowdsourcing that utilizes collective intelligence to solve specific problems or generate ideas. While Wikipedia is one of the earliest applications of crowdsourcing, the potential of crowdsourcing is vast, ranging from data collection to ideation, from micro-tasking to testing, and it is often used in creative design industries, such as Istockphoto and Threadless.

InnoCentive is an example of crowdsourcing for R&D. The platform, which can be customized and branded as required, allows companies and research institutions to post challenges to a global talent pool of independent researchers and enables scientists to receive professional recognition and financial awards for finding innovative solution (Brabham, 2008). In medical research, platforms such as PatientsLikeMe allow patients worldwide to share and analyze data related to their conditions, making them stakeholders in the R&D process and facilitating rapid, large-scale and real-world studies (Wicks et al., 2011).

Moreover, hackathons, which are originally technology-focused events where programmers collaborate intensively over a short period to produce a working software solution, have evolved to address socio-economic and climate-related challenges. The NASA Space Apps Challenge uncovers the potential of hackathons in global STI cooperation. It is the largest annual global hackathon that unites participants across continents to foster innovative solutions for global challenges related to space exploration and earth science.[48]

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[47] Contribution from the Government of Brazil.

[48] The success of global hackathons lies in the diversity of perspectives, backgrounds, cultures and education of participants. For instance, in 2022, the NASA Space Apps Challenge registered over 30 thousand participants,

The United Nations has also been leveraging these new approaches to drive global STI collaboration for sustainable development. Examples include Unite Ideas, UN Big Data Hackathon, Open SDG Data Hub, and Building Blocks.[49] As the Secretary-General's innovation hub, the UN Global Pulse could coordinate related efforts and foresee partnerships with successful non-profit experiences, especially for digital innovation, to promote global STI collaboration.

D. Innovation

1. Technology and knowledge transfer

Technology and knowledge transfer is a multifaceted process involving the conveyance of knowledge, skills, procedures and equipment from one organization or country to another (Etzkowitz and Leydesdorff, 2000). Lack of commitment and limited financial resources would threaten the sustainability of the transfer mechanism.[50] Traditionally, technology and knowledge transfer was thought to be a linear process from advanced economies to less advanced ones. However, recent decades have witnessed a shift towards more interactive and networked technology and knowledge transfers, encompassing transfers within and between sectors and involving public and private partners (Etzkowitz and Leydesdorff, 2000). In addition, the benefits derived from these interactions vary according to the capacity to absorb and effectively utilize transferred technologies (Cohen and Levinthal, 1990). Wide disparities in technological capabilities may impede effective transfers,[51] especially in frontier technologies such as AI, where AI talent training programs and the set up of cooperative laboratories may make the process smooth (WIPO, 2019).

Within the UN system, there are three major initiatives that support technology and knowledge transfer: the UN Technology Bank, the Global Environment Facility (GEF) and the UN Climate Technology Centre and Network (CTCN).

The UN Technology Bank, established in 2017, aims to assist least developed countries (LDCs) to build their STI capacities and technological base (Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, 2023). The support is implemented through three pillars of work that facilitate South-South and North-South technology transfers by aligning the technology demands of LDCs with appropriate solutions. The first focuses on the assessment of the STI ecosystem of LDCs, mapping the key developmental challenges and identifying the technologies, technical know-how and innovative capabilities required to find sustainable solutions (Technology Bank for the Least Developed Countries, 2023a). The second focuses on the identification of appropriate technologies for transfer to LDCs (Technology Bank for the Least Developed Countries, 2023b). The third focuses on capacity building to ensure that the technologies transferred are sustainable and that LDCs develop the technological and innovative capabilities required for seamless and sustainable development (Technology Bank for the Least Developed Countries,

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coming from 162 different countries, with a total of over 3 thousand projects submitted and 22 challenges addressed. For more information, please refer to https://assets.spaceappschallenge.org/media/documents/2022_Space_Apps_Infographic_FINAL.pdf

[49] Contribution from the WFP. This initiative leverages Blockchain technology to enhance cooperation on humanitarian assistance. For more information, please refer to https://www.wfp.org/building-blocks.

