Chapter 4. STI policies for delivering on the Sustainable Development Goals

By

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Science, technology and innovation (STI) policies play an important role in helping countries achieve the Sustainable Development Goals (SDGs). However, STI policies and frameworks must embed the SDGs to address themeffectively. This chapter identifies and successively discusses in five sections the priority areas for action to embed the SDGs more fully within STI policy frameworks. This includes (1) support for "mission-oriented" R&D partnerships between public research, business and other stakeholders relating to specific challenges; (2) stronger support for interdisciplinary research that is inclusive of gender and citizens; (3) international STI co-operation on "global public goods", such as climate, biodiversity and global public health; (4) closer alignment of national-level STI governance structures with the emerging "global governance framework" for the SDGs; and (5) seizing the opportunities of digital technologies to address the SDGs. Finally, the chapter stresses the need to embrace digital technologies, including the necessary data infrastructures and policies, to help address the SDGs.

Introduction

The age-old adage that "necessity is the mother of invention" is a reminder that since ancient times, humans have invented tools and technologies to satisfy basic human needs, such as shelter, food, water and energy – four of the 17 Sustainable Development Goals (SDGs). The SDGs aim to achieve socially inclusive economic development within the ecological boundaries of the earth's capacity to sustain human activity. However, the challenges they present, and more generally, the "sustainability agenda" itself, bring into question the dominant focus on economic growth and the rate of innovation inherent in most countries' science, technology and innovation (STI) policy frameworks. Of course, economic growth and societal challenges are not mutually exclusive. Some countries have chosen to invest in SDG-enhancing innovation that can be introduced to the market, thereby contributing to their own economic growth.

Figure 4.1. The SDGs

Source: Global Reporting Initiative (n.d.), "Sustainability Disclosure Database", *http://database.globalreporting.org*.

The SDGs also represent a challenge from the standpoint of STI policy because of their interdependencies. Solutions to achieve the Goals cannot be solely technological: they must also involve social innovation and collaboration with stakeholders, beyond the traditional government-science-industry interface. At the same time, the SDGs themselves only reference STI implicitly, rather than explicitly. For example, innovation features explicitly in only one of the Goals, SDG 9: "to build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation" (Figure 4.1). The term "science" is absent in the description of the Goals. Among the 169 targets, 14 targets explicitly refer to "technology", and another 34 relate to goals in technological terms (United Nations, 2015, 2016). The remaining 121 targets include certain technological dimensions, but technology is only one of many means to implement them.

This chapter identifies and discusses the priority areas for action to embed the SDGs more fully within STI policy frameworks. This includes redirecting resources towards specific challenges through "mission-oriented" R&D partnerships between public research, business and other stakeholders. Initiating ambitious international co-operation will need to be initiated to protect, produce and preserve "global public goods" (e.g. climate, biodiversity and global public health). This contrasts with the present situation, where national competitiveness is still the main driver of STI activities. Better interlinkages between development aid and STI policies for SDGs could help leverage limited public resources, especially in developing countries, where societal challenges are especially acute. At a more holistic level, a closer alignment of STI governance structures and functions (e.g. policy advice, steering and funding, co-ordination, and evaluation and monitoring) with the emerging "global governance framework" for the SDGs will be key to co-ordinating these two policy domains. Finally, the chapter stresses the need to embrace digital technologies, including the necessary data infrastructures and policies, to help address the SDGs.

The need to reset overarching STI policy frameworks

STI policy frameworks will need to evolve to pinpoint the challenges raised by the SDGs. Policymakers, scientists, analysts and laypersons are calling for reframing innovation policy to consider not just the changing nature of innovation (i.e. globalised, technological and non-technological, open and digital), but also its responsiveness to societal demands for inclusiveness and other societal challenges, such as epitomised by the SDGs (OECD, 2017; Weber, 2017). This push for a more pro-active and responsive innovation policy is illustrated in the recent calls for "directionality" and "mission-oriented" innovation strategies to tackle grand challenges. Such calls also apply to traditional science policy, reflecting concerns about responsible innovation and research – especially in fields (e.g. artificial intelligence [AI], gene editing and neurosciences) where science and technology move faster than legal and ethical rules. The transition towards open science and open data also challenges purely "national" and "scientific peer-based" science-governance models, rendering science not only more permeable, but also more transparent and accountable to society (Dai, Shin and Smith, 2018).

Reframing STI policy is not straightforward. Pleas for "transforming" innovation-policy frameworks have not outlined clear pathways for policymakers, nor have they proposed new levers for government policy. At best, they have proposed incremental reformulation of traditional supply and demand-side instruments (such as R&D funding, human-capital development, networking and clustering policies, and regulatory and demand-led approaches), by instilling sustainability and directionality considerations (Box 4.1).

Box 4.1. In my view: The progressive evolution of innovation policy towards societal challenges

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For many years, policymakers have developed innovation models and policy instruments to target investments in science and technology in order to maximise their economic impacts. More recently, the focus of innovation policy has broadened significantly not only to include innovation for economic growth, but also to address the formidable twin challenges of environmental sustainability and sustainable development. This expanded scope means that policymakers increasingly need to use multiple policy framings to achieve the diverse outcomes many governments are now demanding from their investments in innovation.

Innovation for economic growth

For decades, the National Innovation System (NIS) framework, aimed primarily at fostering economic growth, has dominated innovation policy. Innovation policies within the NIS framework aim to stimulate firms to increase their innovation activities in order to spur job creation, boost competitiveness and increase gross domestic product (GDP) growth. The policy instruments under the NIS model include support for basic research in universities; favourable tax treatment and direct subsidies for R&D in firms; and support for creating linkages between the various actors in the system to build their innovative capacities. Such policies include cluster policies, to stimulate collaboration between firms; research centres, to increase links between firms and higher education institutions; education policies, to support firms' absorptive capacities; support for high-growth innovative firms; and support for the commercialisation of public research. The NIS framework remains the central framing used by innovation policymakers today. Its continued importance is reiterated in the OECD Innovation Strategy 2015, which stresses that innovation must continue to provide the foundation for new businesses, new jobs and productivity growth, and is an important driver of economic growth and development.

Innovation for environmental sustainability

The emergence of acute environmental challenges – including climate change, resource depletion and pollution – has led to the recent development of System Innovation (SI), a second framework for innovation policy. SI is a horizontal policy approach combining technologies and social innovations to tackle systemic problems, such as sustainable housing, mobility and health care. It involves many actors outside of government (as well as different levels of government) and takes a longer-term view. While the NIS framework aims to strengthen and enhance the productivity of an existing innovation system, the challenge of attaining environmental sustainability has shown that many current sociotechnical systems are no longer environmentally sustainable. An SI approach, designed to bring about fundamental change in the systems that provide us with energy, food, health and transport (among others), is necessary. Recent OECD work on SI shows that policies aimed at transitioning sociotechnical systems to more environmentally sustainable configurations differ significantly from policies aimed at increasing the economic performance of existing systems (OECD, 2015). Among the challenges facing policymakers in the context of SI is the need to develop a vision of what future sustainable systems will look like, including which technologies are likely to play important roles in the future system; what infrastructures will be needed; and how business models and behavioural patterns will need to change. To facilitate the transition, policymakers will need to lengthen planning and investment horizons; co-ordinate across government ministries and levels; establish and maintain long-term collaborative partnerships; place increased emphasis on diffusing knowledge and existing technology, as well as inventing technology; and manage and overcome resistance to sociotechnical change. As countries respond to the pressing challenge of environmental sustainability, OECD countries are increasingly adopting SI as a supplemental framework to the NIS for guiding innovation-related investment decisions and setting policy objectives.

