GUIDEBOOK

for the preparation of

Science, Technology and Innovation (STI) for SDGs Roadmaps

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United Nations Inter-agency Task Team on Science, Technology and Innovation for the SDGs (IATT) Sub-Working Group on STI Roadmaps co-led by World Bank, United Nations Department of Social and Economic Affairs (DESA), United Nations Conference on Trade and Development (UNCTAD) and United Nations Educational, Scientific and Cultural Organization (UNESCO)

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CHAPTER 1.

Introduction

1.1 Background and Objective

The 2030 Agenda for Sustainable Development, unanimously adopted at the United Nations Summit in September 2015, positioned science, technology and innovation (STI) as key means for achievement of the Sustainable Development Goals (SDGs), and launched the United Nations Technology Facilitation Mechanism (TFM). The Annual Multi-Stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum) has been the main TFM platform for discussing topics of common interest to Member States and STI stakeholders in the context of the 2030 Agenda. (For more background on the TFM and key STI mechanisms, see ***Annex 1***.)

In the Addis Ababa Action Agenda, Member States committed to "adopt science, technology and innovation strategies as integral elements of our national sustainable development strategies" (paragraph 119). At the 2017 STI Forum, participants highlighted that STI roadmaps and action plans were needed at the subnational, national and global levels, and that these should include measures for tracking progress. These roadmaps need to incorporate processes that evaluate what is and is not working, and produce continual revisions that create a real learning environment.

Science, technology and innovation (both technological and non-technological) can lead to economic growth by increasing productivity, reducing costs and increasing efficiency. STI also helps to address and alleviate societal challenges, while finding effective ways to tackle environmental challenges. In other words, it feeds into the three components of sustainability: economic, environmental and social. The role of STI in economic and social progress requires not only appropriate infrastructure, resources and capabilities to produce new inventions, but also the capacity of individuals, communities and companies to absorb and apply them. It is only by understanding and supporting the whole process of technological and innovative development and dissemination, and the readiness of its final recipients to accept, own and implement change, that we can strive to achieve sustainable and inclusive growth.

In the context of the SDGs, the TFM work on STI has covered four broad discussion areas:

- **STI for or as individual Goals/targets in SDGs.** While innovation is the most visible focus of Goal 9 (build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), as reflected in the 2030 Agenda language, STI is formally agreed as a means or end for 12 out of the 17 Goals, and 26 out of the 169 targets.[1] The Addis Ababa Action Agenda (AAAA) includes more than 20 commitments for STI. More broadly, STI Forum discussions have shown that STI can contribute to virtually every Goal and target, either directly or indirectly.

- **STI for SDGs as a system.** Beyond disciplinary or sectoral STI contributions (such as for food, health or energy), interdisciplinary approaches and science-policy interfaces have deepened understanding of interlinkages across multiple SDGs, enabling policymakers to pursue synergies or manage trade-offs (such as between economic and social or environmental goals). Systemic gender disparity among key STI actors in science, technology, engineering and mathematics (STEM) fields, beyond the targets under Goal 5, has been recognized as a key issue to be addressed. Traditional knowledge held by indigenous communities is also seen as part of important STI contributions to inclusive development.

- **International cooperation for STI for SDGs, related to (but not limited to) Goal 17.** While technology transfer has long been debated during United Nations deliberations,

1 *Not all of these targets are accompanied by corresponding metrics under the Global Indicator Framework. For a full list of explicit references to STI in 2030 Agenda language, see* ***Annex 2***.

a broader set of issues needs to be examined to facilitate capacity development and materialize the full potential of STI contributions towards the Global Goals, in the context of diverse STI supply and demand conditions across developed and developing economies, and through market and non-market mechanisms.

- **Emerging risks of STI in achieving the SDGs and leaving no one behind.** New and emerging technologies, such as artificial intelligence, have raised global concerns about displacing jobs, undermining the advantage held by most developing countries in unskilled labour, and exacerbating inequalities within and between countries.[2]

STI Forums have enriched these discussions, while the breadth and depth of the interrelated issues have presented challenges in identifying practical courses of actions to maximize opportunities and mitigate risks. Meanwhile, reflection on the status of the SDGs has made it clear that "business as usual" is not an option and has added a sense of urgency to deliver on the promises of STI in reaching the last mile, addressing the needs of those being left behind, changing the trajectory and accelerating progress.

In this context, an STI for SDGs Roadmap has been proposed as a useful approach to strengthen country ownership and elevate the policy debate on STI for SDGs, inform on the areas of common interest among United Nations Member States, improve the complementarity of United Nations system initiatives on STI in a demand-driven manner, and effectively facilitate relevant national and international efforts.

The diversity of stakeholders involved so far in deliberations on STI for SDGs Roadmaps has entailed a "Tower of Babel" challenge: namely, the absence of a shared framework and language across these different professional communities – scientists, technologists and innovators rooted in public, private, academic and civil society organizations. In response, **this Guidebook is designed to facilitate the development of STI for SDGs Roadmaps by providing a framework, common language and step-by-step advice** for practical policymaking and communication purposes.

This Guidebook is intended for interested national and local governments, agencies and institutions that wish to use roadmaps as a policy tool to harness STI as a means to achieve the SDGs. It may also be of interest to stakeholders taking part in the dialogue – an essential stage in design, implementation, monitoring and adjustment of the STI for SDGs Roadmaps – and to a wider public audience wishing to advance global and national SDG agendas. The Guidebook first focuses on the design stage of the roadmaps, demonstrating that the design underpins effective implementation and monitoring.

2 *Other concerns often discussed at the United Nations and other international forums relate to ethical, security (both cyber and physical, such as autonomous weaponry) and human rights aspects, not necessarily within the scope of the SDGs.*

Box 1.1

Concepts and Definitions[3]

Science, technology and innovation are three different domains, each associated with a distinct set of actors, although there are strong relationships among them.

- **Science is fundamentally the pursuit of knowledge through systematic studies of the structure and behaviour of the physical and natural world and societies.** Scientists or researchers across public and private institutes are the key actors, often organized and represented through academies of sciences, professional societies, universities or other research institutions. Governments typically have a ministry responsible for science policies, and funding agencies administering research programmes.

- **Technology is the practical application of knowledge for a given end.** Publicly funded scientists conducting applied research, as well as private sector scientists, engineers and product/service developers, are the key actors in developing and applying new technologies. Meanwhile, broader actors within industries and government line ministries disseminate, adopt or adapt existing technologies, for use in fields such as agriculture, health, energy, education, defence, infrastructure and environment.

- **Innovation is a new way of producing, delivering or using goods and services, based on new technology, or through new business models or forms of economic or social organization.** While also applicable to public administration and service delivery, innovation has so far been largely a private sector undertaking by industries and entrepreneurs, farmers and individuals who develop better ways of producing or using goods and services. The current waves of social innovation and community-based innovation (such as indigenous solutions) are calling for a new understanding of this phenomenon.

In the past, innovation was seen as a linear process to turn scientific discoveries into commercial applications of new technologies. From policymakers' perspectives, the fields of science, technology and innovation were typically considered highly specialized domains. They were left to experts who were often facing challenging political, administrative and budgetary environments, as well as inherent uncertainties and long timeframes. In some developing country contexts, STI has also been regarded as an unaffordable "luxury".

Today, policymakers have a more mature understanding of STI and approaches to STI policies (as reflected in the rest of this Guidebook). Many governments have interministerial mechanisms, such as national STI councils or commissions, which provide a favourable environment for multi-stakeholder dialogue, planning for a coherent STI policy mix, and coordination and interface with the implementation of sectoral policies. Yet, in many countries, the focus of STI policy is still transitioning from predominantly scientific and economic objectives towards achieving a closer integration with broader social and environmental aspirations in line with the SDGs. (See ***Table 2.1*** for a broader discussion of different types of innovation.)

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3 There are many definitions of innovation. See, for example, the Oslo Manual on innovation (OECD/Eurostat, 2018); UNCTAD, 2017 and 2019; Cirera and Maloney, 2017. For this Guidebook, we have adopted a broad definition including many types; see ***Table 2.1*** *on page 42.*

1.2 Rationale of STI for SDGs Roadmaps

The rationale behind creating realistic and action-oriented STI for SDGs Roadmaps is to speed up the process of developing new, or adapting existing, solutions in time to meet the SDGs and targets by 2030, and to ensure that the three dimensions of sustainability are properly addressed (***Box 1.2***).

STI for SDGs Roadmaps are not created in a vacuum. Most countries already have or are developing their infrastructure and capabilities for research, development and innovation. However, there has so far been a shortage of systematic assessment and discussion of national and international experiences in developing and implementing policies, action plans and strategies on STI specifically for SDGs, using systemic and consistent frameworks.

Three related policy frameworks provide a national context for STI for SDGs Roadmaps:

1. **National Development Plan.** Most countries have developed some national plans and industry policies (occasionally framed as a growth strategy), with varying levels of detail and usefulness.

2. **National STI Plan.** These vary widely in scope, as well as in the degree to which they directly relate to the national development plans. Sometimes they are conceived independently of national development plans, mostly by science and technology ministries. In other cases, they are more closely aligned with national development plans.

3. **National SDGs Plan.** Since the global agreement on the United Nations Sustainable Development Goals in 2015, countries have also begun drawing up plans on how to reach these Goals and specific targets, and many are explicitly including them in their national development plans. Developed countries tend to have strategies to guide development cooperation in line with the SDGs.

These three generic, yet distinct, types of plan may or may not have areas of overlap. The focus of this Guidebook is to encourage greater use of STI to help meet the SDGs in all three types of plan – the intersection of the three circles. The basic proposition is that STI can accelerate the attainment of SDGs if it is properly integrated into plans to achieve the SDGs.

STI for SDGs Roadmaps may be stand-alone documents, or part of other planning and implementation documents such as National Development Plans or STI Plans. For effective implementation, it is useful to maximize the synergies with other planning documents, to avoid duplication and reduce waste – i.e. to maximize the opportunities for convergence among the three circles.

Figure 1.1: *STI for SDGs Roadmaps as an intersection of three types of national plans*

Source: Authors

Box 1.2

Why focus on STI for SDGs Roadmaps?

Human progress has been based on advances in science, technology and innovation. This was clearly seen with the dramatic increases in growth and productivity accompanying the first industrial revolution, based on water and steam power to mechanize production. That was followed by the second industrial revolution, based on the internal combustion engine and electricity to create mass production; and by the third, based on electronics and information technology to automate production. But industrial revolutions also created pressure on the environment and entailed social costs such as disruption of traditional life and increased inequality within countries, and there was also a great divergence in uptake between countries that led these revolutions and the developing world.

We now realize the need to also consider social and environmental aspects in development strategies, as reflected in the SDGs. We are also entering a new period of rapid development and convergence of emerging technologies in the physical, digital and biological spheres, which many are calling a fourth industrial revolution (World Economic Forum, 2016). These emerging technologies and their convergence offer tremendous opportunities but also carry enormous risks. Developing countries are far behind in productivity because they are not fully using technologies already available in developed countries. It would seem easy for developing countries just to import technology from developed countries to catch up rapidly. However, persistent large productivity gaps indicate that it is much more complicated, as this creates issues of dependency and lack of development of endogenous potential as a basis for long-term growth.

Historically, some countries – such as Japan and the Republic of Korea – have been very successful at technological catch-up and have become technology leaders themselves using STI as part of their development strategies. This involved explicit STI strategies, including the development of their science base, human and institutional capital, and effective government policies working closely with the private sector to build firms' capabilities and to foster rapid adoption of foreign technologies and their domestic dissemination. Developing countries such as China and India have been explicitly including STI in their development strategies for achieving rapid growth, and are now also focusing on inclusiveness and environmental sustainability.

Developing countries need to establish effective strategies to use STI to further their economic and social development to achieve the SDGs. They need to take advantage of technologies that already exist, make effective use of the potential offered by new emerging technologies, and also mitigate the risks they present. That is why it is so critical to develop effective STI for SDGs Roadmaps and why the highest levels of government need to be involved in developing and implementing these strategies.

1.3 Need for strengthened international partnerships on STI for SDGs

Few countries will be able to achieve the SDGs through business as usual. Continuation of the current pace of poverty reduction (SDG 1, target 1.1) is likely to leave 23 per cent of the African population below the poverty line by 2030[4] (***Figure 1.2***). Many countries are also going to fall far short of other goals.[5] Effective use of STI may change the trajectory and accelerate progress towards the future we want, particularly if developing countries are able to benefit further from international partnerships. For example, the M-Pesa mobile money service in Kenya, which increased financial inclusion from less than 30 per cent in 2006 to 90 per cent in 2019, was partly made possible by a grant from the UK Department for International Development (DFID) to a private company.[6] Given the limited maturity of national innovation systems in developing countries and their low institutional capability, there is much that can be done by the international community in partnership with developing countries to use STI inputs to make progress towards the SDGs.

However, the climate for international cooperation is worsening. There are many reasons for this, including the global slowdown in growth, the decline in overall development aid and diversion of development funds to humanitarian emergencies, the downsizing of operations by cash-strapped United Nations agencies, and increased skepticism towards multilateralism. Sudden crises, such as the recent COVID 19 global emergency, clearly show the need for international cooperation, especially in the STI domains, to find evidence-based solutions and to build robust STI systems that can respond to such crises.

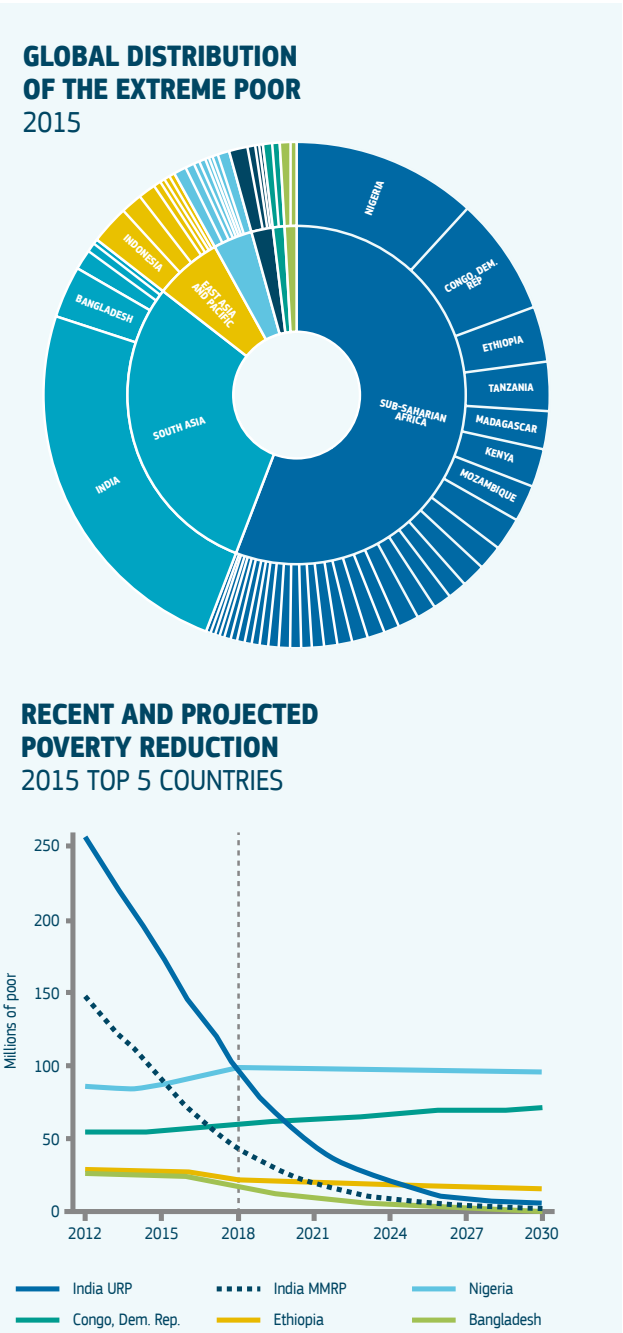

Figure 1.2: *Business as usual will leave Africa further behind*

Source: World Bank (2018a)

4 *World Bank (2018a), Poverty and Shared Prosperity 2018*

5 *See the United Nations Secretary-General's assessment of four-year progress towards the Sustainable Development Goals. Available at* ***https://undocs.org/E/2019/68***

6 *M-Pesa, and other case studies, are described in the background paper on pilot countries.*

In addition, looking forwards there are many trends that will increasingly challenge our ability to achieve the SDGs.[7] These include climate change and extreme weather; rapid environmental depletion (particularly of water and air quality) and deforestation; global pandemics; erosion of trust in government and international institutions; increasing inequality within and between the richest and poorest nations;[8] further slowdown in global economic growth; the risk of new global financial crises; great competition for power and the risks of regional frictions escalating into conflicts; and the increasing rate of technological change and innovation, bringing many opportunities but also many challenges (see ***Box 1.3***).

There are many opportunities for the international community to improve coordination, coherence and complementarity of development assistance to effectively harness STI for SDGs. Countries can join forces in regional or global efforts to exploit comparative advantages and pursue economies of scale. International partnerships on STI for SDGs can be strengthened in the following three ways:

- **Build** capacity of countries' STI ecosystems, which includes designing and implementing STI for SDGs Roadmaps.
- **Boost** international flow and supply of STI, which includes finding synergies and filling gaps in implementation of STI for SDGs Roadmaps.
- **Broker** STI coalitions to meet the Global Goals, which includes provision of STI global public goods.

This Guidebook reviews a landscape of international STI opportunities and challenges in the context of the SDGs and provides a set of guidelines on how developing and developed countries can participate in and benefit from international partnerships.

7 *See: Global Sustainable Development Report (GSDR), 2019; International Institute for Applied Systems Analysis (IIASA, 2018) which argues that "humanity is at a crossroads. Unbounded growth is endangering planetary support systems and increasing inequalities, the rich are getting richer and the poor even poorer."*

8 *The United Nations Development Programme (UNDP) Human Development Report 2019 points out that income measures of inequality are misleading because they do not consider other critical dimensions of well being or the underlying causes of inequality. It argues that is necessary to look beyond income inequality, beyond averages and beyond today. While the gap in basic living standards has been narrowing, a new generation of inequalities is opening up in education, technology and climate change, that unchecked could trigger a "new great divergence" in society of a kind not seen since the industrial revolutions.*

Box 1.3

Challenges and opportunities of emerging technologies for developing countries

A high number of both existing and emerging technologies present not only many opportunities, but also many challenges, for developing countries in meeting the SDGs. They are the result of rapid advances in science and technology. They include digital technologies (such as the Internet, artificial intelligence, robotics, remote sensing, big data analytics, block chain and 3D printing), nanotechnology, new materials and biotechnology (OECD, 2017). Moreover, there is increasing convergence among these technologies, largely facilitated by advances in digital technologies (IIASA, 2019). This is speeding up the rate of technological change, as well as the way research and innovation are done (OECD, 2018). Many new technologies already available offer opportunities for leapfrogging, as well as for reducing the cost of providing better goods and services and improving how they are delivered and used. Rapid advances will continue and will open up even more livelihood and welfare opportunities for people in developing countries. However, the rapid advances in these emerging technologies also raise many challenges. The main challenges and opportunities for developing countries include the following.

1. They may not be able to absorb many of these technologies because they lack many of the complementary factors necessary for their successful deployment and use. Thus, there is a considerable risk that they will fall further behind high-income countries.

2. Some of these technologies, such as Industry 4.0, will erode their export competitiveness based on low cost labour alone, as labour will become a very small share of total costs.

3. The development of higher productivity agriculture, as well as new synthetic materials in advanced countries, may reduce demand for developing country exports of agricultural products and raw materials.