[50] Contribution from ESCWA.

[51] In line with the contribution from UNESCO.

2023c) [52]. However, despite some positive results in certain areas, progress fell short of the goals and targets set, requiring increasing efforts and a more coordinated implementation and coherence across the UN system in supporting STI in the least developed countries (United Nations, 2023e).

Regarding the transfer of environmentally sound technologies, the GEF is the largest public-sector funding source. It supports innovation and technology transfer at the early and middle stages, emphasizing the demonstration and early deployment of innovative options. For instance, the GEF conducts technology needs assessment to identify what technologies are needed to mitigate and adapt to climate change, and it provides financial and technical support to local communities via the GEF Small Grants Programme, for example. By utilizing these programmes, the GEF has gained insights into local-level barriers to technology adoption and has been able to foster grassroots solutions and facilitate effective technology integration.[53] .

As part of the technology transfer framework of the United Nations Framework Convention on Climate Change (UNFCCC), CTCN responds to country-driven requests for services with a focus on building and strengthening developing country capacity to address technology challenges and opportunities for adaptation and mitigation. It supports countries in technology development and transfers across five systems transformations (i.e., water-energy-food nexus, building and infrastructure, sustainable mobility, energy systems and business and industry) through technical assistance, capacity building and networking and knowledge sharing (Climate Technology Centre & Network, 2022).

The experiences of the above initiatives highlighted the importance of providing tailor-made technical assistance to developing countries by harnessing the expertise of a global network of technology companies and institutions. Better understanding of the socio-technology context would help facilitate the adoption of technology and create transformative change compared to a technology-centric approach with weak stakeholder engagement (United Nations Framework Convention on Climate Change - Technology Executive Committee, 2022)

An option is to allow developing countries to use the CTCN and UNFCCC mechanisms to leverage technical assistance and support their technology needs. Moreover, fostering interlinkages and coherence in technology assessment through regional collaborations supported by partnerships of international institutions could help countries identify the technical support required and formulate a roadmap with detailed and effective implementation actions (UNFCCC, 2022; Constituted Body GST synthesis report | UNFCCC, 2023).

2. Test beds

Test beds, which are controlled experimental platforms that mimic specific conditions for conducting testing of new technologies, products or services, play a crucial role in ensuring

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[52] A number of initiatives have been introduced including: STI capacity-building programmes in LDCs in the areas of biotechnology; SDG Impact Accelerator projects in Bangladesh and Uganda to unlock entrepreneurial talent and leverage emergent technologies to improve livelihoods; and an innovation programme focused on supporting LDCs to exploit their latecomer advantages and leverage existing technologies through entrepreneurial activity as well as enhancing their capacity to find, adapt and adopt proven, off-the-shelf technologies. For more information, please refer to https://www.un.org/ldcportal/content/technology-bank-ldcs-0

[53] Since its inception, the GEF has allocated more than $22 billion in grants and blended finance and mobilized $120 billion in co-financing. This has been channeled into more than 5,000 projects in 170 countries, supplemented by 27,000 community-led initiatives through the Small Grants Programme (UNCTAD, 2023a).

that technologies are thoroughly evaluated and refined before widespread implementation. As the innovation landscape has grown more interconnected, test beds have expanded beyond individual institutions or corporations and are now often open and shared platforms. Apart from facilitating collaboration among stakeholders, open test beds can reduce the cost and difficulty of setting up individual test environments and collecting user feedback, especially for developing countries, by pooling resources and existing knowledge while supporting users from their geographical location.