Innovation for sustainable development and human well-being

With the signing of the UN 2030 Agenda for Sustainable Development, a third challenge for innovation policymakers has emerged, namely innovation for sustainable development. Agenda 2030 aims to deliver a more sustainable, prosperous and peaceful global future, and sets a framework for achieving this objective by 2030. This framework comprises 17 SDGs, which cover the social, economic and environmental requirements for a sustainable future. Innovation will play a key role in achieving the targets across all of the SDGs, most notably concerning good health and well-being; affordable and clean energy; clean water and sanitation; decent work and economic growth; industry, innovation and infrastructure; sustainable cities and communities; responsible consumption and production; and climate action.

A range of emerging disruptive technologies, including AI, robotics, terotechnology, gene editing and biotechnology, have the potential to address many of the challenges in Agenda 2030 and the SDGs. More rapid and equitable diffusion of these technologies will be needed if sustainable development is to be achieved in practice and within the timeframe set down. At the same time, emerging technologies are also raising major ethical, legal, economic, policy and social issues. Anticipating and addressing the wider societal implications of disruptive technologies in both developed and developing countries will be important, not only for protecting the public good, but also for realising the full social and economic potential of technological development.

Both the NIS and the SI frameworks are well articulated, and are increasingly being used by innovation policymakers across the OECD to meet the goals of environmental sustainability and economic growth. A policy framework granting equal weight to sustainable development in decision-making, and placing justice and inclusion at its core, still needs to be developed.

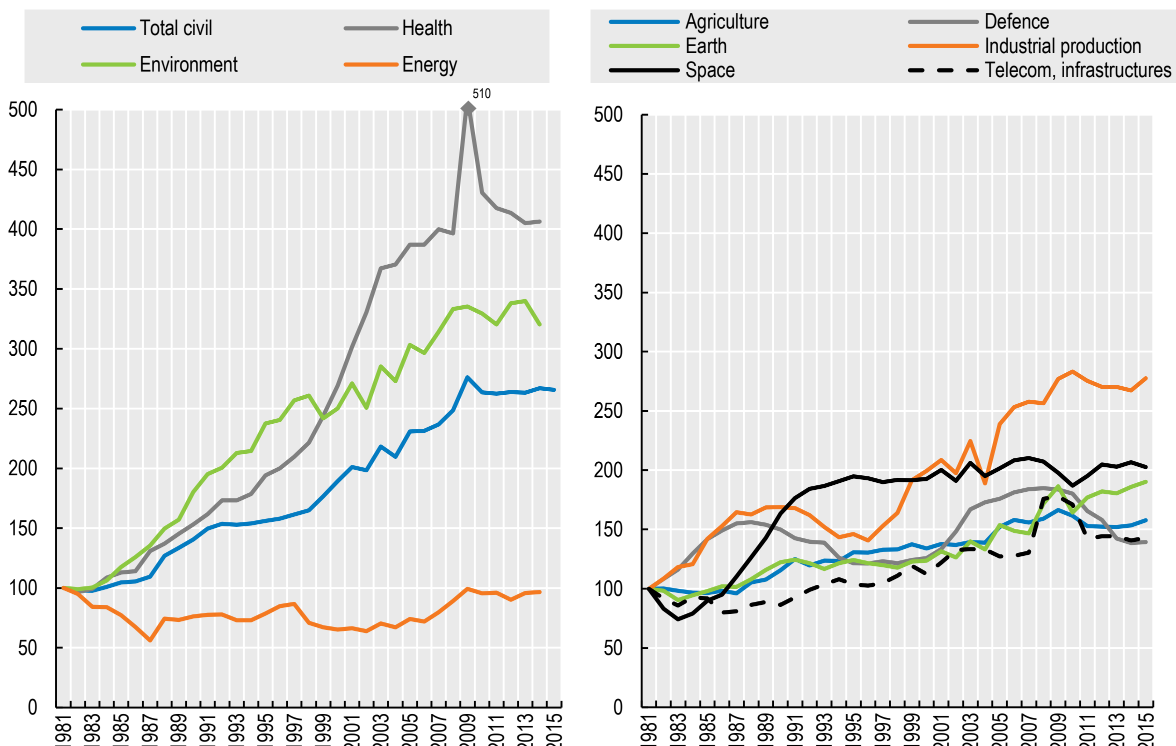
The strategic orientation of research towards the SDGs

The urgency of many global challenges, such as climate change, has revived a long-standing debate on how to apply "mission innovation", defined as "large-scale interventions aimed at achieving a clearly defined mission (goal, solution) within a well-defined timeframe with an important R&D component" (European Commission, 2018). Missions were initially associated with US defence R&D and space programmes, as well as with government-sponsored R&D procurement in areas of national security or independence (such as energy).

Societal needs in areas such as agriculture, health and energy have been recognised in the formulation of modern science policy since the second half of the 20th century, leading to the creation of specialised agencies (e.g. the US National Institutes of Health in the 1940s), research councils and public research laboratories in many OECD countries. However, research-policy agendas have shifted towards environmental and societal challenges in OECD countries since the 2000s (Figure 4.2). The data on national government budget appropriations (GBARD) show an increase in environment and health-related R&D and, to a lesser extent, in earth and space-related R&D. By contrast, growth in the R&D budgets for defence and agriculture has been less strong. Publicly funded energy R&D has also not kept up.

Figure 4.2. Growing societal concerns are changing balances in public R&D budgets

GBARD, OECD index 1981=100, 1981-2015



Note: Environment-related R&D budgets include research on controlling pollution and developing monitoring facilities to measure, eliminate and prevent pollution. Energy-related R&D budgets include research on the production, storage, transport, distribution and rational use of all forms of energy, but exclude prospecting and propulsion R&D. Health-related R&D budgets may underestimate total government funding. Efforts to account for the funding of medical sciences through non-oriented research and general university funds help provide a more complete picture.
Source: OECD (2018a), Research and Development Statistics, www.oecd.org/sti/rds (accessed on 19 July 2018, IPP.Stat, https://www.innovationpolicyplatform.org/content/statistics-ipp (accessed on 19 July 2018).

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In 2016, the estimated total public energy research, development and demonstration (RD&D) budget for International Energy Agency (IEA) member countries reached close to USD 16.6 billion (US dollars), just below the 2015 levels. The total public energy RD&D budget of these countries continues to decrease year-on-year, from its recent peak of USD 19.4 billion in 2012. New public and private initiatives – such as the Mission Innovation pledge taken in November 2015 by a group of 20 countries at COP21 in Paris – are attempting to increase investment in renewable-energy R&D and innovation (IEA, 2017). The Breakthrough Energy Coalition is a global group of 28 high net-worth investors from ten countries committed to funding clean-energy companies emerging from Mission Innovation initiatives (Breakthrough Energy Coalition, 2018).