4. Besides the loss of jobs through competition from advanced countries, the new technologies may reduce net demand for labour, although also creating new job opportunities. This means that there may not be enough jobs for the growing labour forces in most developing countries (especially in sub-Saharan Africa and South Asia), which may lead to increased social instability.

5. The use of many of these emerging technologies tends to increase income inequality, because the benefits go to those who have complementary assets (such as higher education and access to finance) to make use of them, while poorer segments of the population are left behind.

6. The advance of digital technologies is raising many complex issues, and developing countries are at a disadvantage by not being at the centre of global discussion about how to address them. These issues include data ownership (critically important as data has become a crucial new asset for competitiveness), data privacy, data security, the advantages that captive data gives to giant global data players (such as Facebook, Google, Amazon, Baidu, Tencent, credit card and finance companies), cross-border

data flows, and the regulatory and governance issues surrounding the new forms of competition enabled by first-mover advantage on Internet-based platforms.

7. There is huge potential for endogenous innovation and technological development in developing countries. This can be used to build internal capacities to absorb and adapt the existing technologies and develop new solutions targeted to the specific needs of each country.

Developing countries need to strengthen their STI capabilities and use their entrepreneurial potential to take advantage of these opportunities, while anticipating and building capacity to respond to the challenges. They should also develop their own technological capacity to build resilience to the challenges in the long term. For a more detailed discussion of the trends and implications for achieving the SDGs, see Global Sustainable Development Report (2019), IIASA (2018; 2019), Pathways for Prosperity Commission (2018a; 2018b; 2019) and OECD (2017). For more general impact on the prospects for developing countries, see Weber (2017), Hallward-Driemeier and Nayyar (2018), World Economic Forum (2020), McKinsey Global Institute (2020) and Daniels and Tilmes (2020).

1.4 Key elements of an STI for SDGs Roadmap

For the purpose of this Guidebook, an STI for SDGs Roadmap is defined as a forward-looking policy framework, action plan and/or strategy, to continuously guide effective actions that utilize STI to achieve the SDGs with a country-wide scope, including at national and subnational levels, also with implications at the international level. The main characteristics of an STI for SDGs Roadmap, as discussed through STI Forums and related deliberations, include the following.

- **Goal-driven, focused and prioritized**, ensuring alignment with the 2030 Agenda and with a strategic focus on the impact of interventions to accelerate progress and address gaps.
- **Informed by evidence, experience and foresight,** through retrospective STI ecosystem diagnostics or policy reviews, analysis of country-specific challenges or priorities in achieving the SDGs, and assessment of critical contributions from STI, practice-based peer learning and/or modelling and scenario building on technological changes and their socioeconomic impacts.
- **Financed, localized and action-oriented**, taking into account the specific contexts at different territorial levels, (re-)allocating budgetary or other resources, building policy and implementation capacities, improving predictability, incentivizing contributions from key stakeholders, and defining explicit milestones.
- **Coherent and owned by key actors** through multi-stakeholder engagement in design and implementation, having adequate governance structure, reflecting sector-specific deep dives in line with national development priorities, considering synergies and trade-offs, and strengthening enabling STI environments through policy and institutional reforms.
- **Dynamic**, based on learning and course correction through the definition of milestones and measures of success, monitoring and eval-

uation of progress, and informing necessary adjustments including international efforts.

This Guidebook aims to provide general and adaptable guidance, as well as documenting the early experiences of champion countries to foster peer learning and help further refine methodologies and guidance. The specific pathways countries can take towards harnessing STI to achieve the SDGs will differ, depending on their level of development and existing resources and capabilities.

The guidance included in this publication should be treated as general advice that must always be adapted to specific conditions and capacities, including political, social and administrative circumstances. It is not the ambition of the authors to provide a full scientific outlook or theoretical discourse on STI for SDGs, but rather to focus on practical recommendations that can facilitate the concrete process of developing and implementing the roadmaps.

1.5 Structure of the Guidebook

Following this introduction, *Chapter 2* of the Guidebook provides **step-by-step guidance to developing and implementing national STI for SDGs Roadmaps**, targeting policymakers in countries at different levels of development, with special attention to developing countries.

Chapter 3 describes **international partnerships to facilitate effective design and implementation of STI for SDGs Roadmaps**, based on a broad characterization of the global STI system. This chapter targets policymakers in both developing and developed countries, while addressing other international stakeholders who may participate in partnerships related to STI for SDGs.

Chapter 4 concludes with key messages, summary assessments of remaining challenges given the limitations of the proposed approaches to STI for SDGs Roadmaps, and **recommendations for the international community** in stepping up efforts on STI for SDGs through the next cycle of follow-up and review of the SDGs.

CHAPTER 2.

Towards National STI for SDGs Roadmaps[9]

[9] *This chapter has benefited from extensive oral and written comments received during expert group meetings in 2018 and 2019, as well as the 2019 STI Forum.*

The objective of this chapter is to provide a conceptual framework and propose step-by-step guidelines for developing national STI for SDGs Roadmaps. These roadmaps differ from STI strategies in three ways. Firstly, they focus not just on STI strategies for economic competitiveness and growth, but explicitly include a focus on STI for social and environmental objectives as these are central elements of the SDGs. Secondly, STI is not just science, technology and R&D-based innovation. Instead, it is used in a broader sense that goes beyond R&D-based innovation to include non-technical, indigenous, grassroots, organizational and social innovation (see broad coverage in ***Table 2.1***). Thirdly, as a result of this broader concept, unlike traditional STI which has focused on academic excellence measured through scientists and engineering, R&D spending, patents and productivity, the new focus is on how STI thus broadly defined can accelerate the attainment of SDGs, such as eliminating hunger, reducing income and gender inequality, protecting the environment, and promoting inclusive and sustainable development.

This chapter is structured as follows. It starts with a brief discussion about institutional set-up because there are different entry points to developing STI for SDGs Roadmaps. Then it summarizes the framework and the core inputs. The detailed step-by-step guidelines follow. The chapter concludes with some guidance on the need for countries to assess the extent to which their national innovation systems are set up to take advantage of global STI inputs.

2.1 Institutional set-up

STI for SDGs Roadmaps may be developed at the national level by a central agency or ministry in charge of national development plans, by the Ministry of Science and Technology or other agencies in charge of STI plans, or by line ministries or a specialized agency or task force with the specific mandate to develop SDG plans. ***Figure 2.1*** shows the intersection of these three groups, as well as some of the key actors within them.

Ideally, the process would be coordinated at the highest level by the President's Office, the Ministries of Planning or Finance or some other specialized high-level agency tasked with this responsibility. This, for example, is the process being followed in Kenya (***Box 2.1***). However, the initiative may also come from the Ministry of Science and Technology or its equivalent. Alternatively, the initiative in using STI to accelerate achievement of a specific SDG may be taken by a line ministry or local government as part of its SDG Plans. The key point is that, whatever its starting place, developing effective STI for SDGs Roadmaps requires interaction across a broad range of actors representing different parts of government, academia, industries, entrepreneurs, civil society, development partners and other stakeholders.

Regardless of the starting point, this chapter presents a framework and outlines a six-step process that should be undertaken in planning the STI inputs to achieve the SDGs and targets. It should be kept in mind that the attainment of even a single SDG may require many different technologies, innovations and agents, and that the STI component is just one of the many elements (e.g. political will, finance, institutions and organizations, networks, etc.) that are required to achieve that Goal. These guidelines are generic enough that, with some adaptation to the specific context, they should be useful whether the STI for SDGs Roadmap is a stand-alone document or part of a national development plan, sectoral development plan or STI plan that also targets SDGs. ***Chapter 3*** outlines the steps that both recipient countries and donor countries should consider in developing international partnerships using STI to help achieve the SDGs in developing countries.[10]

10 *A companion background paper for this chapter summarizes diagnostic methodologies and tools from different countries for needs and gap assessments, and provides analysis of initial voluntary national STI for SDGs Roadmaps, as well as of the international STI system and its relationship to national roadmaps.*

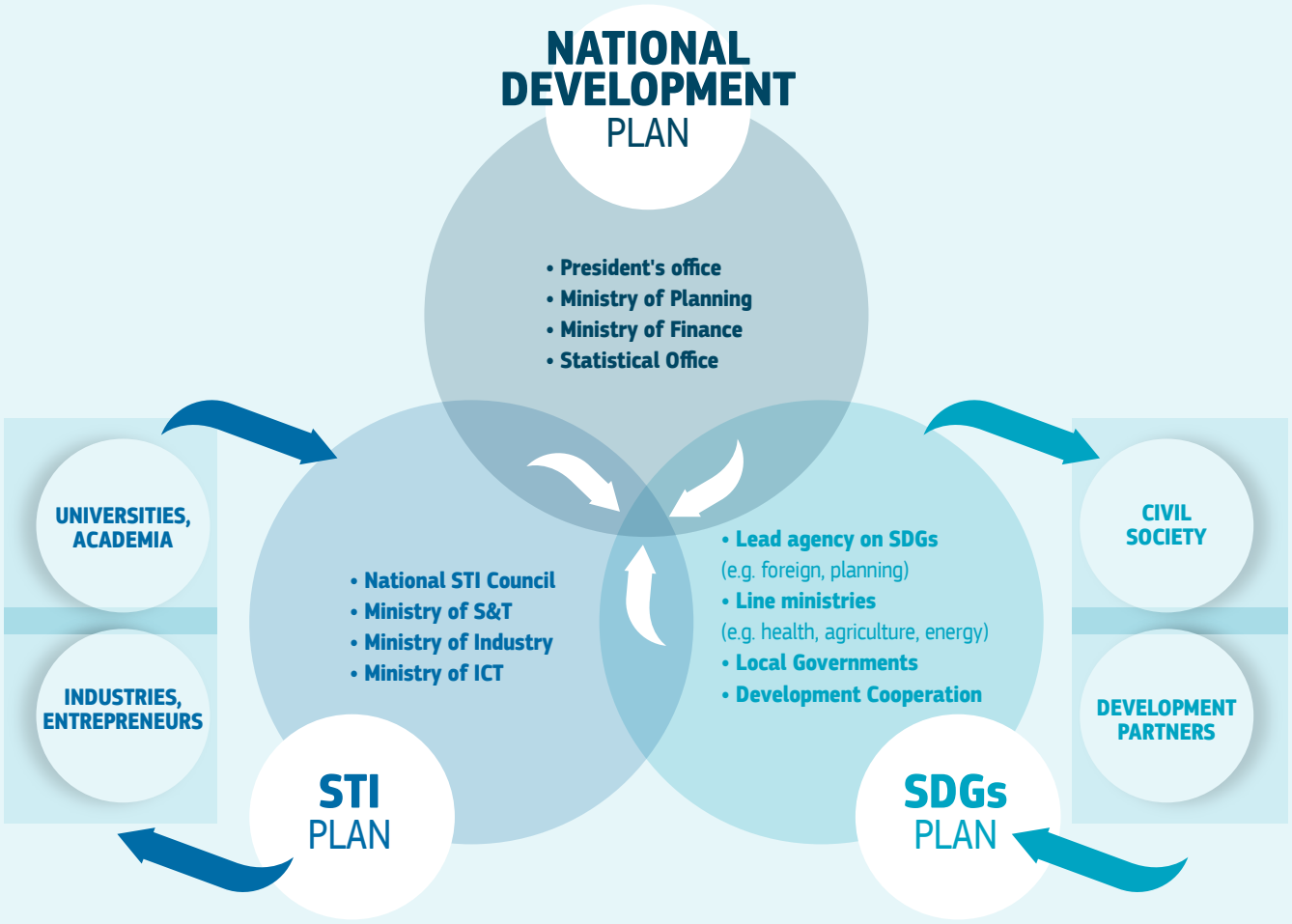

Figure 2.1: *Intersection of Development, STI and SDG Plans and key actors*

Source: Authors

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Box 2.1

An early pilot experience of national STI for SDGs Roadmaps – Kenya

As part of the United Nations Global Pilot Programme on STI for SDGs Roadmaps, Kenya has recently launched an inter-agency committee to develop and implement STI for SDGs Roadmaps. Kenya's approach includes promising characteristics such as the following.

- **Institutional arrangement integrating supply and demand sides of STI for SDGs.** The pilot is owned by the National Treasury, State Department for Planning, jointly with the State Department of ICT, State Department of University Education, Science and Technology, and Ministry of Foreign Affairs, and implemented through the National Commission for Science, Technology and Innovation (NACOSTI). The inter-agency committee invites contributions by line ministries, such as the Ministry of Agriculture, Ministry of Health and Ministry of Industry.

- **Policy frameworks.** The STI for SDGs Roadmap is building on Kenya's SDGs Roadmaps (under Treasury) and STI Policy (undergoing finalization at Ministry of Education), contributing to the current administration's Big Four Agenda, and aligned in scope with the African Digital Transformation Strategy (African Union).

- **Support from international organizations.** The pilot design is supported by diagnostic inputs and capacity building from United Nations agencies. These include the World Bank (on the effectiveness and efficiency of the government's STI policies, programmes and budget, as well as incoming development cooperation as related to STI) and UNESCO (on the assessment of STI system functioning in the context of the Treasury's and county governments' SDGs gap analysis at national and subnational levels, and gender-inclusive STI policy implementation). These diagnostics are expected to stimulate dialogue among policymakers, academia, private sector and civil society towards collective visioning and planning in directing policy actions, to improve STI contributions to filling the critical gaps in achieving the targeted SDGs.

The first phase of Kenya's pilot roadmap will focus on technological innovations that enhance agricultural productivity for food security, manufacturing (in the context of agro-processing), and delivery of universal health care services, including increased health coverage, disease diagnosis and treatment. These are three components of the Big Four Agenda (the fourth being housing) that contribute to attaining targets under several SDGs. The aim of this first phase is to launch implementable action plans over the coming months in 2020, supported by the African Center for Technology Studies (ACTS) as a knowledge carrier to codify and disseminate lessons to other African countries.

As part of the initial consultations, the World Bank and the Government of Kenya organized a digital agriculture start-up competition in March 2019, synergizing with the fourth Expert Group Meeting on STI for SDGs. Key points that emerged from policy discussion included the need to strengthen links between relevant ministries and countries after devolution; the need for coherent frameworks for data sharing and protection; the

need to invest in human capital and onboard younger or new generation policy practitioners; and the need to strengthen the voice of the domestic scientific community in the face of challenging policy choices.

Source: Government of Kenya, Enhancing the Utilization of Science, Technology and Innovation for the Realization of Sustainable Development Goals in Kenya: Concept Note – the Pilot Programme on STI for SDGs Roadmaps.

2.2 The framework

Figure 2.2 presents a stylized framework for developing STI for SDGs Roadmaps as a series of six sequential steps, plus a set of three core inputs that are depicted in the central hexagon supporting all the steps. The six stylized steps are:

1. Define objectives and scope
2. Assess current situation
3. Develop vision, goals and targets
4. Assess alternative pathways
5. Develop detailed STI for SDGs Roadmaps for implementation
6. Execute, monitor, evaluate and update plan

The framework is stylized because the steps do not necessarily have to be in the sequence outlined, since there are strong interactive effects among the different steps. In addition, the framework has been presented as a circle because the roadmaps need to be continually updated based on evaluation of what is and is not working, and allow for new developments that may affect what is possible (e.g. the development of new technologies). The link between Step 6 and the beginning of the cycle is typically missing in most plans although it is critical, particularly in these times where there are so many changes in the global environment, from trade to severe weather events, as well as the rapid development of new disruptive technologies. Three core inputs – stakeholder consultations, technical and managerial expertise, and data and evidence base – are critical to all the steps.

The objective of this Guidebook is to help policymakers to think and work their way systematically through the key elements that need to be considered in harnessing the potential of STI to achieve the SDGs earlier or more efficiently. The steps outlined are for SDGs or targets that the government decides to address. As previously noted, the STI for SDGs Roadmap does not necessarily have to be independent or self-contained. It should actually be a key element in a national development plan or sectoral development plan being implemented by the government. It may also be part of STI plans, where the focus is on how STI can help accelerate attainment of the SDGs. The key is that the roadmap is a systematic approach to how STI can be used to accelerate achievement of the Goals and coordinate implementation. Some methodologies available from different international organizations can be used to support different steps in developing the roadmap.

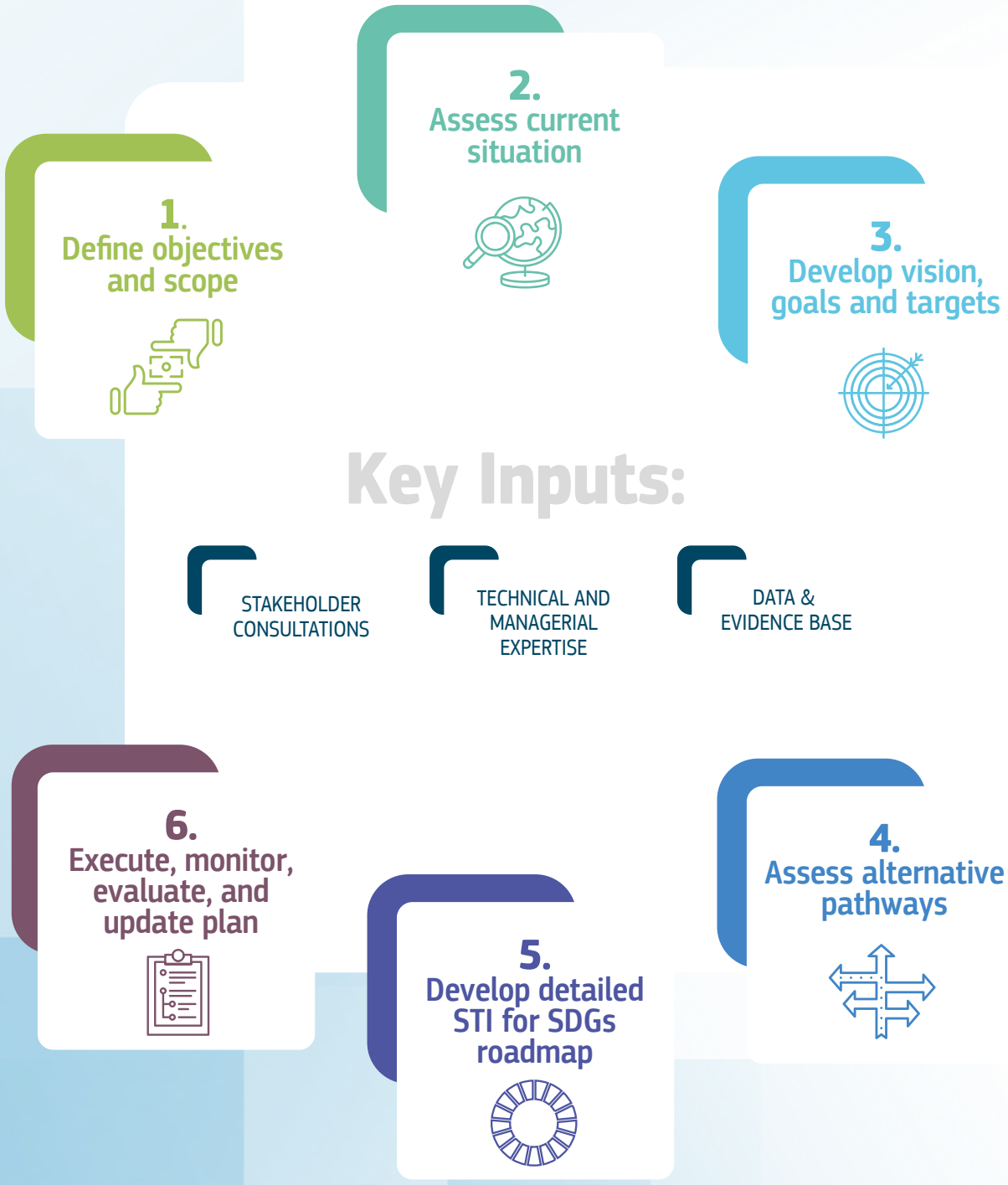
In addition, it is important to be aware that there are three levels to the framework (***Figure 2.3***). The first level is the subnational level, since roadmaps have to be tailored to the specific local context.[11] This is particularly important for large countries, since the context varies widely among regions within a country, and it is important to aim at inclusiveness. The second level is the national level, which is the main focus of this chapter. It assumes that this already aggregates inputs from the subnational levels, which would follow a similar step-by-step process. The third level is the international level. As indicated in ***Figure 2.3***, key inputs coordinated across different levels should constitute a collective policy learning environment, as further developed in the next chapter.[12]

11 *STI for SDGs Roadmaps can also be created at the institutional level for professional societies, such as the National Science Council, or National Academy of Science or Engineering, to help the institution identify how it may best contribute to achieving some specific SDGs to which it can bring its STI expertise. This was emphasized in the InterAcademy Partnership study,* Improving Scientific Input to Global Policymaking with a Focus on the UN Sustainable Development Goals, ***https://www.interacademies.org/50429/SDGs Report***.