One example is the Open Innovation Test Beds (OITBs) funded under the Horizon 2020 and Horizon Europe. Through a single entry point, it offers users from Europe and beyond open access to test beds' facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments, thereby bringing innovation to the market faster, easier and with lower costs and technological risks (European Commission and Directorate-General for Research and Innovation, 2019; Directorate-General for Research and Innovation (European Commission), 2021). Some of the lessons learned include the importance of focusing on SMEs and their needs, offering regulatory and financial advice to users as well as cooperating with technical committees to promote new standards (Directorate-General for Research and Innovation (European Commission), 2021). Complementary to this initiative are the European Pilot Production Network (EPPN) and European Digital Innovation Hubs (EDIHs). EPPN connects the actors along the value chain of pilot facilities to leverage existing European pilot line production facilities in nanotechnology and advanced material technologies (European Network for Pilot Production Facilities and Innovation Hubs | EPPN Project | Fact Sheet | H2020, 2023). The EDIHs support companies to improve business and production processes, products or services using digital technologies by providing access to technical expertise and testing as well as different innovation services, such as financing advice, training, and skills development (European Commission, n/d).

Another example is the Industry IoT Consortium (IIC), a global partnership of industry, government and academia, which is dedicated to accelerating the adoption of IoT (Industry IoT Consortium, 2023a). One of the major initiatives is the Business Deployment Accelerator which identifies end-user business pain points and advises on deployments such as test beds and test drives that help resolve them (Industry IoT Consortium, 2023b). The Testbed program is a controlled experiment platform that replicates real-world conditions for effective testing, covering a wide range of industry IoT technologies, products and services (Industry IoT Consortium, 2023c). Meanwhile, the Test Drives program offers a short-term pilot to users to employ and adopt industrial IoT technologies (Industry IoT Consortium, 2023d). This cooperative model ensures that solutions are comprehensive, adaptable and meet the varied needs of all involved parties. Moreover, the ICC addresses the need for a common architectural framework to develop compatible IoT systems suitable for a wide range of applications across various industrial sectors via the Industrial Internet Reference Architecture (IIRA) (Industry IoT Consortium, 2022).

The abovementioned initiatives offer insights and good practices on how developing countries could benefit from test beds and similar approaches. For instance, the OITBs' single entry point model provides open access to innovators in developing regions to test frontier technologies and accelerate innovation. The EPPN and EDIH approaches interlink the entire value chain of innovation and could be pivotal in integrating fragmented innovation ecosystems, as it is the case in many developing economies (Cunningham et al., 2014). The IIC provides a unique architectural framework on which different solutions can be designed and tested. While these programmes focus on developed countries, it is essential to understand how to replicate such initiatives in developing countries, addressing their specific challenges and needs.

3. Incubators and accelerators

For a new product or service to be transformed into a thriving business, innovators often face a challenging chasm, the Valley of Death. This concept highlights the financial gap from ideation to scale-up in the early stage as well as the multifaceted challenges innovators face, related both to technical and business aspects (Branscomb and Auerswald, 2002). In this regard, incubators and accelerators could guide innovators through turbulent journeys and build a successful business.

Established in 2005, Y Combinator (YC) has been recognized as the most successful startup accelerator based on the main key metrics, such as successful exits, unicorn creation rate, combined valuation and startup founded (Geron, 2023; Cremades, 2018; Pitchbook, 2023). During the 3-month programe, it provides seed money, advice and connections in exchange for equity in the startup. One of YC's hallmark practices is the emphasis on product development and market fit. It nurtures an environment where startups can iterate their products based on real-world feedback. Furthermore, through weekly meetings, it facilitates interactions between current participants and alumni, ensuring a continual flow of guidance and mentorship (Y Combinator, 2023). Key to the success of YC is the strength and relevance of its networks (e.g., investors network, cohort network and founders network) (Y Combinator, 2023). The co-founder matching platform is one of its innovative and successful features, boasting over 100,000 matches across major global cities (YC Co-Founder Matching Platform, 2023). Although YC does not aim at promoting collaboration between countries, it demonstrates the importance of a dynamic, high-quality feedback environment and the significance of networking in the early stages that can help design international incubators and accelerators.