New mission-oriented approaches are also being proposed in the context of the European Union's upcoming Horizon Europe research and innovation programme, which will succeed Horizon 2020. Horizon Europe aims to tackle some of the biggest challenges facing society today, from climate change to inequality, driving collaboration across different industries and bodies in both the private and public sectors (European Commission , 2018). Missions are more concrete than broad "grand challenges", in that they have clear time-bound targets. In a mission-oriented approach, the ambition would not be (for example) "to tackle climate change", but to cut carbon dioxide emissions by a given amount, in a given place over a specified time period. Missions require a "market-shaping" framework, rather than the more traditional and passive "market-fixing" framework focused on correcting market failures (Mazzucato, 2018). Compared to the traditional mission orientation, the new missions focus more clearly on the demand side and the diffusion of innovations; seek coherence with other policy fields; and accept both incremental and systemic innovations.

Lessons from government interventions suggest that although governments have succeeded in some missions (e.g. the Apollo "Man on the Moon" mission), they have also failed in others. These lessons warrant caution, and attention to the design and evaluation of mission-oriented approaches. Some essential interrelated questions arise when analysing the new mission orientation and its potential for addressing global challenges. The technological challenges and measures required to cope with climate change differ radically from those characterising defence and space-related mission R&D programmes, where the main supplier and buyer was the government. Today, the private sector performs most R&D in many OECD countries. Moreover, the outputs of defence and space-related R&D programmes were used by the US Government agencies financing the R&D; hence, transferring the results of R&D from new mission-oriented programmes will not be as straightforward. Without large procurement allowing easy scaling of new technologies, new mission-oriented innovations will probably encounter many of the traditional barriers to technology diffusion and scale.

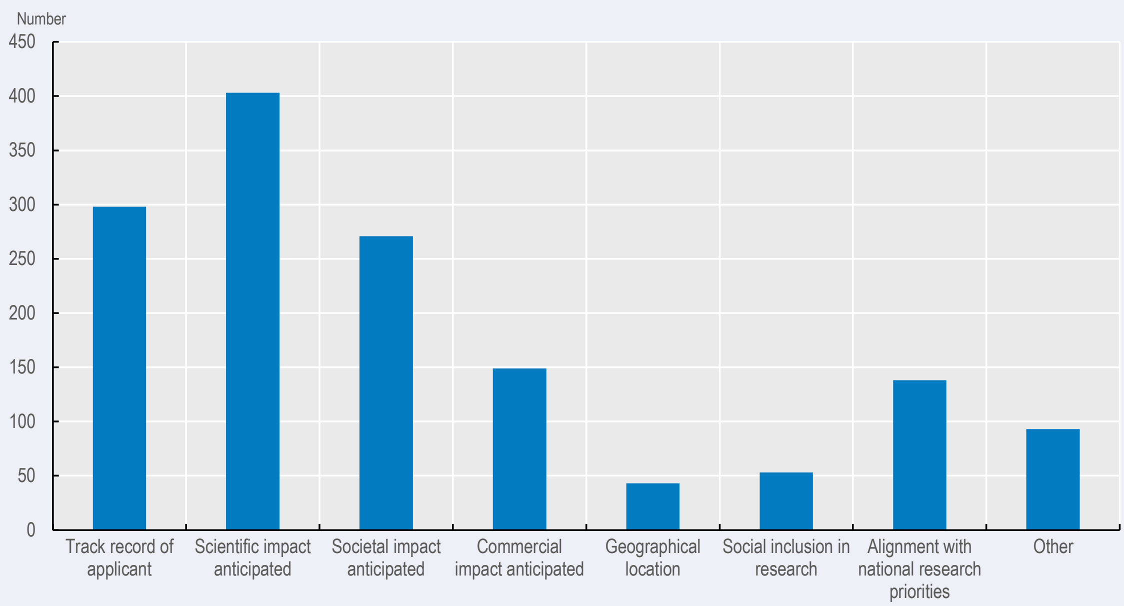
In many OECD countries, the national governance structures do not appear to favour a "challenge" approach. Such an approach requires strong vertical co-ordination, with significant horizontal alignment. This is especially challenging in countries where ministries have devolved the implementation of strategic research programmes to agencies. To succeed, new mission-oriented approaches will not only need to be linked to the SDGs, but will also require significant levels of funding, as well as specific co-ordination mechanisms involving companies and civil-society actors.

Even before the SDGs emerged as a global agenda for sustainable development, many countries had mobilised STI to address social and environmental challenges, especially at the national level. They relied on a variety of policy instruments, such as supporting public funding programmes in specific sectors, promoting public-private partnerships, introducing regulatory reforms and strengthening governance arrangements. Box 4.2 provides an overview of the frequency of use of expected societal impact when selecting research-project proposals in competitive grant schemes, as declared by policymakers in more than 50 countries in the 2017 EC/OECD STI policy survey (European Commission/OECD, 2017). It also analyses the main societal challenges targeted by STI initiatives designed to address such challenges.

Box 4.2. How are countries orienting their STI funding and policies towards societal challenges and the SDGs?

Information on the criteria for public funding to research was collected on 568 public competitive research grants in more than 50 countries through the 2017 EC/OECD STI policy survey, which gathers quantitative and qualitative data on STI policy (European Commission/OECD, 2017). Figure 4.3 shows that expected societal impact is one of the main criteria used to select projects, ahead of possible commercial applications or even alignment with national goals.

Figure 4.3. Main criteria for funding – competitive research grants



Source: EC/OECD (2017), STIP Compass: International Science, Technology and Innovation Policy (STIP) Database, edition 2017, *https://stip.oecd.org*.

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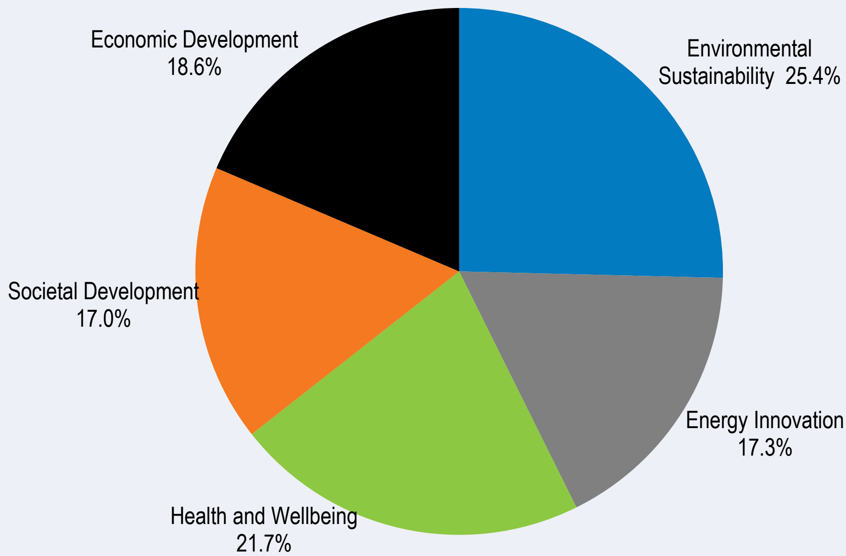
Figure 4.4 provides a snapshot of 200 STI policy initiatives reported by 17 countries and the EU as targeting societal challenges. These are responses to questions on “research and innovation for society strategy”, “research and innovation for health and healthcare”, “research and innovation for sustainable development”, and “research and innovation for developing countries”. Of the 200 policy initiatives, environmental sustainability (SDGs 6, 13, 14, 15) is reported most often as an objective, followed by health and well-being (SDG 3). Energy innovation (SDGs 7) and social development (SDGs 1, 2, 4, 5, 10, and 11) are reported less often.