12 *In addition, there can be multi-country regional roadmaps, such as for the African Union. This will require coordination among the country governments participating, as well as with the bilateral or multilateral agencies, international private sector and NGOs involved.*

Figure 2.2

Flowchart of six key steps in developing STI for SDGs roadmaps



Source: Developed by authors based on analysis of background material and selected countries

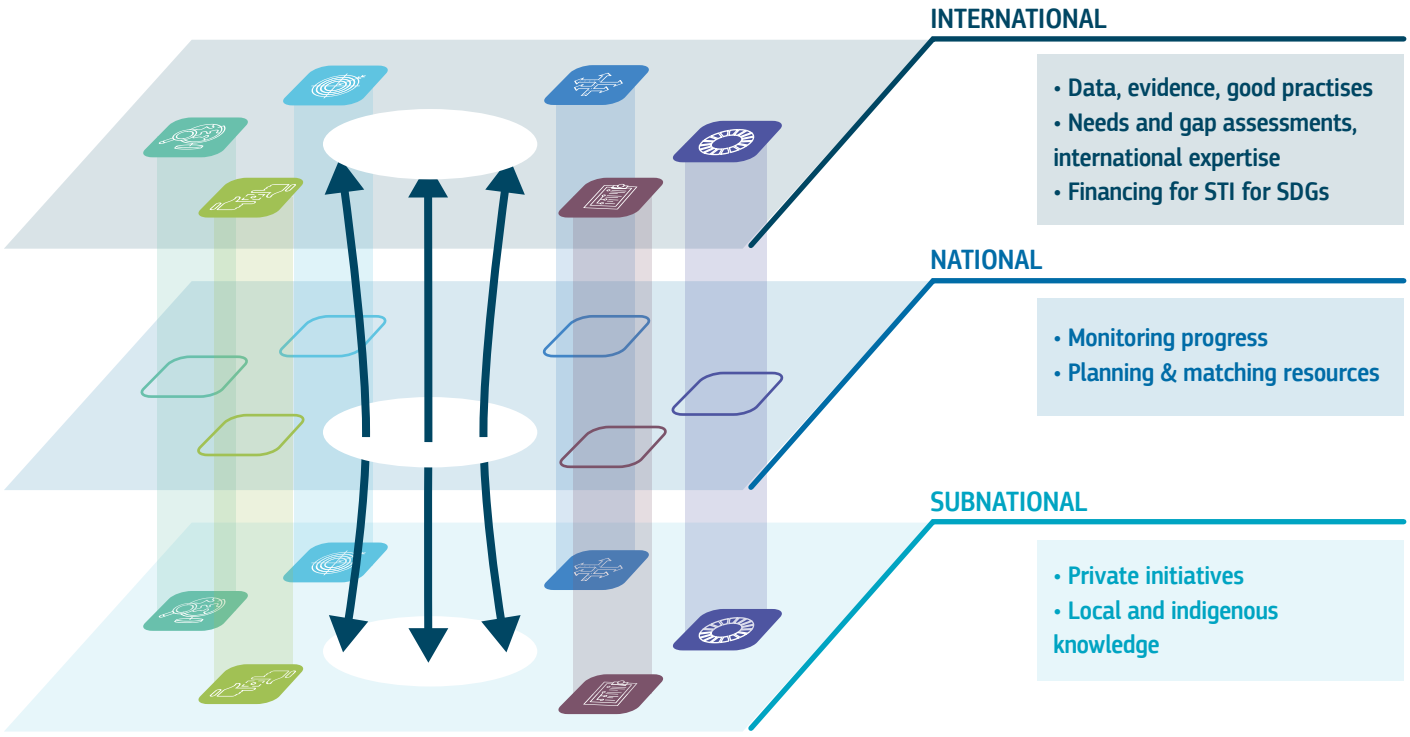


Figure 2.3: *Three levels of STI For SDGs Roadmaps*

Source: Authors

2.3 The core inputs

Although the three core inputs are quite obvious, many STI for SDGs Roadmaps are developed without sufficient attention to them.

STAKEHOLDER CONSULTATIONS

Although the way stakeholder consultations are done may vary across countries, depending on the type of political system and how top-down or bottom-up their policy decision process is, it is an important input for virtually all the steps because of the need to gain stakeholder perspectives and to aim for stakeholder alignment. The broader the scope of the plan, the greater the need to involve all stakeholders to receive input on their needs and priorities. This should be done in a participative way, where stakeholders (from private sector, academia and civil society) are treated as partners and co-creators of the roadmaps. In addition, the consultation process can help to align conflicting interests and improve buy-in from different stakeholders for implementation and monitoring.

A significant risk in developing the roadmap is that the process may be captured and heavily influenced by vested interests. These may be particular groups within governments, or powerful business or political lobbies. To guard against this, those managing the development of the roadmap need to make sure that relevant stakeholders, including those that may be affected, can participate in the discussions, to represent the different views and to keep the process clear and transparent. The methodologies available to involve stakeholders throughout the roadmap process include Smart Specialisation (European Union Joint Research Centre – EU JRC), Science, Technology and Innovation Policy – STIP (UNCTAD) and TIP (Transformative Innovation Policy Consortium – TIPC).

TECHNICAL AND MANAGERIAL EXPERTISE

Expertise, including on scientific, technical, managerial and even political dimensions, is a critical input to define not only objectives and scope, but to assess the current situation and in particular to assess alternative pathways. Expertise, especially on political aspects, is also very important in developing the vision, goals and targets. It is fundamental for developing the specifics of STI input into the SDGs roadmaps, including who does what, how much it will cost, what capabilities are required by the agencies or individuals in charge of different aspects, and what milestones should be set at what points. It is also critical for monitoring progress on implementation of the plan, and even more so for evaluating what is or is not working, what the main obstacles are, how they can be overcome, and how the plan should be updated in light of changes to the context as well as the development of new technologies.

International experts, and assistance from international institutions with experience in analysing SDG gaps and the role of STI in helping to close them, can play a very useful role. The overview of approaches and experience available can be found in the later part of this chapter. Some examples are illustrated with details in the *Background Paper, Overview of the existing STI for SDGs roadmapping methodologies*[13], which offers a wealth of experience and competence that could be very useful at different stages of the roadmap process and depending on needs. The experience of other countries in developing and implementing STI for SDGs Roadmaps is also highly valuable, so there should be systematic efforts to develop communities of practice to foster the exchange of relevant experience and expertise among countries and regions.

On the expertise side, there is also the risk that the process may be captured by particular lobbies who potentially see the roadmaps as a pathway for resourcing specific projects in technological development programmes. The best way to manage this is to seek expert input from a broad enough group of experts and stakeholders with hands-on experience to weigh in on the value of different approaches and specific projects.

DATA AND EVIDENCE BASE

The data and evidence base refers to underlying data and knowledge on the development situation in the country or sector, the current and possible future development of technology, and its applicability to the country. It also includes information on how implementation of the plan is going, both in terms of inputs and outputs, and what specific indicators should be monitored. Other useful data sources are qualitative information on all of the above, as well as information on obstacles or problems in implementation, etc. This input also includes information on the changing context and the potential positive or negative impact of new technologies on the plan. Without well-developed data, it is hard to set priorities, monitor progress and evaluate results.

While general statistical agencies may collect a lot of data, some careful thought needs to be given to what specific types of data and information need to be collected and analysed in order to develop, implement and monitor the roadmap. In many developing countries, data are poor or unavailable. For this reason, one of the first activities that may need to be built into development of the roadmap is data collection and the capability to assess that data. This needs to be supplemented by expert judgment on relevant domestic data, and international data and global trends relevant to the country. Examples of data used in existing approaches and methodologies can be found at the end of the chapter – most of the methodologies available offer excellent tools for assessing the current situation, together with databases and knowledge repositories that can be helpful in the roadmap process. With the advent of increasing digitalization of all kinds of information, as well as better

13 *Matusiak, M., Ciampi Stancova, K., Dosso, M., Daniels, C. and Miedziński, M., Background paper: Overview of the existing STI for SDGs roadmapping methodologies, Publications Office of the European Union, Luxembourg, 2020, JRC123628.*

geospatial mapping tools, in many instances it is possible to use new digital data to provide some of the information that may not be readily available through conventional methods.[14] In addition, there is a need to develop systems to integrate multiple data streams and to channel the data aggregates to decision makers at different levels.[15]

14 *See, for example, the presentation by Dr Xu Zhengzhong on 27 November 2018 at the third Expert Group Meeting on roadmaps in Brussels. See also UNCTAD (2017) on digital tools such as big data and artificial intelligence to support foresight analysis.*

15 *The United Nations Technology Facilitation Mechanism has an extensive reference list for developing roadmaps, which includes not only United Nations agencies but other international and bilateral agencies.*

2.4 The six steps

Step 1.

Define objectives and scope[16]

What is the objective of the roadmap?

STI for SDGs Roadmaps can have many objectives, regardless of whether they are stand-alone documents or part of other planning and implementation documents. Is the objective of this roadmap primarily to help build consensus on a vision, or to develop the details of the roadmap? If it is the former, more effort will need to be devoted to creating that consensus through greater stakeholder involvement and advocacy. But even if it is the latter, it is still necessary to involve those who are expected to be part of implementation, or who will be affected by the roadmap, in the discussions in order to align actions and ensure buy-in. The process of developing the roadmap and building stakeholder alignment is often one of the most valuable aspects of the roadmap, as it facilitates the consideration and integration of perspectives and the involvement of institutions and agents that are critical for successful implementation.

The organization developing the roadmap also needs to consider various practical details. These include ensuring leadership commitment, appointing a steering committee whose members have knowledge and authority to make decisions regarding the scope and boundaries of the exercise, as well as considering how broadly to consult and the types of organizations and experts who are expected to participate in developing the plan. Ideally, the whole process should be endorsed and led by the highest level of government. ***Box 1.2*** presented a rationale for why developing STI for SDGs Roadmaps should be of interest to the President's Office and the Ministries of Finance and Planning.

What is the scope?

Is this a national STI for SDGs Roadmap, a roadmap for the Ministry of Science and Technology to leverage STI to accelerate attainment of the SDGs, a deep dive on one sector or issue, or a subnational roadmap? Is it focusing on a cross-sectoral challenge or a mission-oriented exercise? Is the scope a broad set of SDGs, or is it focused on a single SDG or sector? (See Background Paper for useful references to sectoral roadmaps such as agriculture, education, energy, environment, health, ICT, oceans, STI and water.)

Here it is worth noting that there can be important synergies, as well as trade-offs, between different SDGs. The Independent Group of Scientists commissioned by the Secretary-General of the United Nations has conducted an exhaustive analysis of the SDGs and made an important argument that the Goals are all interrelated and need to be tackled simultaneously in order to take advantage of synergies and offset trade-offs. They have identified six entry points that take account of these interrelationships, as well as four levers that can facilitate implementation of the entry points (see ***Box 2.2***).[17] Thus, it is important to consider these in deciding the scope of the roadmap. Various methodologies are being developed to help countries examine some of those synergies and trade-offs, determine which Goals to focus on, and work towards attaining them most effectively (See ***Box 2.3*** for an example).

16 *For more guidance on initial planning and preparation, see Technology Executive Committee (2013).*

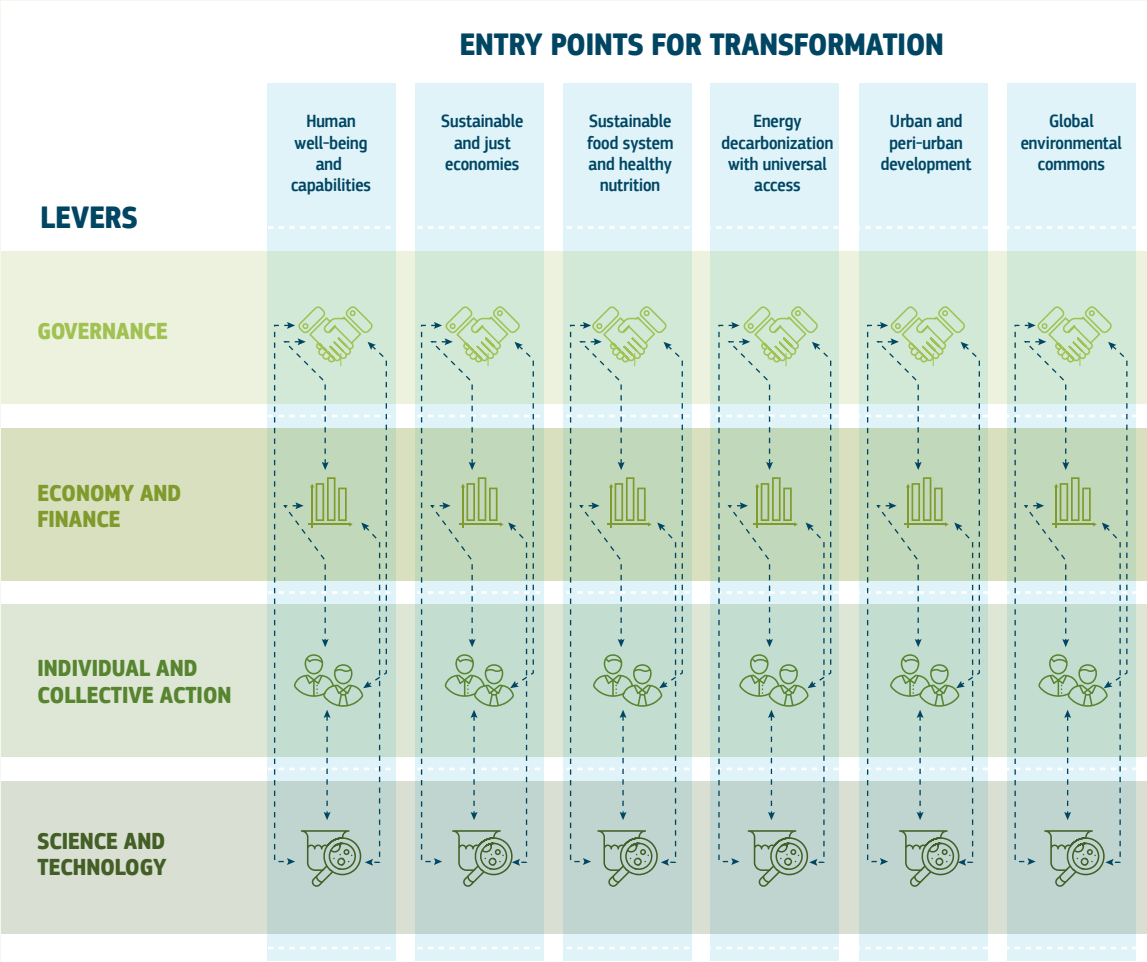
17 *IIASA's The World in 2050 report (2018) has also convincingly pointed out that there are strong synergies as well as trade-offs across SDGs. They have grouped the SDGs into six key transformations that have to be accomplished to achieve sustainable development: human capacity and demography; consumption and production; decarbonization and energy; food, biosphere and water; smart cities; and digital revolution (IIASA, 2018).*

Box 2.2

Key Insights and recommendations from the Global Sustainable Development Report

The first four-year Global Sustainable Development Report (Independent Group of Scientists, 2019), produced by a group of 15 eminent scientists appointed by the Secretary-General of the United Nations, is an exhaustive science-based "assessment of assessments" of the transformations necessary to meet the SDGs. A key insight is that "although we are not on track to reach many Sustainable Development Goal targets ... there is enough scientific evidence to indicate the ways forward ... accelerated results over the next 10 years are possible, but only through an approach that builds on a truly systemic understanding of the indivisible and universal 2030 Agenda ... [and] only if we intentionally address the inherent trade-offs among the Goals, and harness the abundant co-benefits" (p.139). It proposes six entry points that address the underlying systems behind the Goals, and four levers that can help achieve the necessary transformations towards sustainable and equitable development, as summarized in the table below.

It argues that "the entry points alone may not be sufficient, especially if actions do not adequately address global interconnections, or take full account of the non-economic,



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but intrinsic value of nature" (***p.23***). It further argues that while each of the levers can contribute to the entry points, they generally work best together, since these different dimensions need to be addressed in implementation, and the entry points and levers must be adapted to the specific situation of each country. This will require strong political leadership and novel collaboration among governments, business and academia. Therefore, countries need to start with what is politically possible, but also strive to expand the range of actions and actors over time. Furthermore, as clearly highlighted from the title of the report, *The Future is Now: Science for Achieving Sustainable Development,* action needs to start now, and science and technology have a critical role to play. Actions are necessary at both country and global levels. The global STI community needs to do much more to help apply existing STI, but also to develop new technologies that are needed to help attain the Goals. This calls for partnerships to develop greater STI capability in developing countries, as well as global coalitions to develop technologies and innovations that can help strengthen synergies and bridge some of the trade-offs across Goals and targets.

Source: Independent Group of Scientists (2019)

This issue of synergies and trade-offs is something that those developing the roadmap need to consider carefully. Roadmaps with broader scopes are more complex, as they involve many different areas which means broader sets of experts and stakeholders, involving many sectors. This will typically require broader consultation and coordination. But even single SDG roadmaps or sector focused plans can involve experts and actors with different technical skills and capabilities. For example, tackling SDG 2 (Zero hunger) may involve improved seeds, other inputs such as irrigation and fertilizer, training in the use of new technological inputs, better food storage and distribution systems, better marketing systems, improved government targeting of food supply or cash grants to ensure food reaches the poor, better information on health and nutrition, better education and skills, better jobs, etc.

Which specific SDGs and targets?

Because the 17 SDGs are so broad and cover so many targets, tackling them all simultaneously may be very difficult. Therefore, it is important for countries to think carefully about which SDGs and targets they will prioritize, and which they will tackle later as they build up capacity and experience. Presumably, this will have been done in their national development plan, but it can be supplemented in separate STI for SDGs Roadmaps. Various international agencies are creating methodologies to help countries identify where they have the largest SDG gaps, as well as where there are possible synergies. For the SDG gap analysis, benchmarking assessments such as those by Bertelsmann Stiftung and the Millennium Institute may serve as useful references.