Another example is Start-up Chile, a public accelerator focusing on technological and innovative businesses with scale-up opportunities, which has supported over 2,200 innovative start-ups. The key strengths of the initiative are its lean organizational activities, a strong focus, the prominent role of entrepreneurs in co-managing the initiative and the openness to business ideas worldwide, with support for the necessary visas for foreign start-ups. In 2021, over 80 per cent of the budget was allocated to foreign entrepreneurs, representing a noticeable example of the capacity to attract talents from abroad for a developing country to nurture the national innovation system.

An example of a global accelerator is represented by the UNDP Accelerator Labs, the world's largest and fastest-learning network dedicated to sustainable development challenges. With 91 Lab teams covering 115 countries, the extensive network promotes learning across development practitioners in the world (Accelerator Labs | United Nations Development Programme, 2023). The network keeps expanding with the support of new partners to strengthen international collaboration while offering assistance tailored to local circumstances. For example, the Japan Cabinet Office collaborates with the UNDP Japan Unit and UNDP

Accelerator Labs to support the SDGs Innovation Challenge with the aim of co-creating solutions to address local needs with the participation of the Japanese private sector.[54]

A critical aspect of the Labs' work is their alignment with the SDGs. Not only do they contribute directly to these goals, but they also support innovators to align their business model with the global vision for sustainability. Another main feature is the focus on grassroots innovation that taps into local innovations to create actionable insights, especially in the field of sustainable energy solutions, through a multifaceted approach that centers on identifying local solutions by understanding community needs as well as emphasizing rapid experimentation. The Labs aim to accelerate the implementation of new technological solutions, making development practices more agile and responsive through the integration of local insights and collaborations across sectors.

Targeting developing countries, InfoDev is a World Bank Group multi-donor program that supports entrepreneurs to grow their businesses. One of the partnerships is the Climate Technology Program (CTP), which helps clean-tech companies commercialize and scale the most innovative private-sector solutions to climate change through a global network of incubators called Climate Innovation Centers (CICs) (World Bank, 2023). These CICs function as region-specific hubs that offer a range of services, including business support services, financing, market insights and networking across CICs (World Bank, 2010). Also, the CTP is based on an adaptive and localized approach according to the specific regional contexts and needs. One example is the first CIC, the Kenya Climate Innovation Center established in 2012, recognized as the “Most Promising Business Incubator in Africa” (World Bank, 2015)[55].

At UNCTAD, the project “Science, Technology and Innovation Parks for Sustainable Development: Building expertise in policy and practice in selected Asian and African countries” is designed to enhance knowledge and build capacity in four developing countries across Africa and Asia (UNCTAD, 2023f). The goal is to empower these countries through South-South cooperation to craft robust, integrated policies and establish institutional frameworks that favor the growth of their STI parks in order to provide an effective setting for collaboration among researchers, entrepreneurs, and businesses. These parks not only support the international reach of research endeavors but also assist local businesses in becoming integral parts of global value chains, thereby invigorating national and regional innovation ecosystems, promoting economic diversification and fostering talent development. The project’s approach includes hands-on training and practical knowledge sharing, drawing lessons from the successful implementation of STI parks in other developing nations.

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[54] Contribution from the Government of Japan. Also, through the SDG Holistic Innovation Platform, an open innovation platform run by UNDP in collaboration with the Japan Innovation Network, Japanese partners are identified, and this provides an entry point for companies that would typically not work with UNDP.

[55] It serves as an integrated platform that provides advisory services, access to finance and facilities, capacity building and market intelligence with an emphasis on public-private partnerships. For instance, it has successfully brought together extensive local and international knowledge and experiences from the private sector, academia and civil society organizations, as well as worked with the government to improve the enabling environment for local clean technology businesses (Climate Technology Program Brief No. 2, 2016). In addition, the Kenya Climate Venture Facility was established in 2015. This seed fund combined with the Kenya Climate Innovation Center, has the objective of effectively overcoming the financing gap of Kenyan firm’s life cycle to promote testing, validation and scaling of new climate technologies. For more information, please refer to https://documents1.worldbank.org/curated/en/381371506073998670/pdf/119909-BRI-climate-technology-program-in-brief-7-designing-an-innovative-financ.pdf

The journey from innovative ideas to thriving enterprises is fraught with challenges. The above examples demonstrate how incubators and accelerators could help overcome these obstacles. Lessons learned include the vital role of localized insights and collaboration, adaptive approaches to meet regional needs, the value of robust and open networking and partnerships, and lean organizations with a focus on business solutions. Together, these elements illuminate a multifaceted roadmap for successfully navigating the early-stage hurdles and fostering innovation.