Figure 4.4. Breakdown of STI initiatives by targeted societal challenges, 2018



Note: Target sector classification criteria: Environmental sustainability refers to areas related to environmental preservation, global warming and natural ecosystem including clean air, water, land, ocean, greenhouse gas reduction, natural resources management, biodiversity and so on. This target category is relevant to the following SDGs; 6 (clean water and sanitation), 13 (climate action), 14 (life below water), 15 (life on land). Energy innovation refers to areas related to energy efficiency, renewable energy and energy transformation (including electric vehicles) which correspond to SDG 7 (affordable and clean energy). Health and wellbeing refers to areas related to healthcare, disease prevention, vaccination, aging, health promotion and wellbeing which correspond to SDG 3 (good health and wellbeing). Societal development : refers to areas related to make societies and communities more safe, equitable and sustainable which include preventing poverty, quality education, reducing inequalities, demographic change, cities and social infrastructure(including smart city), and so on. This sector is mainly related to the SDG 1 (no poverty), 2 (zero hunger), 4 (quality education), 5 (gender equality), 10 (reduced inequalities), 11 (sustainable cities and communities) and 16 (peace, justice and strong institutions). Economic development refers to areas related to innovation, industry and business development, economic growths which correspond to SDG 8 (decent work and economic growth), 9 (industry, innovation and infrastructure) and 11 (responsible consumption and production)

Source: EC/OECD (2017), STIP Compass: International Science, Technology and Innovation Policy (STIP) Database, edition 2017, *https://stip.oecd.org*.

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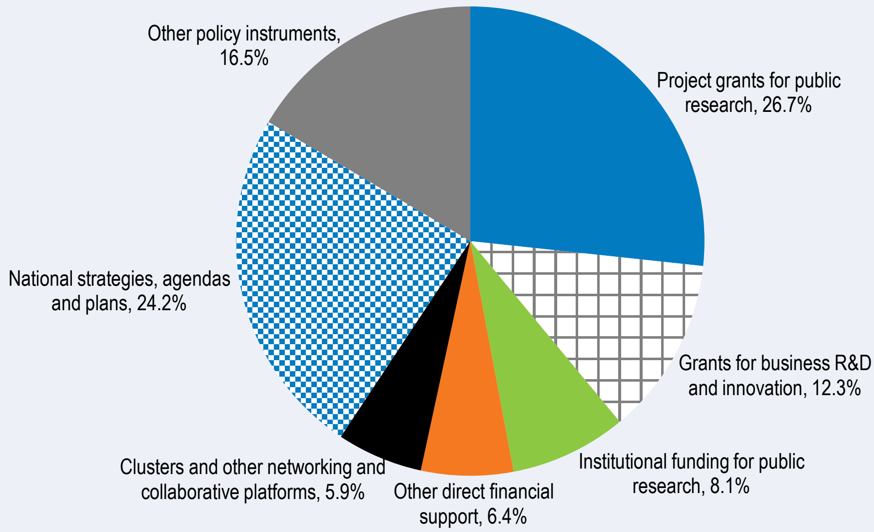
Of the 200 initiatives in our sample dedicated to societal challenges, 27% provide project grants for public research, 24% for national strategies, agendas and plans, and 12% for grants for business R&D and innovation (Figure 4.5).

Figure 4.5. Percentage of STI policy instruments directed towards societal challenges



Source: EC/OECD (2017), STIP Compass: International Science, Technology and Innovation Policy (STIP) Database, edition 2017, *https://stip.oecd.org*.

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STI roadmapping is a key strategic policy-intelligence tool to support better targeting of research and innovation activities. Recognising this, the United Nations has called for Member States to develop STI roadmaps for each of the SDGs.[1] Roadmapping was developed by industry to connect short-term (technological) capabilities with long-term strategic goals. Policymakers have adopted and increasingly applied it in the context of large-scale technological or industrial transitions. The shift from industry-led to government-led roadmapping changes the scope of the roadmapping exercise. Rather than focus solely on technical developments, it now includes broader social, political and technological issues. Considering these "sociotechnical" dynamics, a systemic approach – also integrating stakeholder engagement in STI policy design, adaptation and application – may be needed to enhance the effectiveness of STI roadmaps. When framed around "functional needs", STI roadmaps can better inform decision makers to address regulatory, institutional, infrastructural and behavioural changes. Finally, integrating STI roadmapping with other tools (such as patent analysis) can provide insights on the possible contribution of emerging technologies, improve priority-setting and help target demonstration projects. The IEA has developed a new tool to track progress on clean energy R&D investment by technology area and economic sector which could be used to improve STI roadmapping in the energy space (Box 4.3).

Box 4.3. Better data to enable STI roadmapping: the case of the IEA "Tracking Clean Energy Progress Tool"

The new Innovation Tracking Framework of the IEA identifies key long-term "technology innovation gaps" that need to be filled in order to meet long-term clean-energy transition goals. The Framework, which will be progressively expanded and updated, builds on the Agency's leading in-house knowledge and data on technology innovation and investment; its rich history in technology roadmapping and extensive energy-technology trend analysis; and its unique Technology Collaboration Programmes, which bring together expertise from over 6 000 global scientists and engineers in about 40 technology areas.

The Framework has identified around 100 innovation gaps across 35 key technologies and sectors. Innovation gaps within each technology area highlight where R&D investment or general innovation activity needs improvement. To track developments across key innovation gaps over the past year, the IEA has developed a methodology that looks at the following key innovation aspects: investment patterns; key initiatives from the private or public sector; and general technology improvement, using key metrics.

Source: IEA (2018), IEA website, *https://www.iea.org/tcep*.

Interdisciplinarity and greater inclusivity

Beyond changes to innovation policy, changes in the performance of scientific research are also necessary. First, interdisciplinary research and transdisciplinary research – which goes beyond research between disciplines to create new disciplines, such as sustainability science – will both be needed to identify positive complimentary interactions in the SDGs, as well as trade-offs that can constrain or cancel progress on other SDGs (International Council for Science [ICSU], 2015).

Second, science policy must also address the issue of gender participation (Chapter 7). Gender equality is one of the 17 SDGs (SDG 5). However, because women participate more in the social sciences than in the natural sciences, they contribute less to the provision of scientific evidence and advice in areas such as climate research and energy research.[2] Moreover, owing to their roles in society, women may suffer the consequences of climate change or poverty more acutely, especially in developing countries. Science policy can play an important role in achieving gender equality: not only should science include women in research education and careers, research designs should also control for gender differences.

Third, science policy will need to recognise and embrace more fully the contributions of citizens in the research priority-setting process, as well as the research enterprise (e.g. citizen science). Citizen participation can be contributory (through the collection and provision of evidence) or collaborative (through mentoring and volunteer activities). Citizen-science activities can also help raise awareness of SDG challenges in local communities and facilitate the behavioural changes necessary to implement social or technological innovations.

These three dimensions of a more inclusive science policy are already having important impacts on the way research priorities are set, funded, evaluated and diffused. Inclusivity might also point towards building scientific capacity within developing countries to help them better harness knowledge production to achieve local goals.