The International Science Council has developed a mapping of linkages among SDGs 2, 3, 7 and 14 and is piloting this with the International Network for Government Science Advice (INGSA) in Jamaica.[18] In addition, the Millennium Institute's Integrated Sustainable Development Goals (iSDG) model simulates the consequences of a variety of policies influencing SDGs both individually and concurrently. Other useful tools include the Rapid Integrated

18 See ***https://council.science/publications/a-guide-to-sdg-interactions-from-science-to-implementation***

Assessment and the SDG Accelerator and Bottleneck Assessment, both developed by UNDP, which help developing countries to identify key areas that can trigger positive effects across SDGs. The European Commission has developed an interactive tool tracking interlinkages between different SDGs, which is available on the KnowSDGs Platform[19] accompanied by a dedicated publication.[20] Some other methodologies try to jointly address the economic, societal and environmental challenges faced by countries or subnational territories, at the same time taking into account the synergies and trade-offs (see Background Paper for more details).

Once the specific Goals and targets have been identified, what sources of knowledge and expertise will be needed to turn those Goals into actionable plans? This will be very important for Steps 3 to 5. As noted earlier, it will require data and a good evidence base on what works, specialized expertise, and stakeholder consultations.

How does it relate to the overall national development plan and other strategic documents?

Since most countries have broader national – as well as multiple sectoral – development plans, it is important to consider how this roadmap relates to those other plans. Ideally, the STI planning process should be part of wider planning for SDG agendas and national or sectoral development plans, so the alignment can occur more naturally. The objective of developing STI for SDGs Roadmaps is to outline concrete milestones that can accelerate achievement of the SDGs within whatever planning process countries have for this, by harnessing innovative potential and taking advantage of technological opportunities.

Most countries have begun to articulate the SDGs as part of their development plans, but few have outlined the role that STI will play in reaching those Goals, or even more importantly how STI can help to ensure that the Goals will be met. It is also important to consider how STI for SDGs Roadmaps relate to overall STI plans or sectoral development plans (the intersection of the three circles in the Venn diagram in ***Figure 2.2***), as there is the potential to improve synergies across them. From the review of country plans undertaken in preparation of this Guidebook, as well as the five ongoing country pilots,[21] it is clear that there is room for much more integration across the different plans (see Progress Report on the five pilot countries). This closer integration has the potential to leverage resources and actions, as well as to improve the efficiency and effectiveness of the actions considered in the various plans.

19 *The platform is available here:* ***https://knowsdgs.jrc.ec.europa.eu/interlinkages-visualization***

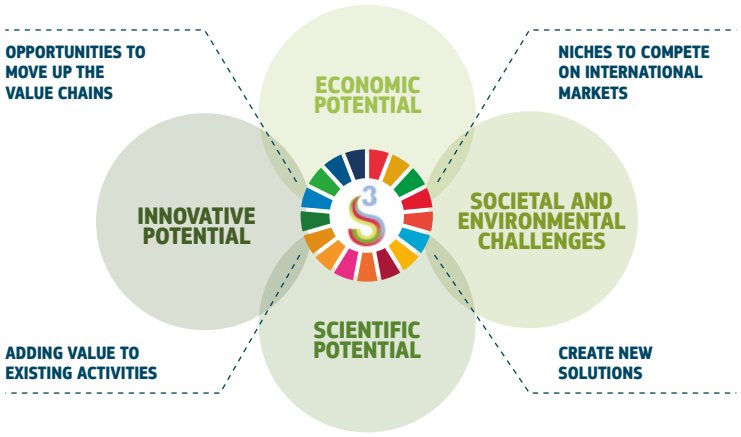
20 *European Commission (2019),* Interlinkages and policy coherence for the Sustainable Development Goals implementation: An operational method to identify trade-offs and co-benefits in a systemic way, *JRC Technical Reports.*

21 *The Guidebook is currently being piloted in five countries: Ethiopia, Ghana, Kenya, India and Serbia.*

Box 2.3

An early pilot experience in national STI for SDGs Roadmaps – Serbia

Serbia, as one of the Global Pilot countries, has decided to use the Smart Specialisation approach in developing the national STI for SDGs Roadmap. The country is being supported in this effort by the European Commission Joint Research Centre (EU JRC) and the United Nations Industrial Development Organization (UNIDO). The Serbian government has approved the Serbian Smart Specialisation Strategy in 2020.

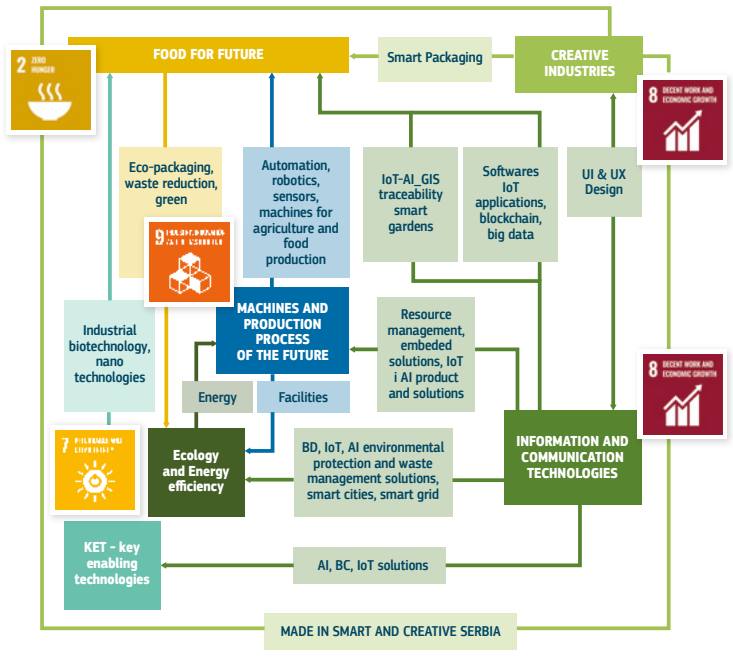


Smart Specialisation concept: Localised STI Roadmaps for SDGs

The systemic approach means that the new Roadmap is perceived from the perspective of a territory, where socioeconomic and environmental systems interact, and the resulting development and transformation challenges are jointly addressed by STI inputs. In the case of Serbia, this approach resulted in the definition of six interrelated priorities, as shown below.

Information and communication technologies	Food for Future
Custom Software Development	High Tech Agriculture
Software Solutions Development	Value Added Food products
Future Machines and Manufacturing Systems	Sustainable Agrifood Production
General and specific purpose machines	**Creative industries**
Information in the Smart Management Service - Industry 4.0	Creative audio-visual production
Smart Components and Tools	Video Games and Interactive content
	Smart Packaging
Key Enabling Technologies (KET)	
Energy Efficient and Eco-Smart Solutions	

Serbia's Smart Specialisation priorities. Vertical and Horizontal priorities and cross-innovation



Source: Serbian Smart Specialization Strategy

Including possible synergies and trade-offs between different government priorities enables the negative consequences of investing in single SDGs to be foreseen and avoided. At the same time, it is possible to scale up the efforts and build wide coalitions for the achievement of Goals and targets.

Source: Fuster Martí E., Matusiak M. (ed), 2019

Assess current situation

What is the current situation regarding the selected SDG(s) and targets?

Establishing a baseline for the country's current situation regarding the selected SDG(s) is critical to developing a successful roadmap, because it is important to know where a country is in order to set realistic goals.[22] In addition, it is necessary to assess what will impact that situation moving forward. For example, how are trends (e.g. population growth, climate change and extreme weather, water and food availability, conflict and security) likely to impact the targeted SDGs, and how may STI address or exacerbate them. This involves assessing not only SDG gaps, but how they may evolve under different scenarios. Methodologies for exploring future scenarios will be discussed in the next step. However, under this step, it is important to assess not only what the current gaps are, but how they are likely to be impacted by emerging trends, in order to understand the magnitude of the challenges and help to prioritize the Goals.

There are various methodologies that can help identify SDG gaps. These include Sachs (2018), OECD (2017) and Millennium Institute (2018). However, it is also important to assess the challenges in making significant improvements to the Goals. This requires expertise on the specifics of the country's economic, social and environmental situation,[23] as well as on what technologies are in use, how widely diffused they are, and what other technologies could be used and deployed.

For the STI component, it is also important to benchmark where a country is with respect to its overall STI system. The *Global Innovation Index* benchmarks 126 countries according to 80 indicators divided into innovation inputs and innovation outputs.[24] The World Economic Forum's Global Competitiveness Report benchmarks countries on 12 pillars, several of which are highly relevant to innovation.[25] The UNESCO Institute for Statistics is working on thematic STI indicators in six areas: STI framework conditions and governance, infrastructure for STI, human capital for STI, R&D and other S&T activities, innovation processes and outputs,

22 *DESA has an online database of the United Nations family's repository of actions, initiatives and plans on the implementation of the 2030 Agenda and the SDGs. It is available at* ***https://sustainabledevelopment.un.org/content/unsurvey/index.html****.*

23 *Such a connection is made in the updated Smart Specialisation methodology currently piloted in Serbia as part of the Global Pilot Programme.*

24 *Cornell University, INSEAD and WIPO (2018).*

25 *The World Economic Forum's Global Competitiveness Report provides indicators relevant to international competitiveness, in the context of what they call the Fourth Industrial Revolution (****http://gcr.weforum.org/****)*

and knowledge exchange and transfer.

There are also various methodologies to analyse countries' STI systems. These include the UNCTAD STIP Review Framework, the UNESCO Global Observatory of Science, Technology and Innovation Policy Instruments (GO-SPIN)[26] and the OECD Reviews of Innovation Policy. The European Union uses Smart Specialisation Strategies (Research and Innovation Strategies for Smart Specialisation – RIS3), for which it has developed very useful diagnostic methodologies to analyse a country's or region's situation and develop concrete strategies. These have now been implemented in all European Union Member States and many countries outside the European Union.[27] In addition, given limited fiscal resources, governments should review the efficiency and effectiveness of spending on STI. One methodology already available for this is the World Bank public expenditure reviews (PERs) in science, technology and innovation, which include an STI needs assessment and reviews of policy mix and of the quality of instruments (World Bank 2016).[28] There are various others, including sectoral approaches where STI is applied in the context of a specific policy (industrial, agricultural, gender, etc.), and modular approaches best suited to various steps including assessing current situation (see the Operational Note for this Guidebook and the Background Paper on methodologies).

In assessing a country's current situation, an important dimension is its progress towards gender equality as per SDG 5, which has implications for the STI for SDGs Roadmaps both as an input and an output.[29] Two thirds of the world's 750 million illiterate adults are women. In addition, women are underrepresented in STEM education, and in R&D personnel, technical publications, patenting, innovation and management. Meanwhile, women spend on average more than three times as many hours as men in unpaid care and domestic work, limiting the time they have for education, paid work and leisure; when they are paid, their wages are lower than those for men.[30] There is much room for improvement in laws, regulations and attitudes to address gender equality, as well as in the use of technology to reduce time spent on chores to give women more time for education and work, and to improve their access to education and jobs through digitally enabled access and other technologies and innovations.

What financial resources are available or can be made available to meet those Goals?

It is also important to assess whether there are enough resources available to match the needs and level of ambition for achievement of the Goals. Governments in all countries, and especially developing countries, are fiscally constrained and have multiple demands on those limited resources. What existing resources can be allocated to an STI for SDG Roadmap? What additional resources can be obtained by the government for this task? How can resources from the private sector, NGOs and civil society be leveraged for this? How can they be secured?

What capabilities are available or need to be developed to meet those Goals?

The assessment should also include what capabilities need to be developed in government, the private sector, the NGO sector and civil society to

26 *GO-SPIN launched a very useful electronic platform to assess countries' national innovation systems. It is available at* ***https://gospin.unesco.org***

27 *For details on the diagnostic tools and their application, see their online platform at* ***http://s3platform.jrc.ec.europa.eu/***

28 *In addition, the World Bank has developed a useful practitioner's guide to innovation policy, which provides helpful advice on instruments to build firm capabilities and accelerate catch-up in developing countries (Cirera and others, 2020).*

29 *On the input side, see UNESCO* Measuring Gender Equality in Science and Engineering: The SAGA Toolkit *(available at* ***http://unesdoc.unesco.org/images/0025/002597/259766e.pdf****). On the output side, see Gender Equality and Big Data, which shows how big data can be used to facilitate and assess progress on gender equality (available at* ***https://unsdg.un.org/resources/gender-equality-and-big-data-making-gender-data-visible****).*

30 *See United Nations Secretary-General's Report (UNESCO, 2019) for more details on gender inequality.*

implement the plan. What support can be obtained from abroad? What twinning and training arrangements may be possible? What skills development plans need to be included in the roadmap? This is a complex task. To accomplish it, countries should take advantage of technical expertise that can be supplied by various international agencies, including many from the United Nations system (such as DESA, UNCTAD, UNESCO, UNDP and WIPO), international organizations (such as the European Union and OECD), multilateral financial institutions (such as the World Bank, Asian Development Bank, African Development Bank, Inter-American Development Bank and European Bank for Reconstruction and Development), bilateral country programmes and NGOs, and private companies (see ***Chapter 3***).

Step 3.

Develop vision, goals and targets

There are various tools and methodologies for developing visions, goals and targets. Which to use will depend on the level of detail and depth that is desired, and on pragmatic considerations about availability of time and willingness of stakeholders to participate.

Nevertheless, regardless of what (if any) formal methodology is chosen, some of the key questions to be considered include the following.

What is the vision?

Developing a credible vision for advancing the attainment of SDGs also requires that the political leadership for the initiative understands the current situation and can set goals that are realistic in terms of resources, capabilities, technologies/innovations and timeline.[31]

How ambitious is the vision?

Countries also need to decide how ambitious to make the vision and the goals. This is a political as well as an economic decision, and it depends on how progress on the selected SDGs fits into the overall strategy, resources and capabilities of the country, and the extent to which greater STI input could accelerate attainment of that SDG. In addition, it will be dependent on social acceptance of the vision and of its key elements. For some developing countries, it also depends on the type and magnitude of foreign technical and financial assistance they may receive or can try to obtain.

How will the vision be developed and how will ownership be sought?

A practical consideration is how the vision will be developed and how ownership will be shared. Based on the experience of many countries, this will depend on the level of leadership and commitment by high-level stakeholders, and the extent to which they are involved in governance of the implementation of the roadmap. Success in obtaining stakeholder ownership will also depend on the process through which the vision is developed. Visions generated through broad consultation processes are likely to achieve greater ownership and credibility, which can facilitate implementation. However, the broader the scope of the vision, the larger the number of stakeholders that may need to be involved, and the more difficult it may be to reach a consensus. This is an important trade-off that needs to be considered.

Approaches to developing visions include models exploring forward-looking scenarios on issues such

31 *While developing vision has been presented as the third step, it could just as easily have been presented as a fourth step after more work has been done on the alternative technology/innovation pathways. This illustrates the iterative nature of developing roadmaps.*

as climate change, trade or income distribution, as well as foresight workshops, alternative futures, horizon scanning, scenarios and others.[32] The main purpose of these tools is to consider more ambitious alternatives to simple projections of current trends. Their main value is that they can help policymakers and relevant stakeholders to develop plausible narratives for alternative futures, and to think systematically about likely implications for the country's future. This helps to set out the goals and to open up an outside-the-box discussion about a future state that might not otherwise be considered. Once a consensus emerges about what policymakers want that state to be, they can begin to develop pathways for how to reach that state with an STI for SDGs Roadmap. The methodologies that offer support in vision building include Smart Specialisation (EU JRC), STIP (UNCTAD) and TIP (TIPC). Some countries also set up specialized agencies or institutions to help assess future trends and how they may affect what a country needs to do. In addition, some United Nations agencies – such as UNESCO, UNCTAD and UNDP – apply these methodologies in workshop settings to assist developing countries with this step.

What are the specific Goals and targets over the short term (three to four years), medium term (five to eight years) and long term (eight to ten years, to 2030)?

The timeline for meeting different Goals and targets also needs to be developed as part of the vision. They need to be spelled out in further detail, if not here then under Step 5 of the roadmap. In addition, consideration needs to be given to how that vision will be communicated. Beyond the preparation of a document, when and how will it be launched? Should the vision be part of other major government announcements or should it be launched independently? Should the vision be announced early to create momentum and support, or should it be launched only when the full STI for SDG Roadmap has been developed? This will depend on country-specific circumstances and traditions. However, it should be articulated at the highest level possible and launched through mass media, including the press, television and social media, in order to help create momentum and alignment.

Step 4.

Assess alternative pathways

This is the most critical step in creating an STI for SDGs Roadmap, because it is the phase of explicit consideration of STI inputs towards accelerating the achievement of SDGs. This is also where current STI for SDGs Roadmaps are weakest, particularly in developing countries.[33] Part of the reason is that most STI for SDGs Roadmaps available have been developed for advanced countries, which can draw on greater capabilities for mission-oriented research to create new technologies. That said, for developing countries, innovation covers a broader space than pure research for scientific or technological purposes, as it includes new ways of pro-

32 *Foresight methods and techniques can be used to support many steps in the process. See: Commission on Science and Technology for Development,* Strategic foresight for the post-2015 development agenda *(23 February 2015),* ***http://unctad.org/meetings/en/SessionalDocuments/ecn162015d3_en.pdf****; UNCTAD,* Digital tools for foresight *(October 2017),* ***http://unctad.org/en/PublicationsLibrary/ser-rp-2017d10_en.pdf****; UNESCO,* Transforming the Future: Anticipation in the 21st Century *(2018),* ***http://unesdoc.unesco.org/images/0026/002646/264644E.pdf****; UNDP Foresight Manual,* ***https://www.undp.org/content/undp/en/home/librarypage/capacity-building/global-centre-for-public-service-excellence/Foresight-Manual2018.html***

33 *This conclusion is also reached by a review of STI roadmaps. See Carayannis, Grebeniuk and Meissner (2016), International Energy Agency (2014), and Miedzinski, McDowall and Fahnestock (2018).*

ducing, delivering and using goods and services that may already exist elsewhere, and which can accelerate the achievement of SDGs if they can be effectively harnessed in the local context. There are also a few methodologies that offer support in assessing alternative pathways – for sectoral STI policies, UNIDO uses the Strategic Industrial Intelligence and Governance (SIIG) approach which includes this step, while UNCTAD proposes STIP to jointly examine various dimensions: economic, societal and environmental challenges. Other methodologies recommend foresight and other techniques but do not use them systematically.

Table 2.1 presents a comprehensive overview of innovations, ranging from incremental process improvements to system innovation (OECD, 2015)[34] and including grassroots,[35] pro-poor, inclusive and frugal innovation.[36] The use of the term "innovation" in this report will vary depending on the context. Sometimes it will refer to globally new technology, or it might be a product or service that exists elsewhere in the world but is new to the local context and may need to be adapted to the conditions in that context, or it could be in reference to an indigenous innovation that needs to be scaled up and diffused to other users. An effort is made in the text to clarify how the term is being used, but the reader will often have to infer it from the context. In addition, different types of innovation are needed in different local contexts. For example, if the focus is on diffusing an existing well-tested technology, for example solar energy, there may still be a need for a great deal of innovative activity to apply it. Organizational innovation may be needed to work out suitable business models to make it economically feasible, considering the socioeconomic profile of future customers. Product innovation may be needed to adapt existing technology to the local context (e.g. design of rooftops, climate and other natural conditions, regulatory requirements including standards). In addition, as noted in the Introduction, there needs to be an equal, if not greater, focus on non-technological aspects of innovation such as alternative business models, organizations, delivery systems and social aspects, including barriers to using new technologies.

Figure 2.4 presents three archetypes of technology/innovations in terms of their relative importance for STI for SDGs Roadmaps in developing countries: existing technology/innovations, emerging technology/innovations, and new technology/innovations which have yet to be developed. In this discussion, innovation is used in the traditional sense to mean technology to produce and deliver a product or service that is new to the developing country context. It is critically important for a country to assess alternative pathways for how technology/innovations can be effectively harnessed in the local context.