E. Summary

This section has reviewed key programmes and initiatives on regional and global STI cooperation and highlighted the good practices and lessons learned. Table 3 presents a summary of examples discussed under each of the four elements for STI development for easy reference.

Table 3: Summary of examples on regional and global STI cooperation

Key elements	Collaborations	Examples
Strategic Planning	International STI agenda	• ASEAN Plan of Action on Science, Technology and Innovation 2016–2025 (APASTI) • African Union's STI Strategy for Africa 2024 (STISA-2024) • European Organization for Nuclear Research (CERN) • Consultative Group on International Agricultural Research (CGIAR) • Commission on Science and Technology for Development (CSTD) • Technology Facilitation Mechanism (TFM)
	Multilateral STI foresight and assessment system	• UNCTAD's technology assessment and Science, Technology and Innovation Policy Review • Ethics Guidelines for Trustworthy AI • UN multi-stakeholder High-level Advisory Body on AI
	Supportive international rules	• WTO agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) • Trade and Environmental Sustainability Structured Discussions (TESSD) to link trade and the environment
STI Prerequisites	Digital infrastructure	• Programme for Infrastructure Development in Africa • Central Asia Regional Economic Cooperation Program • Asia-Pacific Information Superhighway (AP-IS) • Broadband Commission for Sustainable Development • Alliance for Affordable Internet (A4AI) • European Data Act

	Capacity building activities	• Foundation for Science and Technology (FCT) • Africa Higher Education Centers of Excellence (ACE) Project • Marie Skłodowska-Curie Actions (MSCA) • UN interagency task team on STI for the SDGs (IATT) • UNCTAD's Young Female Scientist Programme, Young Scientist PhD Programme and Bio-Circular-Green Economic Model
	ODA for STI	• Official development assistance (ODA)
R&D	Research funding	• Horizon Europe • European Cooperation in Science and Technology (COST) • Green Climate Fund (GCF) • The Bill and Melinda Gates Foundation
	International research collaboration	• The Asia-Pacific Research and Training Network on STI Policy (ARTNET on STI Policy) • Ibero-American Science and Technology for Development Program (CYTED) • EUREKA • International Science Council (ISC) • Coalition for Epidemic Preparedness Innovations (CEPI) • Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) • Global Biodiversity Information Facility (GBIF)
	Alternative modes of technology creation and distribution	• The Human Genome Project • InnoCentive • The NASA Space Apps Challenge
Innovation	Technology and knowledge transfer	• UN Technology Bank • Global Environment Facility (GEF) • UN Climate Technology Center and Network (CTCN)
	Test beds	• Open Innovation Test Beds (OITBs) • European Pilot Production Network (EPPN) • European Digital Innovation Hubs (EDIHs) • Industry IoT Consortium (IIC)
	Incubators and accelerators	• Y Combinator (YC) • Start-up Chile • UNDP Accelerator Labs • InfoDev Climate Technology Program (CTP) • UNCTAD's STI Park Development project

Source: UNCTAD.

IV. The role of the CSTD in facilitating global STI cooperation

The CSTD was established in 1992 as the United Nations focal point for STI for sustainable development. Over the years, the CSTD has contributed to facilitating global cooperation in science and technology by acting as a forum to discuss policy issues raised by rapid technological change. The CSTD favors the sharing of best practices and lessons learned, the foresight of critical STI trends in key sectors of the economy and society, the strategic planning in STI, and draws attention to new and emerging technologies (Economic and Social Council, 2023).