The international STI co-operation imperative

While every country needs STI to meet its own national SDG goals, STI capabilities are unevenly distributed across the globe. Some countries are resource-rich but knowledge-poor, whereas other countries have knowledge that is insufficiently connected to the industrial sector or actual societal needs. International co-operation offers a way for research and innovation actors to come together. It also creates spillovers from technology transfer between companies, research institutions and countries.

Public support for international co-operation in research and innovation is predominantly predicated on enhancing national research excellence, competitiveness and the anticipated returns in terms of national productivity, exports and growth. The "national" perspective in STI policy has served OECD countries very well in the pursuit of economic growth. International co-operation in science, as it emerged in the post-war period, aimed to reinforce national capacities by sharing costs among countries, notably through the creation of international research infrastructures. Meanwhile, the underlying model of "competitive-co-operation" that characterised scientists' interactions helped countries advance their national goals and targets.

Today, this national growth-grounded perspective appears at odds with the need to protect, produce and preserve global public goods, such as a stable climate and biodiversity. The challenge for countries is how to balance their national priorities and goals (e.g. competitiveness and research excellence) and engage in co-ordinated and concerted action at the international level to solve global public-good problems.

Recent OECD analysis based on sample data from ÜberResearch's Dimensions for Funders database, which gathers data from national funding councils, showed that research projects that could relate to one of the 17 SDGs represented only about 11% of the total number of projects funded in 2015. International co-operation occurred in about 2% of these projects, meaning that international co-operation for SDGs represents about 0.2% of all STI projects (OECD, 2017). There exists a lack of dedicated funding for large-scale and longer-term co-operation. Fragmented funding, as well as divergent rules and procedures for research funding, are also a problem. Changing this situation could imply major changes both in the formulation of science and technology national policies and instruments, and the distribution of roles between different actors.

OECD work on international STI co-operation has identified several factors holding back international co-operation, as follows:

- national research focus
- global public-good problems, with individual countries unwilling to pay the costs of action ("tragedy of the commons")
- lack of knowledge of partners' capabilities, especially in developing countries
- lack of trust and legal regimes
- weak intellectual property rights (IPR) protection, especially in less-developed economies
- low government and business capacity in partner countries, including insufficient skills and lack of necessary research infrastructure to enable international co-operation

- national STI governance frameworks that hinder international co-operation if they are not well aligned
- fragmented bottom-up and non-state initiatives (e.g. universities, non-governmental organisations, foundations).

The OECD is currently considering whether to revise its existing principle-based Recommendations on International STI co-operation. These proved useful to countries, by drawing political and funding attention to issues such as IPR enforcement in academic collaboration, and removing barriers to scientist and researcher mobility. The current Recommendations predate the Internet, and were devised at a time when science was less data-driven and intensive. As science becomes increasingly data-driven, international STI co-operation policies and initiatives will need to integrate the data-science infrastructure dimension to ensure relevant data can be accessed and shared among international partners and other stakeholders. Thus, while some of the Recommendations' principles are still valid, they do not offer guidance on how to mobilise contemporary STI for societal challenges, such as the SDGs. Adding new considerations – e.g. incentives for researchers to share their data, while respecting privacy and IPR regulations – would make the Recommendations more relevant.

Moving from a national to an international perspective also means shifting the emphasis from competition to co-operation, including with non-state stakeholders. This may require hybrid funding systems, new types of research bodies and new public-private partnerships that effectively make international STI co-operation for the SDGs and other grand challenges a national priority.

The European Commission's framework programmes are increasingly open to global participation from non-EU countries. The European Union (EU) has increased the number of science and technology agreements with third countries in recent years. EU mobility programmes, like the Marie Curie fellowships, now support researchers from more than 80 countries. The latest communications from the European Commission on Horizon Europe indicate even closer alignment between the EU societal challenges and the SDGs. Indeed, the EU is carrying out a "mapping and gap analysis" of its policies against the SDGs, to determine how STI tools could support actions to fill the gaps or improve policy coherence (European Commission, 2016).

Linking development aid and STI policies

The flow of private-sector capital into developing countries has a major impact on growing new industries, building infrastructure and financing the human-capital development that is essential to STI. Most financial flows from OECD countries to developing countries come from private sources, i.e. investments, migrant remittances and foundations. Financing for STI activities in the context of development assistance remains marginal in absolute terms: according to OECD Development Assistance Committee (DAC) statistics, OECD donor countries only devote around 5% of development assistance to STI activities (OECD, 2017).[3] OECD data also show that philanthropy funding for development, supporting research activities or activities channelled through universities, think tanks, research institutes, etc., amounted to around USD 6 billion over 2013-15 (25% of the three-year total) (OECD, 2017).

There exists growing recognition among donor and recipient countries alike that STI-related official development assistance (ODA) financing could be used to leverage total investment in research and innovation. Donor-country aid agencies and charities, such as the Wellcome Trust, the Bill & Melinda Gates Foundation or Canada's Grand Challenge programme (Figure 4.6), have integrated research and innovation (including social innovation) in their efforts to help developing countries build the necessary government and business capacities to achieve the SDGs.

In response to the 2030 Agenda, the OECD DAC has revised its peer-review methodology. It also agreed in October 2017 on a set of Blended Finance Principles for Unlocking Commercial Finance to the SDGs, which will provide donors with a coherent framework for blending finance activities (OECD, 2018b).

Figure 4.6. Promoting social and technological innovation in developing countries: The approach of Grand Challenges Canada

Source: Grand Challenges Canada, 2018

Many of the vehicles used by aid agencies and charities involve partnerships with firms and community groups to bring new technologies into developing countries. In 2015 alone, USAID was involved in 360 partnerships with the private sector, generating USD 4.9 billion in cash and in-kind contributions. For example, USAID has a long-standing partnership with Merck, which provides doses of the anti-parasite medication Ivermectin to Africa and Latin America, to fight onchocerciasis and elephantiasis. The programme now reaches 250 million people annually, delivering a total of 2 billion doses since its inception in 1987 (National Academies, 2017). The UK Government's aid strategy, Tackling Global Challenges in the National Interest, recognises the importance of research as part of its contribution to aid. The strategy allocates significant new resources to research programmes/initiatives (e.g. the Global Challenges Research Fund and the Newton Fund) to enhance the contribution of science to overcoming key global development challenges.

The entry of research-funding councils and research ministries into ODA programmes has led to some tensions: should collaborative research with developing countries focus only on excellence or should it instead focus on providing technological solutions to development problems? Some argue that there is no trade-off between excellence in science and development sponsored research and indeed there is anecdotal evidence that development funded research is as equally cited as academic research. Another tension is the focus on more applied research and solutions that can be commercialised immediately, as opposed to longer-term basic research projects – yet longer-term basic research is needed to develop institutional learning capacity. Indeed, the mobilisation of development related STI investments will have to confront the challenge of how to translate and scale up solutions so that they address a given challenge and at the same time foster broad-based economic development. Too often STI initiatives in developing countries fail to scale up or to become embedded in a developing country because of lack of entrepreneurship and finance or business environment that is constrained by outdated state regulations or even corruption, which acts as a "tax" on economic activities (Box 4.4).