For the planning horizon to 2030, the reality is that most developing countries will be best served by taking maximum advantage of broad dissemination and use of existing technology/innovations, as well as emerging technology/innovations. This is why they are in the broader bottom parts of the pyramid in ***Figure 2.4***. The potential of new technology/innovations yet to be developed is represented in the narrower top part of the pyramid. However, drawing on historical precedents with developing, testing and applying new technologies, the time frame to 2030 is too short to

34 *One perspective on transformative innovation is the notion of system innovation (Geels, 2005; OECD, 2015).*

35 *Examples of grassroots innovations include those developed by rural innovators in the course of carrying out their farm and non-farm activities as they seek better and more efficient ways of doing things. However, they tend to be known only locally, so there is a big challenge in highlighting them and scaling up their dissemination. In India, the Honey Bee Network has developed an extensive database and support network for identifying, highlighting and disseminating grassroots innovations.*

36 *Pro-poor, inclusive and frugal innovation refers to innovations that have been designed to address the needs of poorer, marginalized populations. They may include both high-tech and low-tech innovations. These include use of satellite technology to identify sources of clean water for poor rural communities, advanced but low-cost eye surgery to remove cataracts for as low as $30 per person, low-cost water purification pumps, and low-cost solar stoves for rural communities. For more examples, see some of the innovations presented at the Global Solutions Summit in June 2018 prior to the third STI Forum in New York (**www.globalsolutionssummit.com**).*

Table 2.1

Innovation is diverse: the main faces of innovation for the SDGs

Product and service innovation

- Innovative technologies serving particular economic or social needs, including enabling technologies (e.g. ICTs) and technologies underpinning specific socio-technical systems (e.g. renewable energy technologies)
- Innovative products
  - New products that provide value to users because of their features
  - Inexpensive, durable, repairable, re-usable, recyclable, biodegradable materials and products with enhanced accessibility and reduced environmental impact
- Innovative services
  - Business to Business (B2B): new services that reduce the cost or time, or improve the quality of production, management or distribution processes
  - Business to Consumer (B2C): provision of new services that meet the needs of consumers at lower costs or provide them faster or more efficiently

Organizational (institutional) innovation

- New ways of organizing the production or delivery of goods or services (including government services) that reduce the cost or time of producing and delivering them
- Better ways of managing the production of goods or services or their delivery, which can increase efficiency, quality or accountability under new objectives such as pollution control, waste reduction, corporate social responsibility (CSR) or inclusiveness

Marketing innovation

- Faster delivery or lower cost of marketing products and services, including through social media and other internet-based platforms, as well as product differentiation through eco-labels, fair-trade labels or labels confirming that production has respected human rights
- Science-based campaigns and awareness raising (e.g. water and sanitation or sustainable consumption)

Business model innovation

- New ways of organizing businesses and their products and services. For example,

using internet-based platforms to match supply and demand for goods (e.g. Amazon) or services such as personal transport (Uber and Lyft) or short-term apartment rentals (such as Airbnb) without owning assets

- Changes to value proposition and product-service systems of companies (e.g. circular economy business models, including product sharing and functional sales)

Pro-poor, inclusive innovation and frugal innovation

- Various types of innovation designed to address the needs of poorer, marginalized groups
- Affordable products from the informal sector that have potential to reduce life cycle environmental impact, due to reduced use of resources and energy and re-use of materials and components. Region-specific terms include *jugaad* (India), *jua kali* (East Africa) or *gambiarra* (Brazil). Products or services designed or redesigned to reduce their cost and complexity (may be modular but may still be high-tech), while retaining their core functions.

Grassroots innovation

- Innovation that involves grassroots actors (NGOs, communities) in the process of applying knowledge to sustainable development challenges, which are often defined at a local level

Social innovation

- New collaborative arrangements with social and environmental benefits (e.g. supply chain innovations rewarding primary producers, energy cooperatives, repair cafes, eco-villages)

System innovation

- System changes underpinning a number of mutually reinforcing innovations, often implemented by many organizations, which together have potential to transform functional systems delivering key goods and services to societies, such as health, water, food, shelter or mobility. For example:
    - Circular economy approaches changing waste management systems (integrated approaches to collection, sorting, processing and disposal)
    - Integrated solutions to urban systems (e.g. multimodal mobility systems)

Source: Authors, based on Oslo Manual (OECD/Eurostat, 2018); UNCTAD (2017, 2019); Miedzinski and others (2017); Radjou and Prabhu (2015); Dutrénit and Sutz (2014) and Cirera and Maloney (2017).

expect that even if they are developed, they could be broadly disseminated.[37] Currently, only a few developing countries (such as China, India, Russia and Brazil) have the R&D capability to develop new transformative technologies, with the bulk of these new technologies likely being developed in advanced countries. There is, however, an important role for international collaboration to develop new technologies that may be relevant for developing countries, as will be covered in ***Chapter 3***.

What existing technologies and channels can help attain those goals?

Benchmark assessments confirm that developing countries are far behind the global technological frontier in most technologies, ranging from agriculture to manufacturing and services. Although there is wide variance among developing countries, comparative studies of productivity across sectors show that, on average, developing countries are operating at less than 2 per cent of the productivity achieved by developed countries in agriculture, 5-20 per cent of average productivity in manufacturing, and 5-25 per cent of productivity in services.[38] This means that developing countries could go a long way towards attaining some of the SDGs by using technology that already exists.

A key issue is how developing countries can access those technologies, given that 68 per cent of the population in low-income countries, and 61 per cent in lower middle-income countries, live in rural areas (World Development Indicators, 2018). Moreover, more than two thirds of the labour force in low-income countries, and roughly 40 per cent of that in lower middle-income countries, is still engaged in agriculture, mostly in subsistence farming. For smallholder farmers and low-income populations, grassroots, frugal and pro-poor innovation offer ways of narrowing this innovation gap.

And for these types of innovation, one of the major challenges is how to adapt, scale up and deploy available technologies.

There are multiple channels for accessing existing technology. These include obtaining technology through foreign direct investment (FDI), importing capital goods and components that embody the more efficient technology, licensing technology, obtaining technical assistance through arms-length market transactions or as part of bilateral government technical assistance packages or dissemination by NGOs or professional societies, accessing foreign education and training, and copying and reverse engineering. However, just because the technology or innovation already exists somewhere in the world, and there are many ways to obtain it, does not mean that it can easily be acquired and used. For example, to attract FDI that may bring in the desired technology, the country must be of interest to the foreign investor and this involves not just attractive market opportunities, but a good business environment and other broader enabling conditions. In addition, there is the issue of how

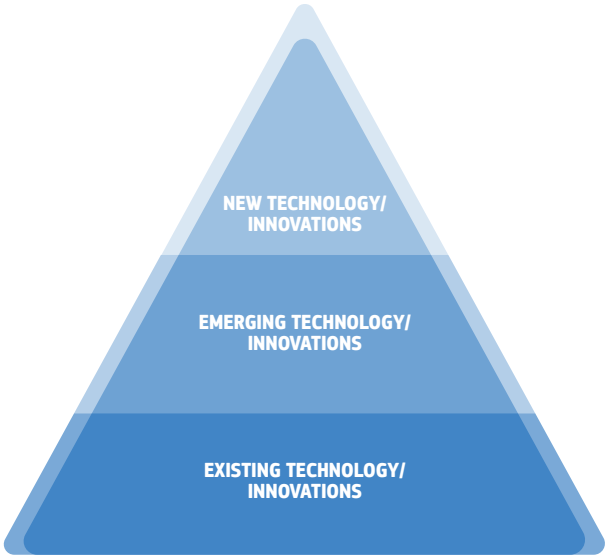


Figure 2.4: *Pyramid of relative relevance of different technology/innovations in achieving SDGs*

Source: Authors

37 *For a very revealing analysis of the time it has taken different technologies to diffuse globally, see Comin and Mestieri (2014).*

38 *See for example OECD (2014) and Cirera and Maloney (2017).*

that technology is to be disseminated within a country and across different regions and actors.

What does the STI system have to offer to enable dissemination of the innovation?

It must be kept in mind that technology is just one of many inputs required to actually have an impact on use. What are also required are financial resources, entrepreneurial incentives, and firms with the appropriate organizational and managerial capabilities that can deploy the technology/innovation to get goods and services to firms or consumers who can benefit from them. For example, the dissemination of medical technologies/innovations, such as vaccines, requires a system of health providers. Something as simple as oral rehydration therapy, essential to reduce mortality due to dehydration from diarrhoea, requires not just a few cheap chemicals but also trust in the providers by the target population, as well as clean water – which is usually not easily available in the communities where the problem is most endemic. *Figure 2.5* is a schematic representation of some of the key components of the technology/innovation deployment system.

Technology deployment may involve existing technology that is already ready for dissemination. New technology, however, often has to be applied in prototypes and tested before it is fully deployed. In addition, once tested and debugged, it often has to be scaled up to reduce production costs, which also helps to foster its uptake. More steps would therefore be required within the technology box, but they are not represented here to avoid cluttering the schematic representation.

No technology works in isolation; it typically requires complementary inputs. For industrial products, these may involve different types of raw materials or components and some source of energy. For services, it includes hardware as well as software and other forms of non-technical innovation, including business models and new forms of organization and delivery of services.

Technologies also require supportive infrastructure. This includes energy infrastructure, such as fossil fuels or alternative energy systems (e.g. wind farms or solar energy) for electricity generation. Increasingly, a good ICT infrastructure of fibre-optic cable and wireless networks is critical for digital technologies such as cell phones and other connected electronic devices which are becoming ubiquitous in our new context.

Development and deployment of a technology or innovation also requires finance. Given the risks involved in developing and testing new technologies, this often requires some source of finance which may be the developers' own capital, seed funding, or some sort of grants by governments or NGOs. Only once a new technology is beyond the conceptual stage is it likely to attract venture capital or social investment funds. And even when a technology has been widely demonstrated to be effective, it is often not easy to attract capital to finance expansion. Banks are risk-averse, so they

Figure 2.5: *Technology/innovation is just one element of the deployment system required to reach beneficiaries*

Source: Authors

typically require some sort of tangible collateral before they are willing to make loans. New start-ups almost by definition do not have many physical assets beyond the potential intellectual capital associated with the new technology. Therefore, specialized sources of finance need to be developed as part of the deployment ecosystem. In addition, consumers may need access to financing to buy the product or service, so it will also be necessary to address how that financing can be extended to consumers. For poor target populations, this may require innovative financing schemes that bypass the formal financial system. These can include innovative FinTech financing, using digital systems to deliver small amounts of finance and to track repayment history.[39]

Deployment of the technology/innovation also requires entrepreneurship. Someone – be it a company, NGO or government agency – needs to take the initiative to roll out the technology to the ultimate beneficiaries. For technology/innovations that are new to the target environment, there is often some risk that they will not work without modifications or that there may not be uptake because of high cost or cultural or other social reasons. Therefore, someone has to take the risk. In addition, the effective use of technology requires skills, including not only basic literacy, but also often specialized technical skills, such as how to use the Internet or new applications.

Another requirement for deployment is a delivery system (see ***Box 2.4***). For commercial technology/innovations, this is typically through private firms with an incentive to deploy the products or services because they make profits from such sales. For social technology/innovations in sectors such as basic education, preventive health, security and social protection, it is typically some sort of government organization or NGO. These are not generally already in place for the delivery of new technologies. Therefore, they have to be developed as part of the delivery ecosystem. In addition, for some technology/innovations (such as in the health or agricultural sectors), the delivery system needs to gain the trust of the users before it will be accepted.

What emerging technologies may help attain those Goals?

There are also several emerging technologies that may allow cheaper or more efficient ways of meeting some of those Goals. For example, rather than building central power stations and an extensive grid system to provide electricity to communities, new off-grid solar power technologies make it possible to reach rural communities at a fraction of the cost. Also, the advent of cheap cellular telephone and wireless service technologies are making it possible to provide phone and even telephone-based Internet services to rural communities at a fraction of the cost and time needed to expand traditional wire-based telephone or cable services. Similarly, new water purification technologies, for example using advanced nano-technology membranes, may make it possible to provide water to rural communities more cheaply than by extending more expensive conventional water supply systems. Artificial intelligence also has the potential to bring in a wave of complementary innovations with wide impact and may help to plug some of the skill and knowledge gaps in developing countries.

However, it must also be kept in mind that some disruptive technologies, such as artificial intelligence, automation and robotics, 3D printing and new materials, may also have negative impacts on the growth and development prospects of developing countries. Automation and robotics may wipe out the low labour cost advantage of developing countries, which has allowed them to produce labour-intensive manufactured products. 3D printing may also lead to displacements and reshoring of global supply chains, which have provided an entry point for developing countries into

39 *See, for example, some innovative financing systems such as those offered by Aamra e-banking in Bangladesh (**https://www.aamratechnologies.com/**), Credit Ease in China (**http://english.creditease.cn/**), Ignite Power in East Africa (**https://www.ignite.solar/**), and Shared Interest in South Africa (**https://www.sharedinterest.org/approach**).*

manufacturing.[40] New materials and synthetically produced foods may reduce exports of metal and commodity crops which have been critical for developing countries' exports and growth. In addition, some of the emerging technologies such as nano and biotechnologies may have negative side effects, including environmental and biohazards.

Thus, it will be important to constantly scan the horizon for the potential positive or negative impacts of emerging and new technologies. This means that the assessment of alternative roadmaps must also consider what special regulations or compensation programmes need to be put in place to protect the populations who are negatively affected by the rapid dissemination of emerging technologies. Regulations may include increased security and privacy protection measures, while programmes may include both skills retraining and better systems of social protection.

What new technology development possibilities may be available through new global development efforts?

There is also the possibility that global innovation initiatives in agriculture (more drought- and pest-resistant crops, more nutritious food), energy and environment (advances in alternative energy technologies, carbon capture and sequestration), health (new vaccines or better diagnostic and preventive medicine, affordable organ replacement), water (more affordable desalination and water treatment technologies) and other areas can open up new, more cost-effective ways of meeting some of the SDGs. Therefore, it is important to consider the potential of these new technologies and how countries should position themselves to take advantage of them. For example, what kinds of scientific/engineering/technical skills, physical and virtual infrastructure, institutions (technology and training centres, business incubators/technology parks, etc.) may be necessary for the country to be able to acquire/develop/use these new technologies?

What alternative innovation pathways are there to reach those Goals?

Because there can be different ways of using STI to meet some of the SDGs, it is critical to explore different pathways. This analysis should consider what would be required for each pathway in terms of alternative existing technology/innovation routes and deployment ecosystems, as well as the potential offered by emerging and new technologies and other forms of innovation. For each technological/innovation route, the costs need to be considered, as well as the organizational capabilities required to effectively diffuse it at the country or regional level. This will allow an overall comparison of these different routes.

It is also important to appraise the distributional impacts of these pathways, considering their impact on gender and on different age groups and ethnic groups, as well as territorial aspects. These impacts can be positive or negative and need to be considered in making the decision on which pathway to take. This also highlights the need to have specific policies in place to offset some of the negative impacts for some groups. It is likely that some technology/innovation routes will be more effective for reaching certain specific populations. For example, for electricity, a conventional centralized power grid may be more cost-effective for dense urban populations, while other options such as off-grid solar or wind-powered electricity may be more cost-effective for dispersed, rural populations. This requires significant scientific, technological and managerial input to examine the feasibility and cost-effectiveness of different routes. This would probably need not just local, but international expertise.

It is generally expected that successful new technologies and innovations will have falling costs and become more competitive as they are further developed and scaled up. Also, old technologies typically reach a saturation point and are even-

40 *There are cautious opinions on the impact of 3D printing and other digital technologies on trade prospects for developing countries, as recent empirical analysis shows otherwise. See Freund, Mulabdic, and Ruta (2019), Rodrik (2018), and UNIDO (2019).*

Box 2.4

Some relevant insights from the Global Solutions Summit

Five key points emerged from the Global Solutions Summits held in New York just before the third and fourth United Nations STI Forums in 2018 and 2019. The 2018 Summit brought together social entrepreneurs, foundation executives, high net worth individuals, NGOs, scientists and government officials around the topic "From the Lab to the Last Mile: Technology Deployment Business Models for the SDGs."

1. Useful concept of the **global last mile** challenge. This was broader than the conventional geographic concept related to proximity to the grid and included the challenge of getting existing technologies relevant to the attainment of critical SDGs to poor, marginalized populations. The point was that merely deploying technologies, such as water purification filters, drought-tolerant seeds, health clinics, off-grid solar or wind electricity, off-grid refrigeration and food processing, and other small-scale distributed solutions, was not going to reduce fragility or ensure long-term resilience. The latter would require strengthening of local social capital – to share assets and information, promote self-help approaches, and link communities and local networks with government and formal institutions.

2. **Scaling up the challenge.** Many entrepreneurs have developed relevant technologies and innovative new business models and forms of financing for the delivery of these goods and services to poor communities. However, after reaching thousands – or even hundreds of thousands – of poor people, it is clear that this is still not sufficient to reach the hundreds of millions of people who must be reached if we are to achieve the SDGs. What is required is a way to radically scale up and massively deploy these successful innovative solutions.

3. **Building an efficient and effective deployment ecosystem.** Scaling up and replicating successful business models to deliver SDG solutions requires an ecosystem offering the necessary technical and financial resources, human capital, supply chains, infrastructure, political support, entrepreneurship, innovative business models and delivery systems, and financing. This entails a two-pronged strategy. First, developing a platform "so that all the disparate elements of the ecosystem ... can find each other and join forces more easily," such as through online platforms. Second, "building the capacity of local organizations, institutions and individuals to participate more actively and fully in the deployment process".

4. **Bringing finance to the last mile.** This implies going beyond the Addis Ababa Action Agenda, of increasing development finance from billions to trillions of dollars, and developing innovative financial conduits so that these funds can be invested in increments of thousands or millions of dollars. Private businesses, NGOs and social enterprises are developing some of these innovative conduits via traditional and non-traditional banking systems, as well as new FinTech solutions, to reach the last mile customers.

5. **Generating income to deliver the SDGs.** The problem of reaching last mile customers is that they cannot afford the services. Therefore, effective STI for SDGs Roadmaps must address the income constraint. There is a feedback loop from extending basic SDG services to communities to the income that is generated for them to be able to buy these services. Some NGOs have realized this and have expanded their role from technology suppliers to income-generating market access programmes. This also requires building of social capital, which is a time-consuming process. It needs to be factored into programmes to help achieve the SDGs.

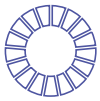
The key implication of these findings is that discussions of STI for SDGs Roadmaps need to also focus on the non-science dimensions of the technology deployment ecosystem.

Source: Watkins (2018) and Watkins (2019)

tually replaced by newer technologies. Attention must be given to the ecosystem required for the deployment of different technologies. In addition, for alternative pathways, the social aspects of the adoption of new technologies need to be taken into account, such as trust and acceptance of the technologies by the users. Ideally, in evaluating each technology/innovation pathway, the following should be considered: capability of the different agents needed in getting the service to the users – including firms, government, NGOs and community organizations, depending on which are the main delivery agents; physical and digital infrastructure requirements; complementary inputs; financing; government policymaking and delivery capability; and the relative costs and benefits of using the different technological routes.

The choice of innovation pathways in STI for SDGs Roadmaps needs to consider existing STI capabilities and the extent to which they are aligned with the SDGs. Put simply, different types of innovation are needed to accomplish the SDGs in different contexts, and they require different capabilities from firms and other actors to be successfully implemented, scaled up and diffused. For example, if one of the priority goals is to provide universal access to clean low-carbon electricity, governments need to assess knowledge and innovation needs in relation to existing STI capabilities, and system conditions relevant for achieving this goal. This requires a systemic understanding of both generic STI capabilities (e.g. STEM skills, entrepreneurial potential, absorptive capacity) and specific capabilities needed to adopt and diffuse renewable energy technologies and upgrade energy infrastructure in the country. The focus on STI capabilities needed to address specific challenges is important, as they may differ considerably between various topics, actors, technology areas, economic sectors and regions. This appraisal will allow planners to better tailor policy intervention in STI to address the SDGs, while making sure that policy portfolios cater for the specific policy and country context.