The works of the CSTD cover specific issues related to science and technology and their implications for development. It therefore contributes to advancing the understanding of science and technology policies, particularly for developing countries, as well as to the formulation of recommendations and guidelines on science and technology matters within the United Nations system (UNCTAD, 2023d). The CSTD provides in-depth analysis and proposes recommendations on priority themes defined for the annual meeting with the aim of leveraging STI for sustainable development. See Table 4 for an overview of the themes discussed in the last five sessions.

Table 4: List of priority themes discussed in the past five sessions of the CSTD

Meeting	Priority theme
Twenty-sixth session (27 - 31 March 2023)	• Technology and innovation for cleaner and more productive and competitive production • Ensuring safe water and sanitation for all: a solution by science, technology and innovation
Twenty-fifth session (28 March - 1 April 2022)	• Industry 4.0 for inclusive development • Science, technology and innovation for sustainable urban development in a post-pandemic world
Twenty-fourth session (17 - 21 May 2021)	• Using science, technology and innovation to close the gap on Sustainable Development Goal 3, on good health and well-being • Harnessing blockchain for sustainable development: prospects and challenges
Twenty-third session (10 - 12 June 2020)	• Harnessing rapid technological change for inclusive and sustainable development • Exploring space technologies for sustainable development and the benefits of international research collaboration in this context
Twenty-second session (13 - 17 May 2019)	• The impact of rapid technological change on sustainable development • The role of science, technology and innovation in building resilient communities, including through the contribution of citizen science

Source: UNCTAD.

The twenty-sixth session of the CSTD in March 2023 covered two priority themes: *i)* Technology and innovation for cleaner and more productive and competitive production, and *ii)* Ensuring safe water and sanitation for all: a solution through science, technology and innovation

Under the priority theme "Technology and innovation for cleaner and more productive and competitive production" participants discussed how countries could take advantage of technologies and innovation for cleaner, more productive and competitive production. The discussion highlighted the differences in speed and capacity to develop and adopt green technologies across countries and the risk of leaving countries with low resources and capacity behind (i.e., missing the green windows of opportunity). These considerations lead to the recognition that the international community should support countries in need by facilitating joint initiatives and sharing technical know-how (Commission on Science and Technology for Development, 2023a). The critical role of international cooperation in adopting a more partnership-oriented approach and in supporting North–South, South–South and triangular cooperation on STI for green technologies was also highlighted, as well as the need to establish a multilateral system for technology assessment (Commission on Science and Technology for Development, 2023b).

Under the priority theme "Ensuring safe water and sanitation for all: a solution through science, technology and innovation", participants recognized that partnerships with non-governmental organizations could play an effective role in helping underserved communities access water and sanitation, and recommended countries to build a bridge between science and politics by creating a community of parliamentary experts to address water access challenges neutrally under the umbrella of science (Commission on Science and Technology for Development, 2023a).

These discussions and recommendations demonstrate the role of the CSTD in providing an open platform for strategic planning as well as coordinating and imparting directionality to international STI collaboration.

During the years, interaction among CSTD members in response to the needs countries raised at the CSTD, has resulted in several programmes for international collaboration in STI, ranging from knowledge and technology sharing to research capability building. Some of the recent activities include: *i)* the CropWatch Innovative Cooperation programme which aims to facilitate and stimulate agricultural monitoring of developing countries for the advancement of SDG1 of zero hunger (UNCTAD, 2023g)[56]; *ii)* the Young Female Scientist Programme and the Young Scientist PhD Programme aiming at building human capital in STI-related fields in developing countries through educational programmes[57]; *iii)* a South-South cooperation training workshop on the Bio-Circular-Green economy model for inclusive and sustainable growth (UNCTAD, 2023h)[58]; *iv)* a technical cooperation activity on satellite technologies for sustainable urban development (Pinelo, 2023); and *v)* a workshop in harnessing STI for disaster risk reduction. These activities signify the role of the CSTD in sharing lessons learned and best practices and more importantly, in channeling experiences and theoretical knowledge to have policy impact and facilitate concrete collaborations between Member States and other actors in the STI sphere.