Box 4.4. In my view: Technology deployment for the SDGs

Alfred Watkins, Chairman, Global Solutions Summit

The global development community has devoted substantial time, attention and resources to encouraging scientists and engineers to find innovative solutions for the SDGs. As a result, we now have proven, effective and affordable solutions to many pressing development problems, including off-grid renewable energy; potable water; off-grid solar-powered irrigation; high-quality community health clinics; and off-grid food storage, refrigeration and processing. These new solutions should (in principle) make it even more affordable and feasible to hit many SDG targets – especially in the least-developed countries, where enormous progress should be possible simply by deploying proven solutions that are already widespread elsewhere. But if this is correct, why are we not on track to achieve the SDGs?

In almost all cases, the binding constraint is not a lack of scientific expertise, technological know-how or proven, cost-effective solutions. The binding constraint is that we have not yet figured out how to address the less glamorous and more mundane organisational, entrepreneurial, financial and business-development issues associated with getting these solutions into the hands of tens – if not hundreds – of millions of people in emerging markets. Tackling this deployment challenge will require progress along a wide range of fronts, almost none of which require scientific expertise. Consider, for example, just a few of the tasks required to supply potable water to the millions of individuals who lack daily access to safe drinking water:

- An innovator or equipment supplier may have developed a cost-effective, efficient and affordable nano-filtration mechanism. But a nano-filter cannot produce potable water without pumps, hoses and cisterns; a power supply (grid, solar, bicycle, diesel), water-quality monitoring equipment; a retail-distribution system; and a payment-collection mechanism. Someone has to organise this supply chain in thousands of communities.
- Those same innovators and equipment suppliers may already be selling purification systems to buyers in the United States or the European Union. However, they do not necessarily have sales contacts in Africa, Asia and Central America, nor do they have the personnel, financial resources and inclination to search for potential customers in numerous far-flung countries. Somebody needs to link the supply of technology with the people who need that technology.

- Somebody has to take responsibility for managing local procurement; organising construction; maintaining and repairing the equipment; obtaining the necessary permits; registering and operating the business; and handling all the other mundane, but essential tasks associated with providing potable water in a single community. In other words, someone – presumably an entrepreneur – has to figure out how to incorporate this game-changing technology into a financially sustainable, efficient and game-changing organisation. The scientist who invented the nano-filter may be an expert in new materials, but may not have the expertise, business acumen, organisational skills and personal inclination to handle these other tasks.
- Last but not least, the households and communities themselves may know in broad terms what they need, but they don't necessarily know where to find it; how to look for it; how to evaluate competing technological solutions; how to organise so many dispersed actors and mundane tasks; how to organise a village enterprise or coop; and how to negotiate terms and conditions with potential partners who are vastly more experienced and sophisticated.

To date, the development community has treated these deployment challenges as an afterthought, on the grounds that – as Ralph Waldo Emerson claimed in 1882 – if we "build a better mousetrap…the world will beat a path to your door." The Global Solutions Summit, convened at UN Headquarters in June 2018, was organised on the premise that technology deployment is not as simple and automatic as Emerson suggested. If that is true, then we can no longer afford to relegate technology deployment to an afterthought in the STI/SDG dialogue. It is an indispensable piece of the puzzle and requires at least as much attention as the quest for new discoveries.

Three important conclusions emerged from the Global Solutions Summit:

Transferring scientific insights from the lab to the last mile should be thought of as a supply chain, with scientists occupying the most upstream position, engineers and inventors in the next spot, and deployment officials filling out the remainder of the supply chain. If STI is going to impact the SDGs, we need mechanisms for passing the baton from scientists and engineers to the diverse groups of non-scientists who are best-suited to implement the essential deployment processes.

Technology deployment requires an effective and efficient deployment ecosystem – one that empowers all the actors in the deployment process to find each other and join forces, and then to transfer the lessons of successful experience from country to country. We need to devote more time and attention to these ecosystem issues.

Bilateral and multilateral development agencies, along with the United Nations, the OECD and others, will not be the ones to deploy these new technologies and development solutions in dozens of countries. They need to figure out how best to empower others – e.g. foundations, NGOs, local entrepreneurs, local universities and technical training institutes – to handle these tasks.

Changing STI governance for sustainability transitions

The contribution of STI to achieving the SDGs will depend on leadership and effective governance arrangements for economic policy making in general and STI systems in particular. At the national level, evidence based on the OECD Country Reviews of Innovation shows that countries' innovation performance depends in part on the quality of STI governance. This quality rests on the set of publicly defined institutional arrangements, incentive structures, etc., that determine how the various public and private actors engaged in socio-economic development interact when allocating and managing resources for STI.

However, national STI governance institutions and structures are not static. Technological and scientific progress, and the global expansion of innovation, have increased the number of actors investing in and setting the agenda for science and technology. Large private firms (such as Alphabet) are investing in basic research in AI. Small entrepreneurial firms are using digital technologies to provide solutions to SDG challenges in developing countries, without any government support. Large charities increasingly shape global agendas for health research, forcing government ministries to re-assess their own priorities. Participatory approaches to STI agenda and priority-setting and evaluation are increasingly common (Chapter 10), as illustrated by the monitoring of the SDGs by independent scientists (Box 4.5).

Box 4.5. Independent scientific advice for monitoring implementation of the SDGs

Before leaving office, former Secretary-General Ban Ki-moon appointed 15 eminent scientists and experts to monitor the implementation of the SDGs and draft the quadrennial Global Sustainable Development Report. The report will be presented to all heads of state at the General Assembly in 2019, without previous government negotiations and agreement. This innovation in UN procedures gives independent scientists an independent say. One of the experts' main tasks will be not to look at the SDGs in isolation, but to study their synergies and possible contradictions. They will also need to consider SDG priorities from the perspective of science and policy.

Source: United Nations (2018), "STI Forum 2018 – Multi-stakeholder forum on science, technology and innovation for the Sustainable Development Goals", 5-6 June 2018, *https://sustainabledevelopment.un.org/TFM/STIForum2018*.

The connection between responsible research and innovation, and the SDGs (e.g. ending poverty; zero hunger; health and well-being; clean water and sanitation; reduced inequalities; climate action; life on land; and peace and justice) is manifest. It reflects the growing scrutiny and accountability underlying the funding of both public and private R&D (Chapter 10). However, STI policy in many OECD countries (and beyond) is driven by an economic rationale: it is a means to correct for market and system failures. STI governance frameworks have not systematically considered sustainability or the knock-on effects of technological progress. In most countries, governments and businesses only deal with the negative or unexpected effects of technological innovations (e.g. neurotoxic pesticides and toxic vaccine adjuvants) once they have emerged.

SDGs bring many challenges to STI governance arrangements and processes. On the one hand, meeting the SDGs and the underlying 169 targets requires greater "directionality" in national research and innovation agendas. On the other hand, interdependence among the various SDG goals means that achieving progress in one goal can leverage progress in another goal, but may also offset progress in yet another goal. Some seemingly effective technologies for solving certain challenges may also generate negative effects on other challenges – for example, solar energy is a zero-carbon renewable source of energy, but solar panels can generate pollution if toxic components are improperly released into the environment. There also exists a risk of conflicting objectives or budgetary arbitrage in the context of limited research funding. The question of how STI is part of the institutional frameworks in countries' national governance systems, and influences public decision-making, is important when designing efficient and acceptable policy tools.