Step 5.



Develop detailed STI for SDGs Roadmap

Step 5 is focused on developing the STI for SDGs Roadmap, along with key instruments and priority actions to be taken to accomplish the vision and contribute to the SDGs. As a decision-making phase, the process needs to be embedded in and aligned with established policy processes, and fully engage key actors with powers and competences to make formal commitments. It is key that the process is transparent and takes full account of the evidence and deliberations in the preceding steps.

The process should result in a roadmap document – an action plan. The document needs to build on the preceding steps. It should introduce key findings from the baseline analysis and provide an account of the roadmap deliberation process, especially how different voices and interests were considered in elaborating and comparing alternative STI pathways. The methodologies such as Smart Specialisation (EC JRC), STIP (UNCTAD) and TIP (TIPC) offer support and guidance during this step of roadmap development.

The action plan should present:

- Key challenges and vision of the STI for SDGs Roadmap
- Objectives, concrete targets and milestones for the roadmap, explaining how they link with key strategic documents for the country
- Description of selected innovation pathways and technology areas, explaining how the roadmap supports their deployment at scale
- Policy instruments and other actions (e.g. public-private partnerships) included in the roadmap, with an explanation of how they contribute to the roadmap objectives as a portfolio, and taking into consideration the capabilities of government agencies for implementation
- Expected timeline for implementation, taking into account contingencies, key dependencies and sequencing of actions
- Roles and responsibilities of government and other stakeholders in implementing and coordinating the roadmap
- Allocation of resources over time
- Partnership and communication strategy to sustain stakeholder involvement and ensure inclusive governance of the roadmap
- Monitoring and evaluation system to track progress on implementation of the roadmap
- Feedback loops using monitoring and evaluation to adjust the roadmap

Some of the key issues are discussed below.

What will be the role of government vs the private sector or civil society?

Generally, roadmaps for attaining the SDGs will be developed by government. However, given the nature of the SDGs, government is not always the key actor or even the most important actor. For some (such as quality education; clean water and sanitation; peace, justice and strong institutions), the government may have a strong role to play, be it through the direct provision of services, financial support, or the regulatory environment. For many others (such as decent work and economic growth; industry, innovation and infrastructure; affordable and clean energy), it will be both public and private sectors that will roll out the services or undertake the activities that will help attain the Goals. For still others (such as no poverty; zero hunger; good health and well-being), it will be a wide variety

of actors, including non-governmental actors and civil society. Therefore, policymakers need to think about what it will take to incentivize and mobilize the other actors, drawing on government policy, regulation, direct government provision, government expenditures, subsidies, grants, etc.

What will be an adequate policy mix?

Policymakers need to develop an appropriate policy mix and instrument portfolio. The choice of instruments for these portfolios depends on the type, maturity and level of disruptiveness of supported innovations, the institutional and implementation capacity of the government and its agencies, and the innovation capacity of the actors targeted by direct or indirect policy support.

Design of policy instrument portfolios should consider how various policy instruments can incentivize actors with different needs and capacities, and leverage and funnel investments into innovations needed to accomplish the SDGs. These include changes to the country's regulatory regime, as well as specific instruments designed to encourage or support desired activities.

Table 2.2 outlines some general regulatory levers and policy instruments relevant for STI for SDGs Roadmaps. Changes to the regulatory regime are primarily used to open the economy to global knowledge inflows and provide the right signals for the use of technologies that are relevant to meet the SDG needs. In particular, they include regulations to encourage greater social inclusion and environmental sustainability, which may not be reflected in current market signals. This also includes dealing with the challenges of emerging technologies, such as new forms of unfair competition facilitated by proprietary digital platforms and issues such as data ownership, privacy and security, which are relevant to developing as well as developed countries

The objectives of policy instruments providing support can be grouped into three broad categories:

- **Adoption and use of existing and emerging technology/innovations.** In most low-income countries, production and services are provided by very small, informal firms operating in manufacturing, services and subsistence agriculture. They have limited knowledge of existing technologies that could improve the production, delivery and quality of goods and services and help to meet the SDGs. Innovation is largely indigenous or grassroots, although there may be a small modern sector. Thus, the key focus is not so much on encouraging research, but on encouraging the use of existing technology/innovation and scaling up grassroots innovation. The aim of the instruments is therefore to provide technological information and disseminate innovation, strengthen management capability, upgrade skills and improve the basic national quality infrastructure. **Promotion of non-technological innovation.** In many cases, the need for innovation is not technological but social, organizational or managerial (concerning business processes, marketing, etc.). This type of innovation is particularly important in developing or transition economies, as it enables businesses and societies to adapt to change and accept it. It can also help to achieve many SDGs, as it promotes social change and localized (non-technological) solutions. In this case, it is important to include instruments that support the development and promotion of new solutions to societal problems and challenges. The innovative projects may be proposed by the private sector, but also by NGOs and other civil society organizations.

- **Adaptation of existing and emerging technologies and innovations.** This is typically more relevant for countries at the middle level of technological development and with more diversified productive sectors, as their innovation and entrepreneurial systems allow them to exploit more sophisticated technology and business models and proactively adapt them to specific local conditions and needs. Here, the focus also includes supporting greater interaction between R&D and the needs of firms and society, and the commercialization of adapted technology.

- **More ambitious creation of new technologies and system-wide innovations.** This typically has greater relevance for countries with more advanced technological capabilities and productive sectors, and includes support for more ambitious and transformative system innovation. The focus here is on encouraging more collaborative approaches to big challenges and on helping to mitigate the risks.

Regardless of the level of development and technological capability, countries may opt to use instruments supporting a combination of all three types. Challenge-driven approaches to STI policy, such as mission-oriented or transformative innovation policy, are likely to use instruments from all three categories. Even countries at low levels of technological development may find they need to use policy instruments in the second or even the third category for specific SDG needs. For example, to encourage research to adapt agricultural technologies to specific soil, climate and water conditions, agricultural practices and domestic tastes; or to bring in advanced emerging technologies, including digital technology systems, and adapt them to the local context. Likewise, even advanced countries may need to use policies in the first category to help small and medium enterprises use existing new technology.

The choice and design of STI policy instruments to support the selected pathways must consider existing policy and institutional capacity to deploy and implement specific instruments and portfolios, but also the needs of stakeholders, including civil society and the private sector. Often, classic policy instruments are not sufficient to address these needs, so it is also necessary to stimulate and encourage innovation in the public sector. There needs to be a critical and pragmatic appraisal. It may lead to a decision to include or exclude certain instruments from the portfolio, or to adapt instrument delivery mechanisms or design features to make them feasible and avoid potential problems in implementation. GO-SPIN methodology (UNESCO) offers valuable support in relation to STI policy mix in connection with the SDGs. For detailed assessment of the effectiveness of a policy mix and how to improve it, PERs in STI (World Bank) can be applied.

Adapting the STI policy mix to existing STI capabilities does not need to limit the ambition of STI for SDGs Roadmaps. Governments have a great deal of flexibility in selecting the combination of instruments and adjusting their design features to promote innovation that responds to the specific needs of different target groups and communities. STI for SDGs Roadmaps can become useful frameworks for the design and implementation of policy portfolios that gradually build up the capacity of STI systems to respond to key societal challenges. Roadmaps can create learning-by-doing environments in which governments, in close collaboration with stakeholders, appraise, co-design and gradually improve the STI policy mix, so that it better responds to knowledge and innovation challenges posed by the SDGs.

Who will do what over what time period?

There is also the issue of which actors are to do what and over what time period. This involves spelling out the role of different government ministries and agencies that may be involved, as well as the relationship between the central government and subnational governments. It includes determining how the activities of the different government agencies will be coordinated. A decision also needs to be made on which agency is responsible for coordinating government activities, taking into account what power or leverage that agency will have to effectively carry out the coordination. To make this work and to achieve real traction, all the relevant stakeholders from government, the private sector and civil society need to be brought on board to commit to their respective responsibilities (see ***Box 2.4*** on engaging the private sector). This is why stakeholder involvement is such a critical input for developing a successful roadmap.

What capacities will be necessary in government and other agencies?

Another important consideration is whether the different agencies or other actors, including the

private sector and civil society, have the capacity and skills necessary to successfully fulfil their role. If they do not, then training or capacity building needs to be built into the roadmap. This may add to the cost, but it is essential in order to create a roadmap that can be implemented. To build up domestic capabilities, developing countries can try to obtain technical support from international institutions, develop twinning arrangements for capacity building with bilateral agencies and foreign companies, and build technical training components into loans from the multilateral development banks.

What financing will be necessary and how will it be obtained and delivered?

Another critical issue, which unfortunately is not sufficiently dealt with in most plans, is how the costs of the different initiatives are to be financed. How much will be the government's responsibility and where will it obtain the funding? Will it be from current tax revenues, or will there be a need for additional financing through domestic or foreign borrowing or bond issues, or through new specially earmarked taxes (as has been done in Chile and Colombia, for example, to finance special innovation funds), or special grants from NGOs or other donors? Some countries may prefer to leave the budget details to other documents, but the issue of costs needs to be addressed. If the plan is to have sufficient financial resources for implementation, it will probably have to be vetted by the Ministry of Finance to allow budget trade-offs to be considered and decided upon.

Table 2.2 Illustrative regulatory levers and policy instruments for STI for SDGs Roadmaps[41]

Regulatory framework levers

- Trade and foreign direct investment policy that encourage the entry and use of technologies to help achieve the SDGs, including a good business environment that encourages investment and innovation
- Intellectual property protection, which provides an incentive to develop new technology and also facilitates the transfer of technology by allaying the fear of foreign investors and technology suppliers that their technology will be pirated. In addition, the information contained in patent documents can provide insights into how to develop other technologies.
- Prices that reflect economic costs (e.g. carbon pricing; removing subsidies on carbon-based fuels)
- Regulations to address the challenges of the digital economy, including unfair competition, privacy, security, data access and ownership
- Reskilling and social protection legislation and institutions, to help people nega-

41 For other useful classifications of instruments, see Cirera and others (2020) and UNCTAD (2019).

tively affected by disruptive technology

- Regulations and institutional arrangements underpinning gender equality in STEM, research and entrepreneurship
- Standards and certification for products and processes, to meet safety, health, social and environmental goals
- Intellectual property regulation and incentives (such as purchases of licences), to encourage use and diffusion of technologies helpful for attainment of the SDGs
- Rules and regulations for the development of venture capital and other financing relevant for new technologies that can help achieve the SDGs

Instruments to absorb, disseminate and use relevant technology and innovations

- Public awareness campaigns and outreach activities to support the use of technology/innovations for the SDGs
- Creation and support of online innovation platforms that facilitate access to and transfer of technologies, such as the United Nations Online Technology Platform and WIPO GREEN technology platform
- Business advisory services to build up management capability and help increase productivity and attain safety, health and environmental standards and gender equality
- Establishment of a national network of WIPO Technology and Innovation Support Centres (TISCs) to provide value-added intellectual property services for the support of innovation and use of relevant technologies
- Technology extension services to demonstrate and diffuse new technology/innovations relevant for the SDGs, including scale-up and dissemination of indigenous and grassroots innovations
- Technology/innovation centres to help solve firms' problems related to the SDGs by using relevant new technology/innovations
- National quality infrastructure including metrology, standards, testing and quality control, and awareness programmes on the importance of using these services to meet quality, health and environmental goals
- Supplier development programmes to help firms integrate into domestic and international value chains
- Vouchers for firms to contract specialized technical assistance to use relevant new technology/innovations
- Tax incentives or grants for first (pioneer) firms for using relevant new technology/innovations

- Development of company clusters to generate economies of scale and agglomeration in learning about and effectively using (and developing) relevant new technology/innovation
- Skills upgrading and training programmes in using new technologies, including digital technologies
- Tax incentives or low interest loans to firms or individuals for using products with technologies that help address the SDGs (such as installation of high efficiency furnaces or purchase of electric vehicles)

Instruments to adapt and disseminate new emerging technology and innovations

- Development grants and subsidized loans for emerging technology/innovations that help achieve the SDGs
- R&D vouchers for firms to contract research to help deliver better goods and services for the SDGs
- R&D tax incentives or grants for firms to adapt technology relevant for the SDGs
- Technology transfer offices in universities and research centres to commercialize technology
- Business incubators to support technology start-ups in areas relevant for the SDGs
- Grants for science and engineering training abroad, as well as development of strong domestic universities

Instruments to develop new technologies and system-wide innovations

- Grants to universities and research centres to develop new technology/innovations relevant for the SDGs
- R&D tax incentives or grants for firms to develop new technology/innovations relevant for the SDGs
- Support for clusters and science and technology parks to stimulate the development and commercialization of relevant technology/innovations to help achieve the SDGs
- Procurement specifications for new technological or innovative solutions, accompanied by research grants and promises of large purchases if products or services demanded meet the specifications
- Challenge grants to develop new technologies and innovations to address specific needs in environment, health, education and agriculture to help achieve the SDGs

- Grants and tax incentives for researchers and innovation consortia to develop new technology/innovations in specific targeted areas deemed relevant to help meet the SDGs

- Major government-coordinated initiatives, with significant government funding, to create consortiums of business, the academic community and public research institutes to develop radical new technologies

Source: Authors

Box 2.4

Engaging the private sector to use STI more effectively to attain the SDGs

The private sector is driven primarily by the search for profits, and responds to market signals and the policy environment. It may also be held back by limited information on market opportunities relevant for achieving some SDGs, as well as by incomplete knowledge of technologies and innovations that could provide profitable ways to provide goods and services towards that end. Policymakers, on the other hand, tend to focus their attention on providing goods and services to achieve the SDGs which may not be economically attractive to the private sector. They need to understand this disconnect and seek ways of engaging the private sector's contribution towards leveraging STI to accelerate achievement of the SDGs. They also need to understand that the private sector is highly diverse in terms of the size and capabilities of firms, ranging from small, informal enterprises with limited technological and entrepreneurial capability to large, domestic and foreign multinationals with extensive capabilities and global reach. They must target their strategies and policies to address this complex reality. In addition, many firms, regardless of size, are also sometimes willing to act beyond the profit motive because of corporate social responsibility interests and this goodwill also needs to be harnessed.

Public policy can provide positive and negative incentives for engaging and investing in STI for SDGs, using various instruments. Positive incentives can be provided by instruments ranging from market-based mechanisms (e.g. direct financial support for technology adoption or development of new technologies) to measures supporting industrial clusters and innovation networks in areas relevant for the SDGs (see ***Table 2.2*** for overview of policy instruments). Incentives can be introduced through new instruments or by changing the design features of existing instruments (e.g. changing award criteria for grants and procurement contracts, changing the level of public match funding depending on the risk profile of investments). In addition, public policies can improve information about market opportunities and technologies to help achieve the SDGs (e.g. through market fairs; agricultural, industrial and service industry extension services and demonstration projects; business incubators; science or industrial parks), as well as training for entrepreneurs and workers in using relevant technologies and innovations.

Negative incentives or restrictions discourage investments in STI projects that are not aligned with the SDGs. These include reducing or banning products and materials with proven negative impacts on human health (e.g. toxic chemicals) and the environment (e.g. single-use plastics) and introducing pricing for inputs such as water and carbon that reflect true economic costs. They also include removing existing instruments that introduce perverse incentives (e.g. subsidies for socially and environmentally harmful economic activities, such as fossil fuel use). To make a significant contribution to social and environmental sustainability and to delivering public goods, the right balance needs to be found between positive and negative incentives in the STI policy mix.

As strategic policy frameworks for action, STI for SDGs Roadmaps can play an important role in creating alignments between public and private sector innovation strategies, and build policy environments providing incentives for multiple actors to invest in and collaborate on STI activities with the highest potential to achieve the SDGs. By developing a shared vision and innovation pathways, the roadmapping process can help to identify concrete barriers and to determine incentives needed to prioritize and scale up STI investments conducive to economic, social and environmental sustainability.

Step 6.

Execute, monitor, evaluate and update plan

Needless to say, the key step after the development of the STI for SDGs Roadmap is its execution and implementation. This is where the value of this exercise is to be realized. Some of the key elements to be considered are the following.

How will the roadmap be executed?

Since the roadmap will involve many different parts of government, as well as other actors including the private sector, foundations, civil society organizations and other domestic and international partners, good governance and coordination mechanisms will need to have been developed. Which part of the government will be the lead agency? How will it effectively coordinate with other parts of the government and other actors? How will capacity constraints be addressed? How will other bottlenecks and problems in implementation be handled? How will adjustments be made to the roadmap? To implement roadmaps effectively, proper mechanisms will need to be set up for monitoring, evaluation and updating.

What monitoring and evaluation mechanisms will there be?

For the plan to be credible and effective, there should be provisions for monitoring progress to determine whether it is on target or whether there are problems in implementation that need to be addressed. Who will do the monitoring, how will it be done, using what parameters and with what frequency? The indicators to monitor are not just the traditional STI inputs such as scientists, engineers, technical publications and patents, but also technology licensing, technical assistance, twinning arrangements, etc. More importantly, output indicators relevant to the targeted SDGs need to be monitored, such as reduction in hun-

ger, reduction in income and gender inequality, reduction in greenhouse gas emissions, increases in use of non-fossil fuel energy, reductions in infant and maternal mortality, reduction in the incidence of communicable diseases, increases in life expectancy and preservation of biodiversity. There is also a need to choose appropriate evaluation mechanisms and timing (ex-ante, interim, ex-post), such as through programme theory and formative evaluation methods, open assessments through multi-stakeholder engagements, and rigorous impact evaluations. The methodologies available to support monitoring of the roadmap include GO-SPIN (UNESCO), PERs in STI (World Bank) and SIIG (UNIDO).

Who will do the evaluation?

This step involves not just deciding who will do the evaluation, but also selecting an institution or group that is both appropriately qualified and sufficiently independent from the actors to be credible. This may require building proper provisions into the roadmap to create this capacity in the country.

What mechanisms will there be for continuous horizon scanning for evolving subnational, national and global conditions?

Since technology, together with science and innovation, is such an important factor in the STI for SDGs Roadmaps, there needs to be a mechanism to track the potential impact of new technologies that may open up new opportunities or pose new challenges. In addition, there needs to be continuous scanning for evolving subnational, national and global conditions that may affect the plan, such as trade tensions, fragility and conflicts, the impact of more frequent extreme weather, or other disruptions. Who will be responsible for this and how will it be done? Continuous horizon scanning is often done by specialized departments within government or think tanks.

Some developing countries are already carefully monitoring the impact of some of these trends, particularly the impact of new technologies. Mexico, for example, has undertaken a major effort to assess the impact of disruptive technologies on the country (López-Portillo y Rojas, 2018). This has included consultations with foreign and domestic technology experts, as well as extensive consultations with leaders in various industries and with civil society. This will provide an important input into Mexico's STI for SDGs Roadmap.

How will lessons from the evaluation of progress on meeting targets and changing conditions be fed back to adjust the plan?

This is perhaps the weakest part of most plans, including those of developed countries. There is rarely an explicit mechanism to learn from the evaluations of what is or is not working, in order to adjust the roadmap. In some countries, progress on plans is reviewed on an annual basis. In others, reviews are undertaken every three to four years. The roadmap needs to be treated as a dynamic process that must be adjusted in light of its performance, as well as changes in a domestic and foreign context and technology.