[56] https://unctad.org/project/cropwatch-innovative-cooperation-programme.
[57] https://unctad.org/topic/science-technology-and-innovation/young-female-scientist-programme.
[58] https://unctad.org/news/unctad-and-thailand-partner-strengthen-womens-capacity-use-technology.

V. Conclusion and recommendations

Science, technology and innovation offer transformative solutions that can accelerate progress towards an inclusive, sustainable and resilient world. Yet the opportunities and benefits brought by technological advancement are not distributed equally, with most of them being captured by developed countries, as reflected by the significant concentration of knowledge creation in terms of patents and scientific publications.

The growing technological complexity, the fast pace of technological change and the massive impact of recent waves of innovations call for a collaborative approach to STI; business as usual will not close but widen inequalities, making it more difficult to catch up for latecomers. What is urgently needed is to enhance international solidarity and cooperation, revitalize global partnerships, and give renewed impetus to open, inclusive and equitable collaboration mechanisms.

This issue paper provides a comprehensive review of the status of global STI cooperation under four key elements for STI policy development: strategic planning, STI prerequisites, R&D and innovation. The review highlights good practices and lessons learned from various STI cooperation models that can inform possible approaches to strengthen international collaboration in STI.

The findings stress the importance of guaranteeing open, inclusive and equitable collaboration mechanisms that takes into account the needs and priorities of developing countries. Some of the key features include a good governance structure, strong political will coupled with funding commitment, clear and transparent decision-making and implementation processes, as well as mechanisms that consolidate feedback from different stakeholders.

To strengthen global STI cooperation for sustainable development, national governments, the international community and the CSTD, as the forum for science and technology matters within the UN system, are encouraged to:

1. Reinforce the efforts toward building an inclusive global STI agenda

Developing countries should formulate strategic plans for STI with clear, specific and measurable goals to seize the opportunities brought by technological advancement. The planning should reflect country's strengths and weaknesses in science, technology and innovation and highlight the connections (and missing links) between the national needs and objectives and the international STI agenda.

The international community should support the inclusion of developing countries in the international research networks both financially and providing assistance on how to participate and benefit from specific international settings. Regional mechanisms should put more efforts into mediating between national STI needs and challenges and opportunities at the global level.

The CSTD, and the UN system, should work to improve coordination among different international bodies and experiences, as well as support the consolidation of STI agendas to address the needs and issues common to different countries. It is important for the international community to build consensus on a shared vision and objectives to guide global STI development.

2. Develop a multilateral STI foresight and assessment system

These recommendations largely recall those made during the 19th Annual session of the CSTD (2016).

Countries should perform technology assessment of their national innovation systems at regular intervals drawing from regional and international foresight exercises. The results of these exercises should be shared with other countries to foster mutual learning and favour the creation of synergies on common issues.

The international community should cooperate to establish a mapping system to review and make sense of different technology foresight outcomes, making use also of existing regional mechanisms, and in collaboration with relevant stakeholders.

The CSTD should strengthen its role in coordinating different foresight approaches, at least within international organizations, and favor the convergence to a common understanding of long-term issues to provide directionality to technological development and build consensus on future policies that will take into account the specific challenges and opportunities of countries with different STI strengths and at different stages of development.

3. Build enabling digital and skill environments

Governments should create the conditions for accessible, affordable and high-quality digital infrastructure that supports STI development. This involves bridging the digital divide within the country and creating a regulatory environment that ensures sound competition in the telecommunications sector and interoperability at the international level. Countries should also reinforce their efforts to upgrade STI skills, as well as those required by the digital revolution at all levels, including government officials for an effective design and implementation STI policy.

The international community has a crucial role to play in providing funding and technical assistance to support digital infrastructure, and to upgrade STI and skills of developing countries. Capacity-building activities could include international training programmes, international mobility of researchers, and public-private partnerships dedicated to specific areas (e.g., digital or entrepreneurial training) while emphasizing the empowerment of disadvantaged groups. Moreover, harmonization of international standards and extended participation in the definition of international frameworks can facilitate the implementation of effective programmes in developing countries.