In many countries, the governance of STI policies is still removed from strategic priority-setting, planning and reporting processes for the SDGs. STI data collection has also not caught up with demands for SDG reporting. This is particularly true in developing countries, where STI institutions and co-ordination mechanisms are weak or absent. Until now, STI has not featured prominently in Voluntary National Reviews, which countries undertake voluntarily to report progress on the SDGs at the United Nations High-Level Political Forum, held each July (United Nations, 2018). The UN request for Member States to produce STI roadmaps for the SDGs may lead to closer co-ordination, policy alignment and even integration between the parts of government co-ordinating SDG reporting and those responsible for national innovation strategies.

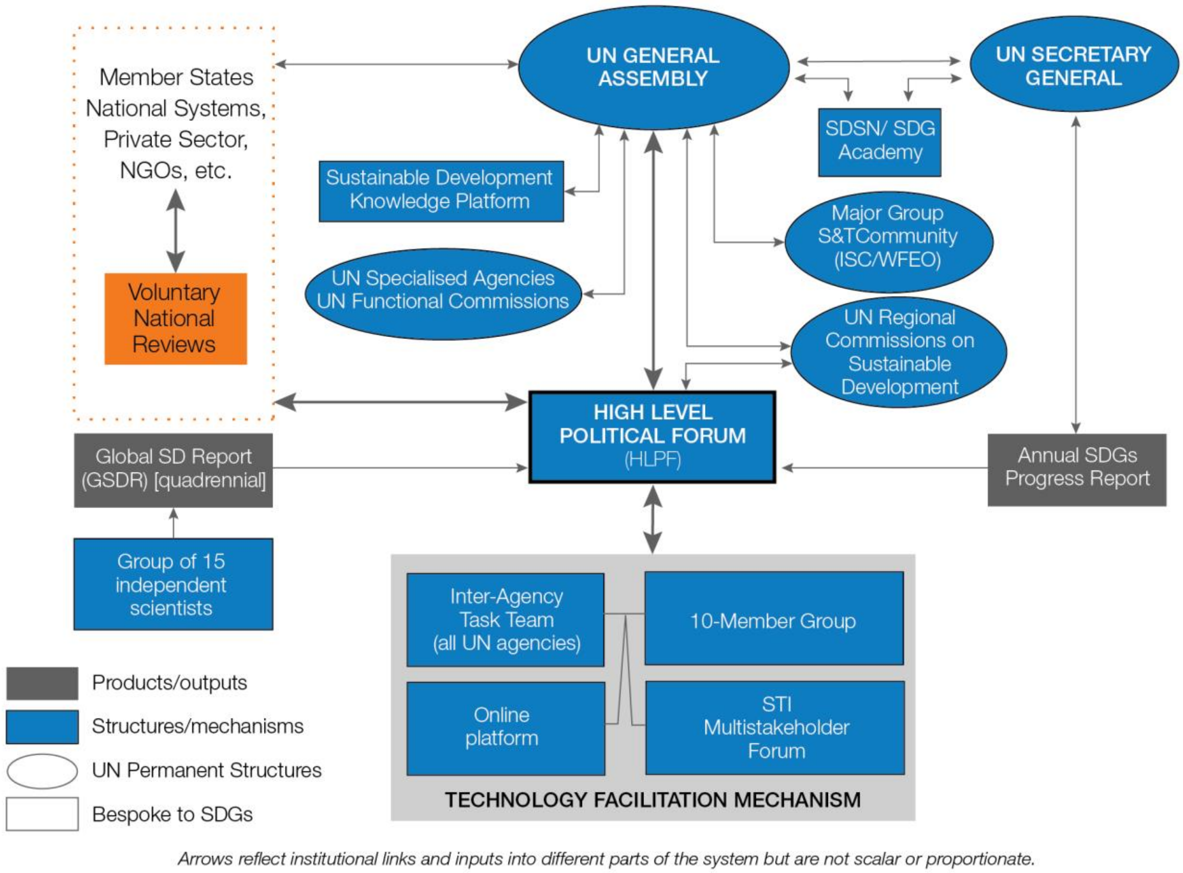
Policy co-ordination is essential: only a comprehensive and wide-ranging strategy to enhance innovation can help address social and environmental goals, while building a lasting foundation for future economic growth and competitiveness. Current national STI governance approaches are inward-looking and fragmented, while international institutions to drive technological innovation for sustainable development remain relatively weak or are absent altogether.

Several countries, like France, Finland, Brazil and Japan, are attempting to align national STI agendas with the SDGs. The Japanese Government established the SDGs Promotion Headquarters, a new cabinet body comprising all government ministers and headed by the Prime Minister. The purpose of the SDGs Promotion Headquarters is to foster close co-operation among relevant ministries and government agencies, in order to lead the comprehensive and effective implementation of SDG-related measures. The interministerial council adopted the SDG Implementation Guiding Principles in 2016, which represent Japan's national strategy for addressing the major challenges to implementing the 2030 Agenda.

How science will inform the decision-making process in SDG governance systems will depend on the legitimacy, credibility and salience of the contributions of both national and international scientific institutions to the various UN structures (e.g. the High-Level Political Forum and the Global Sustainable Development Report) charged with providing STI input (Box 4.5) (van der Hel and Biermann, 2017). The Technology Facilitation Mechanism supports this process. Its objective is to enhance the effective use of STI for the SDGs, based on multi-stakeholder collaboration between UN Member States, UN entities, civil society, the private sector, the scientific community and other stakeholders (Figure 4.7). If STI is to contribute to the SDGs, its role must be communicated to the public at large: shifting public STI resources from national economy and labour market-related objectives will be difficult without jeopardising acceptance and ownership by the general public (Stramm, 2016). The task of science and technology communities, together with other stakeholders, will be to provide evidence and examples of the various roles STI can play in defining and articulating problems related to the SDGs, and implementing solutions.

Figure 4.7. STI inputs to the SDG process

Schematic illustration



Source: The InterAcademy Partnership, "*Supporting the Sustainable Development Goals: A Guide for Merit-Based Academies*", 2017, available at: www.interacademies.org/37864/IAP_SDG_Guide and "*Improving scientific input to global policymaking, with a focus on the UN Sustainable Development Goals*" available at https://www.interacademies.org/50429/SDGs_Report.

One key dimension of the STI governance system is monitoring and measuring the contribution of STI to implementing the SDGs. Monitoring progress on the societal and environmental dimensions of the SDGs will need new indicators. For example, analysis based on detailed budgeting data may provide information on STI "input" commitments to the SDGs, e.g. those relating to poverty or clean water. Intermediate output indicators – such as patents – provide some data and could be used for STI roadmapping exercises.

It is also necessary to explore the contribution of STI through data at the subnational level. New initiatives have developed at the subnational government level: for example, the City of New York's OneNYC[4] has developed indicators based on local data to monitor progress on the SDGs. Non-governmental actors and community groups also help monitor progress: still in the United States, SDG USA[5] conducts research on the measurement and status of US SDGs across the 50 states, highlighting the best state practices and policy options to achieve them.

The drive for improved STI indicators should also capture the multidimensionality and interdependencies inherent in the SDGs. Multidisciplinary research is one example where measurement needs to be improved. The OECD is developing a conceptual approach to measuring transboundary effects (i.e. the impacts of one country's actions on other countries and the contributions to global public goods) within the 2030 Agenda. This approach will begin with a mapping of transboundary effects (which are both explicit and implicit in the SDGs), and a proposal for selecting and assessing relevant indicators (OECD, 2018b).