The framework for continuous learning and monitoring needs to be built into existing policy processes and practices. It needs to include credible and effective feedback mechanisms that ensure lessons from implementation are analysed and acted upon. The framework can benefit from ongoing collaboration with local, national and international stakeholders who can support the collection of data, as well as share relevant evidence and methodological approaches.

A useful mechanism to establish here is a "learning platform" (or "community of practice") developed for the roadmap, which can build on the current Voluntary National Review process for country reporting on plans and progress on the SDGs under the 2030 Agenda. This would make the roadmap more than just an action plan; it would turn it into a learning mechanism bringing together various

ministries and stakeholders and international experience.

It should also be kept in mind, as noted in Step 1 and ***Box 2.2***, that the SDGs are interdependent. Therefore, as experience is acquired in implementing the roadmap and progress is evaluated, it is also important to consider how to broaden the scope of the roadmap to take account of the synergies and address the trade-offs in adjusting the plan and moving forward. This is an area in which sharing of experience and further assistance from specialized agencies of the international community working on these synergies and trade-offs will be very useful.

2.5 Overview of methodologies

The choice of methodology will depend on the country's needs, contexts and objectives. For instance, if a country's need is to explore the effectiveness of STI policy instruments, then GO-SPIN, STIP or PERs may be appropriate. However, if the objective is to develop STI roadmaps that focus on identifying bottlenecks and eliminate weak linkages in the ecosystem, and to harness STI to address social, economic and environmental challenges, then from the list of methodologies reviewed, Smart Specialisation Strategies (S3), TIP or STIP may be more appropriate. Looking at the steps from this Guidebook, it can be seen that different methodologies can also serve best during different steps in the roadmapping exercise.

The review of existing methodologies shows that none of the current approaches is fully comprehensive. One way forward is to explore synergies and complementarities among the methodologies and set up collaborations among the international organizations and agencies. Some of them are highly experienced in stakeholder involvement during the whole process of roadmap design – here the methodologies such as S3, STIP or TIP can be especially useful. In terms of analysing and planning policies and policy instruments, interested countries might look to the expertise of UNESCO in GO-SPIN or the World Bank in PERs in STI. The latter will also be useful for monitoring and evaluation exercises. Most of the methodologies analysed can support the countries in valuable analytical exercises, but few of them offer support for implementation. Those that do are S3, STIP and TIP. Because of these "specializations", the interested countries or subnational territories can choose one or more approaches that match their needs at the different stages of the roadmapping process. Through the combination of different approaches, the capacity-building effect and new collaborations between different organizations can bring additional benefits.

2.6 Ensuring a country takes full advantage of the global STI system

STI for SDGs Roadmaps also need to explicitly consider the international dimension. This includes how they will draw on and make effective use of the international supply of STI inputs, methodologies and approaches, data and evidence-based good practices, technical assistance and financing. The way that most countries tap global STI inputs for their SDGs is very fragmented and uncoordinated. The objective of this section is to help countries to more systematically assess and develop effective plans for accessing and effectively using global STI inputs to accelerate the achievement of their SDGs.

To a large extent, access to and use of global STI resources and expertise is intermediated by a country's national innovation system (see ***Chapter 3***). There are various dimensions to assessing the capacity of the country's national innovation sys-

tem to acquire, adapt, deploy and use global STI to help attain the SDGs. There are several useful methodologies for reviewing a country's national innovation system, as explained in the Background Paper by the European Commission JRC (see also the Operational Note for the Guidebook). What is proposed here is more narrowly focused on the extent to which a country's national innovation system is supportive and "fit for purpose" for effectively tapping into and domestically deploying elements from the global STI system that can help the country attain specific SDGs. Some of the key aspects to cover include the following.

- Assess to what extent the country's innovation system is able to identify and match relevant STI inputs from the global system, and to acquire and make effective use of them. This includes the capacity of government and other agents in the innovation system, in particular firms and other critical implementing agents.[42]

- Assess how well the national innovation system is drawing on relevant global STI inputs. What types of inputs is it receiving, or not receiving, through market and non-market channels? Is the national innovation system making full use of what can be obtained from abroad? If not, what are the obstacles and what is needed to resolve them? Likewise, are international advice and technical assistance being obtained through non-market channels having a positive tangible impact? If not, what are the problems or obstacles and how can they be addressed?

- Examine how well the country's policy and regulatory framework encourages, rather than inhibits, access to global technology and innovation. For example, since multinational companies and many small and medium enterprises are the main players in the creation and dissemination of technology and innovation, what policy or other barriers may there be to attracting relevant foreign investment? Similarly, are there regulatory or policy barriers to accessing foreign science and technology databases? In addition, it is important to assess the adequacy of the country's social policies. Emerging technologies offer many opportunities, but they can also disrupt jobs and increase inequality. Therefore, it is important that there are policies and mechanisms to retrain workers, as well as to provide social protection to people who lose their jobs or cannot find employment as a result of new technologies. It is also important to consider whether policies promote environmental sustainability, as many technologies that can assist in this area require a favourable policy environment. For example, proper pricing of water and energy, and good regulation against and charges for environmental pollution.

- Examine constraints in the country's infrastructure, particularly its STI infrastructure. This should include both its capacity to undertake relevant research to help track, monitor and acquire global technology and innovation, and its capacity to carry out its own R&D to adapt and develop technology/innovations relevant to its own needs. It should also go beyond the STI infrastructure to include the ICT infrastructure (which is now so critical to taking advantage of what digital technologies can offer), the education and skills necessary to use the technologies, and the depth and flexibility of financial and labour markets.

The government should also consider priority areas where STI elements can most usefully be obtained from abroad[43] and what that requires in terms of changes to the national innovation system. There may be options that require fewer international inputs, but this may mean longer lead

42 In a broader analysis of the STI system, it should also include an assessment of STI specialization and the competitive positioning of the country's key sectors and areas of research.

43 The Background Paper on International STI Collaboration includes a brief summary of the broad approach of the five largest donor countries to STI as part of their official development assistance (ODA). Governments of developing countries also need to actively explore how they may derive more coordination and synergy from the STI activities of various United Nations agencies and other actors on the supply side of STI.

times. There may also be seemingly easy options of "quick technology transfer" which may mean faster results, but less building of local capability. A critical issue here is also that of policy coherence. This is complex but important, because some STI roadmaps for the attainment of specific SDGs may work at cross-purposes with others. Open consultations with stakeholders can identify some of these trade-offs and help identify problems, and can be complemented by input from technical experts on alternative ways to address some of them.

Explicit consideration should be given as to what is expected in the short term (next one to two years) versus the medium term (three to five years), and long term (six to ten years).

- Interventions that may be possible in the short run include improving access to information about what is available internationally, changing policies and regulations that may constrain that access, and providing high-impact training and awareness building among policymakers and key actors in the non-governmental sectors. They may also include accessing and deploying innovations that allow leapfrogging, such as smart cell phones rather than fixed-line phones and computers, off-grid solar and wind electricity rather than central electric grids to reach dispersed rural areas, or many preventive medicine practices and vaccines rather than more expensive treatment, etc. This should also include how to strengthen the ability of local researchers and research institutions to participate in international programmes that are developing technologies relevant to attaining the SDGs.

- Programmes that can be launched in the medium term (three to four years) should focus on strengthening key infrastructural elements, as well as the broader innovation ecosystems, that will be necessary to mobilize and deliver STI elements that can accelerate achievement of the SDGs targeted by the country. They should also include strengthening some key STI infrastructure institutions than can help deploy relevant knowledge to meet the SDGs.

- Initiatives with a longer-term horizon include investing in domestic R&D capacity to develop new technologies and effectively deploy them to where they are needed, developing world-class research centres and universities, etc. However, some actions to achieve the medium and long-term outcomes have long lead times, so they need to be started in the short term.

Consideration should be given as to how the country's STI for SDGs Roadmap can draw on regional initiatives, such as the African Union's plans for science, technology and the SDGs, and Digital Transformation Strategy for Africa. In addition to addressing cross-border spillover effects inherent to some of the SDGs (e.g. water resource management in major river basins), there can be important economies of scale in addressing some STI for SDG issues. For example, through sharing of data and experiences of good practice, training programmes, articulation of specific challenges such as regional health hazards, access to safe water, weather monitoring, protection of environment and biodiversity, etc.

In addition, developing countries should consider how they may best aggregate some of their STI needs that require concerted global action, such as developing new vaccines for stopping global pandemics and tropical diseases, and new technologies to help mitigate and adapt to the impact of climate change such as more drought-resistance crops, non-fossil-based alternative energy, etc. Articulating the demand for technologies that can address these needs, and explaining why they are relevant to people in many developing countries, can help trigger a concerted response from the international STI supply system.

CHAPTER 3.

International Partnerships for STI for SDGs Roadmaps

This chapter is about the international dimension of the framework for STI for SDGs Roadmaps presented in ***Chapter 2***.[44] The objective of this chapter is to outline how international partnerships can do more to support the development and implementation of STI for SDGs Roadmaps. It draws heavily on the Background Paper, International STI collaboration and investment for Sustainable Development Goals.

The structure of this chapter is as follows: Section 1 depicts the global landscape of international partnerships for STI for the SDGs. It identifies three main communities involved, provides an overview of the relationship between the global innovation system and that of individual countries, and places the relative size and STI efforts of developing vs developed countries in a different context. Section 2 proposes a three-pillar framework for what the international community can do: build national STI capacity, boost the development and dissemination of STI across countries, and broker international coalitions to create global public goods in STI for the SDGs. Section 3 provides a summary qualitative assessment of the current state of international support for using STI for the SDGs in developing countries. It outlines what the main actors can do: governments, international institutions, the private sector, the science and professional community, foundations and NGOs. Finally, Section 4 highlights three main courses of actions for donor country governments, to help marshal STI to accelerate achievement of the SDGs and link them back to what receiving countries need to do to take advantage of international cooperation.

3.1 Landscape of international cooperation on STI for SDGs

Domains and actors

As in the case of national STI for SDGs Roadmaps, at the international level there are also three policy domains relevant to developing these roadmaps (***Figure 3.1***). Although there is some movement towards greater cooperation, efforts are still quite fragmented. Therefore, they are not as effective as they could be if they were more systematic and included more coordinated actions by their different constituencies.

SDGs Cooperation

The SDGs cooperation community is the newest, only in existence since 2015, although it builds on the Millennium Development Goal community. Progress on meeting most SDGs is occurring naturally as part of the development process. International partnerships for the SDGs are explicit in Goal 17, and innovation is explicit in Goal 9, while more effective use of STI can help to accelerate achievement of all the Goals.[45] Many actors are

44 *This is consistent with the technology-related targets under SDG 17 (17.6, 17.7, 17.8 and 17.16), which focus on international partnerships for STI to help achieve the SDGs (see **Annex 2**).*

45 *Goal 9 explicitly includes innovation in the title. Goal 17 explicitly mentions international cooperation on S&T as one of three main areas for international partnerships. The SDGs can only be achieved if there is more explicit use of STI to help attain them. A content analysis of the 17 Goals found that STI is formally agreed as a means or end for 12 (out of the 17) Goals, and 26 (out of the 169) targets (see Annex 2). However, STI is indirectly relevant for all the Goals, and virtually all the targets can benefit from some element of science, technology or innovation. In terms of the gap analysis for SDGs using the SDG Index and Dashboard commissioned by the Sustainable Development Solutions Network, the Goals that were lagging furthest were Goals 2, 3, 9, 12 and 14. In the mid-ground were Goals 7, 8, 10, 13, 15 and 16. Relatively advanced Goals were 1, 4, 5, 6, 11 and 17 (IATT, 2017). Therefore, if the Goals are to be achieved faster than with business as usual, there is an additional urgency in the demand for STI inputs that can help with the Goals that are lagging furthest.*

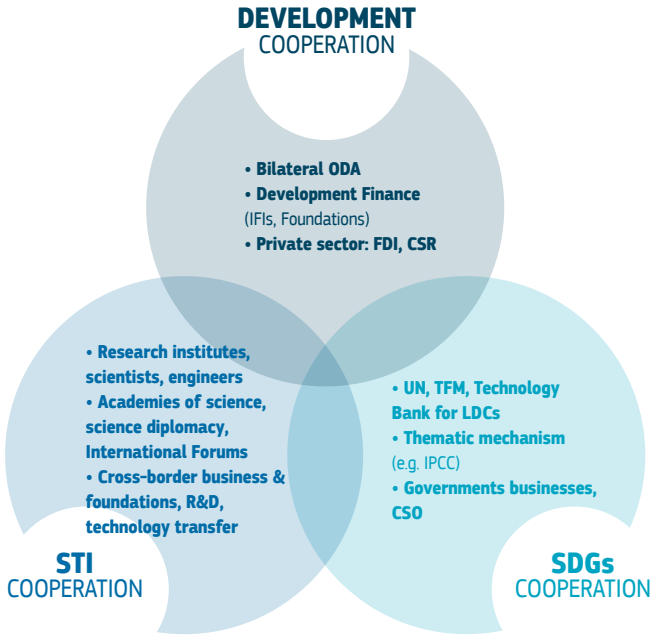


Figure 3.1: *International STI for SDGs cooperation: domains and actors*

Source: Authors

involved in SDGs cooperation communities, ranging from governments to foundations, the private sector, the academic and professional community, NGOs and civil society. International cooperation to help achieve the SDGs is ongoing, and some of the SDGs could be attained with enough time and resources. The key point is to accelerate their achievement. For this to be accomplished, there needs to be a stronger emphasis on leveraging STI more effectively into plans to achieve the SDGs.

Development Cooperation

The development cooperation community includes many actors, ranging from governments, the United Nations system, multilateral development banks and international foundations to civil society organizations, professional societies and individual citizens. The objectives are also very broad, including elements of helping developing countries to achieve the SDGs, as well as strategic national and personal interests. There are elements of STI support in development collaboration, but these are relatively small as described later in this chapter. Moreover, the STI components are not all focused on helping to achieve the SDGs. Nor should they be, as the goals of development cooperation include advancing national interests. However, there could be more effective use of development cooperation to use STI to accelerate achievement of the SDGs. The actions by different players will be outlined in the next section.

STI Cooperation

There is growing awareness that a global innovation system must include more active participation by developing countries; that the system has many key actors – not just governments, academia and the private sector, but indigenous knowledge and frugal innovation holders; and that foundations are playing an important role in funding R&D and innovation, which was previously more limited to governments and the private sector. The STI community is increasingly aware of the need to incorporate SDGs into their work (UNCTAD, 2018, 2019; OECD, 2018). There is a need for a new innovation system that pays more attention to inclusiveness and environmental sustainability, which is partially addressed by some of the ongoing international STI collaborations. To achieve the SDGs, there is a need to direct more STI effort towards those Goals. There is also a need to increase capability in least developed countries to help them to leverage STI for achievement of the SDGs.

To a limited extent, the three communities are slowly converging, as development cooperation is mainstreaming the SDGs, and STI cooperation – which historically has focused more on competitiveness and cooperation in R&D among advanced countries – is beginning to focus more on the SDGs and on helping developing countries to achieve them. However, as will be developed below, there is much more that can be done.

The relationship between global and national innovation systems

Figure 3.2 presents a stylized representation of the global STI system, linking the global STI sup-

ply to a country's national innovation system and the STI needed to accelerate achievement of the SDGs. For explanatory purposes, the international STI supply can be conceived as consisting of global science supply and global technology and innovation supply.

The main forms of science collaboration are training in science and mathematics, joint research with participants from developing countries, formal scientific collaborations and networks (e.g. the Belmont Forum), mobility of researchers and highly skilled labour, and research into the specific needs of developing countries. Science is also transferred by making available the output of scientific work through scientific and technical papers, international science conferences and symposiums, and scientific databases. Many of these collaborations occur through non-market mechanisms.[46]

The main actor in technology and innovation supply is the private sector. The main way that technology and innovation are disseminated to developing countries is through market mechanisms such as the import of manufactured goods (particularly capital goods and technology-intensive intermediary goods), technology licensing, foreign direct investment, ICT and commercial services, patents and trademarks, and training in engineering and management. A lot is also disseminated more informally through non-market mechanisms such as international travel, attendance at international technology and commercial fairs, reverse engineering and copying, and informal networks. The international STI system can interact with the supply as well as the demand side of the national innovation system. The science element interacts particularly with the supply side, while the technology and innovation elements interact primarily with the demand side.

The middle of ***Figure 3.2*** depicts the national innovation system,[47] distinguishing between four main kinds of actors (universities and research centres, firms and organizations, national and subnational governments, and consumers and civil society), and showing the broader context and framework conditions, and the underlying natural resource endowment.

The critical elements are the linkages, flows and accumulation of knowledge, people and finance among the actors. The broader context includes key infrastructures of most relevance to the national innovation system, such as the STI infrastructure (universities and research parks; research centres; business incubators and accelerators; metrology, standards and quality control, etc.) and ICT infrastructure (now a critical infrastructure not just for the national innovation system, but for the economy more generally). It also includes key institutions (finance and venture capital; labour and capital markets) and the policy and regulatory regime (macro policy; business environment, including intellectual property protection and the rule of law; STI, competition, social and environmental policies).

National innovation systems have many objectives driven by key actors (such as the pursuit of knowledge by scientists, the pursuit of competitive advantage by firms, the pursuit of better livelihoods by civil society, and the security, competitiveness and welfare goals of governments). The agreement by the global community on the SDGs in 2015 put another broad, multi-faceted demand on the global and national innovation system, with social inclusion and environmental sustainability as additional key objectives (United Nations, 2015).

46 *These are activities that are not provided through a transaction of money paid for goods or services based on a market relationship. They include grants and prizes, and collaborations where different parties contribute time and effort towards a common goal.*

47 *There is a broad literature on national innovation systems. What is presented here is a brief sketch that highlights the importance of keeping in mind the different agents, as well as the broader institutional, policy and social context in which they operate.*

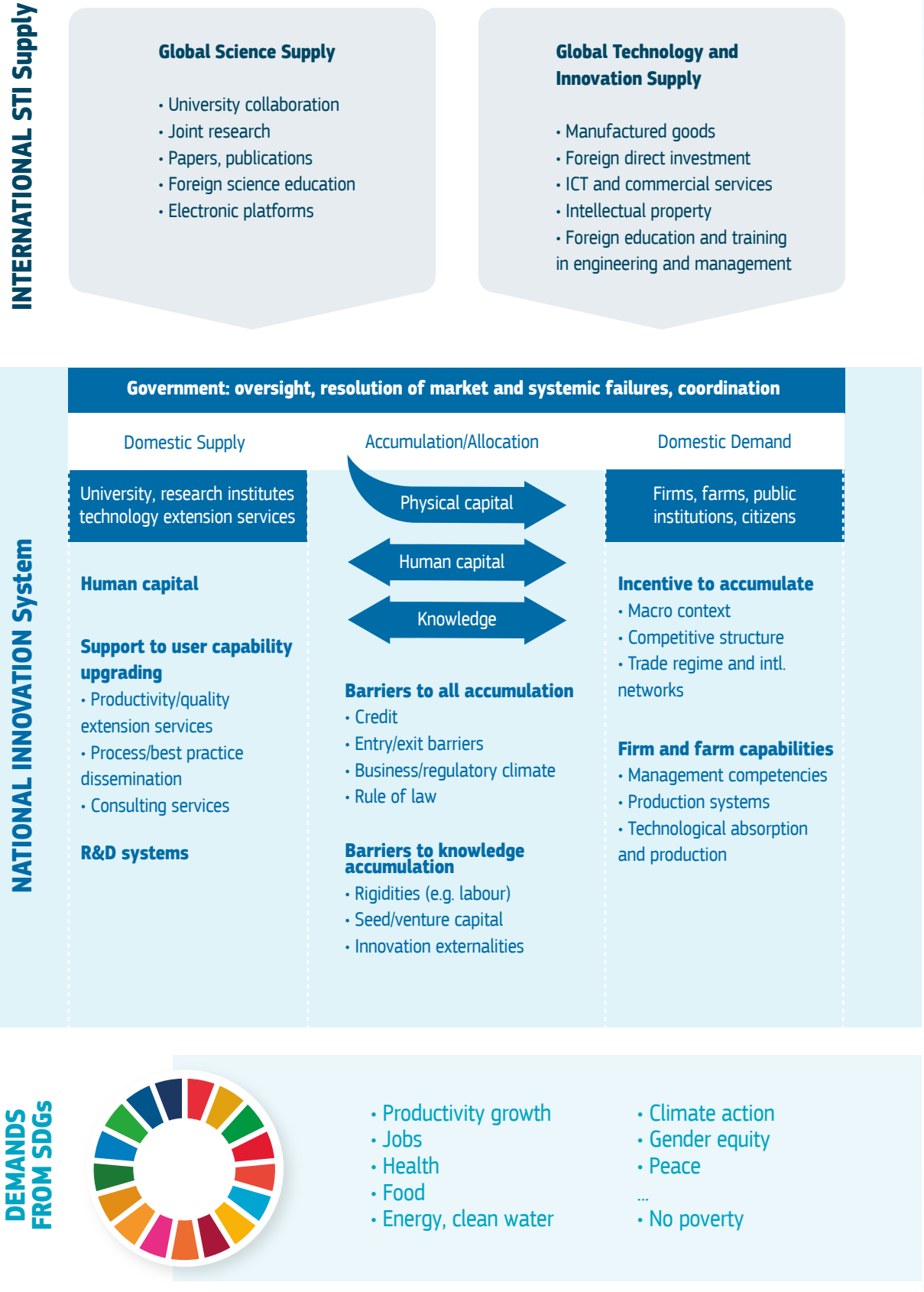


Figure 3.2: *Positioning the national innovation system to benefit from international STI supply and address the SDG demands*

Source: Authors, based on Cirera and Maloney (2017) for the middle part of the figure.