The CSTD should promote interoperability to facilitate seamless communication and connectivity and raise awareness about international digital standards and regulations. Moreover, it should promote best practices in STI training and the removal of obstacles (e.g., via supporting administrative and regulatory agreements) limiting the international mobility of researchers.

4. Foster investment in STI and public-private partnerships

The scarcity of resources for investment in R&D in developing countries hinders their STI development. Governments could mobilize domestic resources by facilitating co-funding schemes and cooperation involving the private sector, as well as target the attraction of foreign direct investments in knowledge intensive activities in specific areas of interest. Moreover, synergies between research and education, and industry and economic ministries could be leveraged to finance those STI efforts closer to commercial applications.

International public-private partnerships could bring in financial support and industry expertise to speed up technological uptake in developing countries. In addition, the international community should increase the share of ODA dedicated to STI. Small changes in budgetary allocations would provide a sensible increase in the support of STI in developing countries, providing the means to finance a strengthened international cooperation in STI. Funding can be also channelled to support the exchange of technical personel between private and public institutions at the international level.

The CSTD should explore the potential for innovative financing models, public-private partnerships, open-source approaches and other resources to strengthen the position of developing countries in collaborative STI projects and initiatives.

5. Strengthen research networks and collaboration among different actors

Governments should actively engage with key private actors of the innovation ecosystem and promote collaborations between the public and private entities to overcome the gap between science and technology and the introduction of innovations in the market. Affiliates of foreign companies can be leveraged to strengthen knowledge exchanges with international partners.

The success of collaborations lies in the commitment to share knowledge and set-up equitable partnerships; political commitment is also key to support international collaborative frameworks. Supporting the participation of researchers from developing countries in international research networks (including through mobility schemes), supporting the organization of international scientific events in developing countries and augmenting research grants with supplementary funding for travel from and to developing countries can facilitate the inclusion of researchers from developing countries in international networks and build up long-lasting collaborations.

The CSTD should support the establishment of monitoring, evaluation and accountability mechanisms to foster international STI collaboration through enhanced trust, transparency, inclusivity and directionality. Partnerships with existing international schemes could help design global collaborative schemes and pool resources from existing fragmented experiences.

6. Promote technology and knowledge transfer

Developed and developing countries should develop collaborative mechanisms to incentivize technology and knowledge transfer among universities, research institutions and the private sector. Priority could be given to the transition from basic to applied research and the application and diffusion of technologies and innovations in the economy.

International partnerships should aim at closing the gaps in knowledge capabilities that hamper effective technology transfer. The international community should explore ways to guarantee that the transfer of technologies from the private sector (capital investment) will benefit also the development of STI capabilities and originate business ideas for innovation in the receiving country (e.g., linking it with training programmes).

The CSTD should support the exchange not only of success stories but also failures to identify key challenges, foster mutual learning and guarantee an effective design of technology transfer projects. The CSTD can also partner with organizations monitoring technology transfer projects (e.g., WTO under article 66.2) to make sense of the different experiences. Moreover, given their prominence in today global economy and developmental structures, the inclusion of international organizations and multinational corporations in the monitoring system could be considered.

Annex: Suggested questions for discussion during the Intersessional Panel of the Commission

To facilitate the discussion at the Intersessional Panel, below presents a set of questions for consideration:

1. How to ensure the alignment of the international STI agenda with the needs and priorities of developing countries? What role could the CSTD play in coordinating STI agendas and imparting directionality to guide global STI development?

2. How to mobilize domestic resources and secure financial support from the international community for the development of STI cooperation? Is there any successful financial model or co-funding scheme that we could learn from to support international collaboration in STI?

3. What are the main barriers that hinder global research collaboration? How could the international community scale up existing efforts, increase synergies and build collaborative mechanisms for cooperation and sharing?

4. How to foster international public-private partnerships and overcome the gap between science and technology and the introduction of innovations in the market? What can be done to promote technology and knowledge transfer and speed up technological uptake in developing countries?

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