In parallel, frameworks that measure overall progress on the SDGs (such as the SDG Index and Dashboards, developed by the Sustainable Development Solutions Network (SDSN) and the Bertelsmann Foundation) might do well to support new STI indicator development, e.g. through reciprocal involvement in international statistical bodies (such as the OECD National Experts Group on Science and Technology Indicators, and Eurostat).

The promise of digitalisation

Enabling and converging technologies, notably information and communications technology (ICT), have been a central feature of technological progress. Digital technologies, such as AI, blockchain and 3D printing, hold promise to help accelerate economic development and progress towards the SDGs.

Digitalisation can help existing business solutions scale and disseminate faster. Emerging business models are allowing technologies to diffuse to developing countries, generating positive impact on the SDGs (Table 4.1). Digital solutions can reach people globally, regardless of their income group. Mobile phones and digital payment systems are just two examples of how digitalisation can bring basic banking services to people in developing countries, enabling entrepreneurship and economic activities everywhere.

However, many barriers hinder the deployment of digital technologies, from the need to finance the underlying ICT infrastructure (such as broadband and cloud services) to insufficiently skilled workers who could help firms exploit these technologies. Insufficient, poor or outdated regulation in the ICT sector regarding market access, data privacy and security, and IPR are hampering the deployment of digital technologies, especially in less-developed countries. These impediments to digitalisation are also preventing convergence between ICT and other enabling technologies, including biotechnology (e.g. synthetic biology) and new materials (e.g. graphene), which could help address problems related to human health and agriculture, and reduce carbon dioxide emissions.

Table 4.1. How the digital transformation can help achieve the SDGs: some examples

SDG focus areas and targets that benefit most from digital solutions	Possible digital solutions	Digitalisation's potential impact, with illustrative data points
Goal 1: No poverty		
• Scientific education • Data science to support targeted poverty alleviation • Eradicate extreme poverty • Reduce poverty in all its dimensions • Ensure equal rights to economic resources and basic services	• Mobile access to telephony and the Internet, includes need for a device • E-learning • Digital payment systems	• Increases access to opportunities to break free of poverty and improve economic participation • One-third fewer people living on less than USD 1.25 per day thanks to extended Internet coverage
Goal 8: Decent work and economic growth		
• Sustain per-capita economic growth and at least 7 % GDP growth in least-developed countries • Improve global resource efficiency and decouple economic growth from environmental degradation • Achieve full and productive employment and decent work • Reduce youth unemployment • Strengthen capacity of domestic financial institutions and expand access to banking	• Connectivity • E-work, e.g. augmented-reality, cloud-based platforms ("platform as a service"), telecommuting, virtual business • Digital solutions that transform production and consumption patterns	• Boosts growth and helps decouple it from resource consumption • Up to 1.38% GDP growth from 10% increase in broadband penetration • 70% cut in oil consumption in 2030 compared to today from all digital solutions examined
Goal 9: Industry, innovation and infrastructure		
• Infrastructure development • Increase access to ICT and provide universal access to Internet • Develop quality, reliable, sustainable and resilient infrastructure • Promote inclusive and sustainable industrialisation • Upgrade infrastructure and retrofit industries with clean technology • Enhance scientific research and upgrade technological capabilities of industrial sectors, including by increasing the number of R&D workers	• Smart manufacturing, e.g. industrial IoT, machine-to-machine, 3D printing and cyber-physical systems • Data analytics and cloud computing, drones and robotics, embedded system production technology • Smart logistics, e.g. IoT/connected vehicles, load units, products and machines; augmented-reality and wearable technologies; commercial unmanned aerial vehicles; digital warehouses • Optimised fleet and route management • Connectivity, e.g. fixed and/or mobile access to telephony and the Internet; includes need for a device	• Boosts efficient and innovative supply, production and delivery of goods • USD 982 billion in economic benefits to industries from smart manufacturing and smart logistics

Source: GESI (2015), System Transformation: How Digital Solutions will drive progress towards the Sustainable Goals, http://systemtransformation-sdg.gesi.org/160608_GeSI_SystemTransformation.pdf.

Data, and related hard and soft digital infrastructures, are important to digitalisation. Much is made of the potential for satellite data to contribute to the SDGs, notably clean water scarcity and sustainable farming. However, access to data – and the computing power and human skills necessary to process and analyse them – is unevenly distributed. Many developing countries lack good-quality government data, as well as basic scientific data on climate, water systems, soil and human health – hence the importance of embedding open-data capabilities in developing countries. The International Science Council, and its Committee on Data for Science and Technology, are working with UN agencies, governments, institutions and other international partners to create regional open-science platforms in Africa, Latin America and the Caribbean (Science International, 2015).

Future outlook

The SDGs aim to achieve economic development that is both socially inclusive and within the ecological boundaries of the earth's capacity to sustain human activity. The main conclusion of this chapter is that for STI to contribute to the three dimensions of the SDGs – i.e. environment, economy and society – the SDGs will need to be more fully embedded within STI policy frameworks. Some avenues for policy action include:

- Instilling greater "directionality" in technology and innovation policies, to focus on the technological and innovation-related targets of the SDGs: this may take the form of challenge or mission-oriented approaches, which must include the demand side and involve stakeholders in policy design and implementation.
- Better use of roadmapping STI for the SDGs, which is a potentially useful tool for identifying technology and technology market gaps: roadmapping should also help address system interlinkages between the various SDGs.
- Stronger support for interdisciplinary research: research should be inclusive of gender and citizens, in order to address the interdependencies inherent in the SDGs.
- Reorienting government-initiated international co-operation in STI towards investments in public-goods problems: co-operation should also foster multi-stakeholder partnerships – including with developing countries – involving business, venture capital and community groups (among others).
- Improved interlinkages between official development assistance and STI policies, including in funding and governance arrangements.
- Better alignment of STI governance arrangements at the national and international levels, with the SDGs at all levels of decision-making, e.g. by linking research agendas and innovation strategies to the SDGs: to meet key sustainable-development challenges, STI actors and institutions must integrate demand and user/citizen/consumer/prosumer perspectives. STI must also play a role in the global governance structures and institutions emerging from the implementation and monitoring of the SDGs at the national, regional and global levels.
- Increased investment in the digital transformation, including in infrastructure and skills will be needed, as well as the removal of outdated regulations that impede technology convergence and the emergence of new business models.

Notes

[1] In the Addis Ababa Action Agenda, UN Member States vowed to “adopt science, technology and innovation strategies as integral elements of our national sustainable development strategies” (para. 119). In the 2017 UN STI Forum, participants highlighted that “the STI roadmaps and action plans are needed at the subnational, national and global levels, and should include measures for tracking progress. These roadmaps incorporate processes that require feedback loops, evaluate what is working and not working, and produce continual revisions that create a real learning environment (IATT, 2018).

[2] The Intergovernmental Panel on Climate Change remains dominated by the contributions of male scientists (80%). This is an improvement over the 1990s, when men performed more than 95% of climate science (Gay-Antaki and Liverman, 2018).

[3] As defined by sector-purpose codes, plus keyword searches in descriptive fields.

[4] https://onenyc.cityofnewyork.us.

[5] https://www.sdgusa.org.

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