3.2 Three-pillar framework for international partnerships – Build, Boost, Broker

The low STI capacity of developing countries is a critical constraint to effective international collaboration.[48] It applies to a variety of actors, including firms and entrepreneurs, research and education systems, government, consumers/users, and civil society and citizens. This is therefore reflected in the three-pillar framework for international STI collaboration proposed below in ***Figure 3.3***.[49]

The first pillar for collaboration focuses on strengthening national STI capacity, mostly in developing countries, to address challenges underpinning the SDGs. It includes building both endogenous capacity and capability to absorb external knowledge and technology. This pillar of international collaboration benefits individual countries directly. The support may be provided by another country (bilateral collaboration), a group of countries, international organizations or scientific and professional societies.

The second pillar for collaboration focuses on boosting international flows of relevant knowledge, technology and innovation across countries, and on supporting cross-border STI collaborations addressing the SDGs. One objective of this type of international collaboration is to shape international STI markets and remove bottlenecks impeding the flow of knowledge, people and finance directed towards the SDGs. This includes adapting international framework conditions to foster existing STI for the SDGs, as well as promoting stronger non-market flows such as scientific, academic and professional cooperation. Another objective is to foster STI collaborations to create new STI that can help countries address local challenges in attaining the SDGs. As a result of this intervention, knowledge, people and investments relevant for the SDGs will reach countries and communities where they are most needed, more effectively. This pillar also includes supplying global public goods (GPGs) needed to facilitate better matching of STI supply and demand, such as data, expertise and scientific knowledge.

The third pillar focuses on engaging in international collective STI actions with the ambition of tackling global challenges. The level of intervention is focused on enhancing the global STI system to endow it with collective capabilities and institutional settings to undertake collective action at a large enough scale to address critical gaps. These collective STI actions have an explicit focus on tackling global challenges and achieving transformative impact. This pillar is key to safeguarding the global commons (common-pool resources) as well as collectively developing new knowledge and solutions to achieve the SDGs. The focus is on planetary STI capabilities.

There is a strong science policy community, and a well-developed science advisory ecosystem, that can be mobilized to help create these coalitions. Part of what is missing is a greater willingness by governments and other actors, including the private sector, to commit resources and organization to supporting these coalitions. Another major challenge is developing appropriate governance to coordinate and manage the multiple actors needed to advance not only the necessary STI, but also the deployment systems to deliver it at a scale that can make a difference.

48 *Also see Colglazier (2018) for a strong rationale of why it is important to create more STI capacity in developing countries.*

49 *Underlying analysis, case studies and a typology of various interventions are elaborated in the Background Paper on International STI collaboration and investment for SDGs; World Bank (2018b) applies the three-pillar "build, boost, broker" framework to creating opportunities and mitigating risks of emerging technologies.*

The pillars, and their respective actions and collaboration mechanisms, are interdependent and therefore need to be "geared" towards fitting each other to maximize collective impact through multiplier effects. These interdependences are not necessarily linear or one-directional. For example, focusing only on strengthening the STI capacities of developing countries cannot overcome bottlenecks in international STI flows or effectively address challenges relating to GPGs. Boosting international STI flows alone will not overcome capability gaps at the national level. Taking international collective action will not replace building country-level capacities.

Successful instruments and collaboration mechanisms tend to address more than one pillar of collaboration. For example, CGIAR (formerly the Consultative Group for International Agricultural Research) includes dedicated activities aimed at building local capacity (build), knowledge sharing, e.g. via participation in multi-stakeholder platforms (boost), and facilitating integrated international collective actions addressing global challenges and global transformations (broker). Similarly, Mission Innovation includes information and knowledge-sharing activities (boost) as well as joint technology demonstration (broker). ***Table 3.1*** summarizes current practices in international STI cooperation for each of the three pillars. Under boosting STI flows, the table distinguishes typical non-market from market mechanisms, since they have different targets for support and instruments. The last column of the table gives some illustrative examples, although many of the examples address more than one pillar. While it is quite challenging to broker global coalitions, there are numerous historical examples as well as some ongoing efforts (see the Background Paper on international STI collaboration).

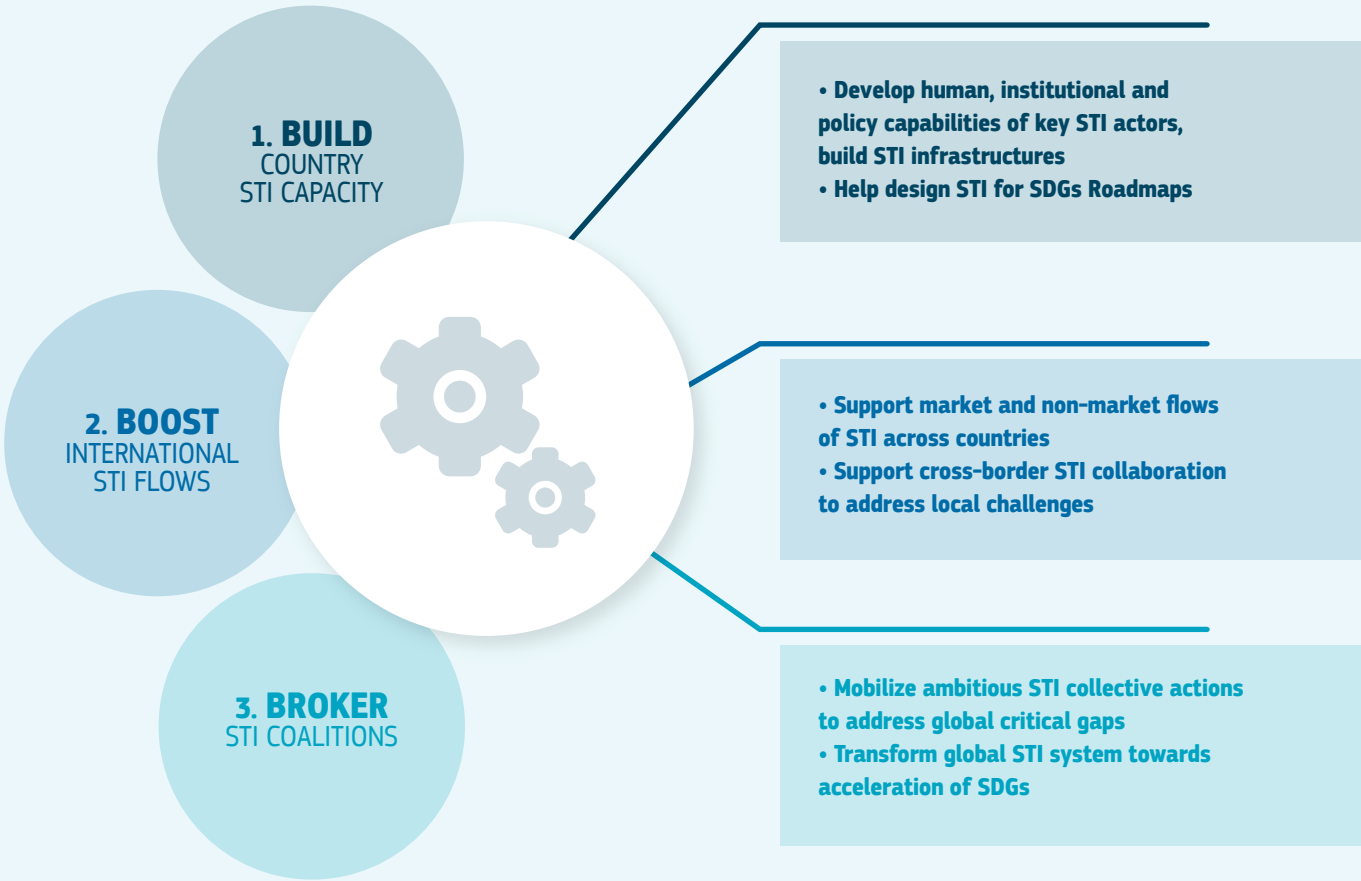


Figure 3.3: *Three pillars for international STI collaborations for the SDGs*

Source: Authors

Given the complexity and urgency of the challenges we face, countries and the international community need to engage in all three pillars of international collaboration to mobilize STI for the SDGs. The three pillars should not be translated into a simple step-by-step strategy (e.g. first focusing on improving country STI capacities, then addressing international knowledge flows and considering international collective STI action). The importance of each pillar of international STI collaboration needs to reflect the specific challenges and context. In some cases, collective STI action for GPGs can be used as a strategic lens to concentrate international efforts to build specific STI capacities and infrastructures in (mainly but not only) developing countries that are either mostly exposed to specific challenges, or could create more value benefiting other countries or disadvantaged communities.

3.3 Key priorities and actors in STI collaboration for SDGs

It is helpful to put the key actors and elements of the three pillars in perspective before outlining what the government can do. ***Figure 3.4*** provides some details on the relative representation of countries at different income levels, in terms of population, GDP and STI activities.

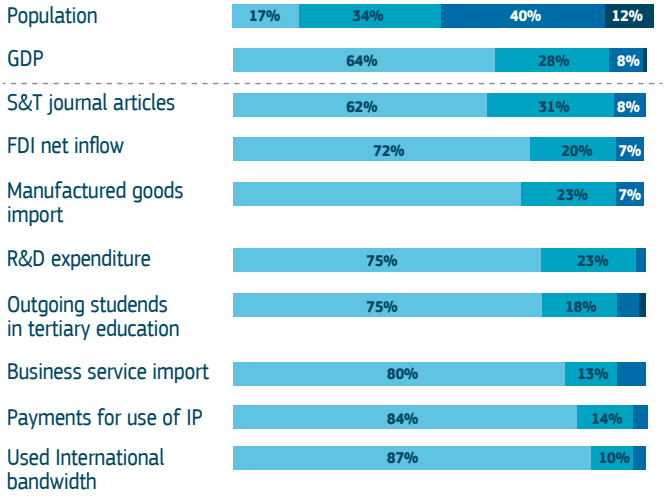
The main points to note are:

- While the developing world (middle- and low-income countries) accounts for 83 per cent of global population, it only accounts for 36 per cent of world GDP. These differences are less pronounced for upper middle-income countries, and most pronounced for low-income countries whose average per capita incomes are only 1.8 per cent of that of high-income countries.
- R&D capability (as proxied by R&D expenditure) is even more skewed, with developing countries accounting for just 23 per cent of world R&D. Moreover, the bulk of the R&D in developing countries is performed by China (not indicated in the table but this is $258 billion or 60 per cent of all R&D by developing countries). Lower middle-income countries account for only 1.9 per cent of global R&D, and low-income countries perform virtually no R&D.
- The output of scientific and technical journal articles is less skewed than R&D expenditures, with developing countries accounting for 38.9 per cent of the total. The lower middle-income countries' share (7.5 per cent) is almost four times as high as their share of R&D expenditures.
- The largest 1,000 companies account for 42 per cent of global R&D ($782 billion out of a total of around $1,860 billion in nominal dollars).[50] Moreover, transnational companies are the main mode of global dissemination of technology and innovation, through their trade and foreign direct investment activities and technical information transferred through supply chain links.
- Cross-border data flow, proxied by international network bandwidth used, is the activity most concentrated in high-income countries (even including China and India, the middle-income countries have small shares). This indicates the serious risks to developing countries of being left behind in digital transformation.

The key points to note are that most science, technology and innovation is performed in high-income countries, to meet their needs and to strengthen their international competitive position. Developing countries have much greater challenges than high-income countries in meeting the SDGs, be-

50 See Jaruzelski and others (2018) for R&D by largest companies.

DISTRIBUTION OF STI FLOWS,
BY COUNTRY INCOME GROUPS



RELATIVE SIGNIFICANCE OF STI FLOWS

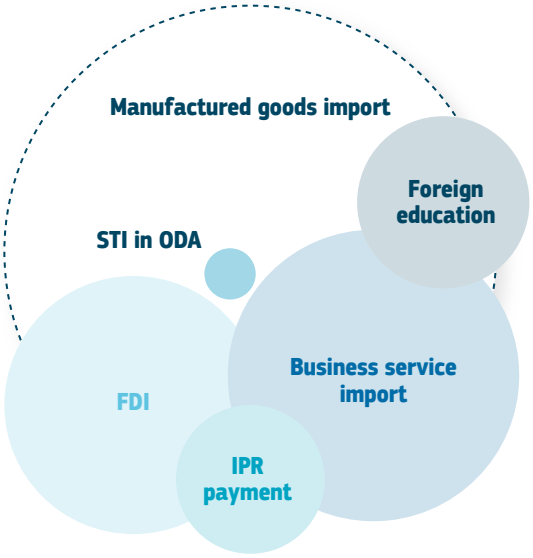


Figure 3.4: *Distribution and significance of STI flows to developing countries*

Source: Authors

cause their SDG gaps are much larger. In addition, most R&D is performed by the private sector, in particular large multinational companies.

To advance international STI collaboration more fit for the SDGs, it is useful to examine the current situation from the perspectives of developing countries. Most of the activities by ODA, STI and SDG communities oriented towards STI for SDGs are non-market.[51] This contrasts sharply with market-driven flows that transfer technology and innovation that may be relevant for the SDGs, and are driven mostly by private sector activity. The main market flows are net inflows of foreign direct investment, imports of manufactured products, imports of ICT and business services, payments for the use of intellectual property rights, and tertiary education abroad, which is an important way to acquire foreign knowledge.[52] As can be seen in ***Figure 3.4*** (right panel), these market flows are much larger than the STI-oriented activities of ODA.

Figure 3.5 quantifies ODA disbursement for science and innovation and for technology, by main ODA donor countries. As can be seen, the disbursements for science and innovation are much larger than those for technology. Combining the data from ***Figures 3.4*** and ***3.5***, the following conclusions can be drawn regarding the relative actions of the key actors with respect to the three pillars.

- ODA for STI is very small compared to market STI flows. In addition, ODA emphasizes capacity building for STI (with debatable outcomes and measurement issues) and funding for R&D, but appears less focused on boosting the flow of existing STI across countries, and very little on brokering global public goods because it is largely delivered through bilateral programmes. However, despite their small size, ODA and multilateral STI-related activities can be used by governments to leverage those of

51 *The activities of NGOs tend to be mostly non-market. The activities of international institutions fall partly under ODA but mostly under market activities by the private sector. This is because, while they finance some STI capacity, they mostly finance many STI-related activities (even R&D activities and STEM education) through commercial loans to governments and projects co-financed with the private sector that deploy existing technology and innovation.*

52 *More details in the Background Paper on international STI collaboration.*

Table 3.1

Current practices in international STI cooperation for SDGs

		UNIT OF INTERVENTION
BUILD STI CAPABILITY		Individuals
		Human capital base and institutions
		Broader STI system
BOOST STI FLOWS	Non-market	Link/strengthen existing STI for SDGs
		Increase new STI for local challenges
	Market	Barriers to markets
		Trade and investment flows
BROKER STI COALITIONS		Norms, values, standards, statistics
		Coalitions addressing critical global gaps
		Transformative STI system (global/regional)

Source: Authors, informed by World Bank and OECD; Background Paper on international STI collaboration for SDGs Roadmaps.

ABBREVIATIONS: *ASEAN, Association of Southeast Asian Nations; ACE, Africa Higher Education Centers of Excellence; TNA, Technology Needs Assessment; PASET, Partnership for skills in Applied Sciences, Engineering and Technology; AOSP, Africa Open Science Platform; GCRF, Global Challenges Research Fund; WEF, World Economic Forum; NVA, New Vision for Agriculture; WRG, Water Resources Group; DE4A, Digital Economy for Africa.*

AREAS OF INTERNATIONAL SUPPORT (INSTRUMENTS AND RECIPIENTS)	SELECT EXAMPLES
■ Researchers: scholarships, research grants ■ Absorptive and innovation capacity of farms/firms: training, Business Development Service (BDS), agricultural/management extension services ■ STI policymakers: training, peer learning, learning-by-doing	ASEAN-India S&T Development Fund
■ STEM education, digital skills, basic and applied research institutes ■ Entrepreneurship/deployment system, intermediaries, networks ■ Public service delivery (e.g. health, education, water, conservation)	World Bank ACE UN agencies STI training programmes
■ STI-related infrastructure (quality systems, connectivity, etc.) ■ STI system diagnostics, policy advice/assistance for reforms ■ Sectoral R&D and innovation systems (e.g. energy)	UNEP TNA STIP/GO-SPIN/PERs
■ University partnerships, exchange programmes ■ Multi-stakeholder platforms, networks, communities of practitioners ■ Facilitate a multi-stakeholder collaborative approach to combine efforts	UN Multi-stakeholder Forum on STI for SDGs, PASET AOSP, EU JRC S3
■ Supply-push: joint research projects ■ Demand-pull: government procurement, prizes	CGIAR, UK GCRF X Prize; Horizon Europe international research partnerships
■ Support development and use of the online technology platform for matchmaking STI supply and SDG demands	TFM online platform
■ Donor/international financial institution projects to crowd in and catalyze R&D, technology transfer and innovation linkages through private capital and blended finance ■ Treaties and other agreements (e.g. intellectual property) conducive to STI flows	Lighting Africa US Feed the Future WEF: NVA, WRG
■ Global visions, strategies, monitoring reports ■ Cross-border monitoring and evaluation systems	UN Digital Cooperation Panel
■ Partnership/funding/governance frameworks ■ Mission-innovation programmes, grand challenges	US PEPFAR, DE4A, WEF Frontier 2030
■ Joint or aligned fiscal/procurement/research policies ■ Explore synergies and promote system-wide leverage to support international partnerships and multi-stakeholder initiatives for the design and implementation of roadmaps	Horizon 2020, TFM

other actors, including the scientific community, NGOs and the private sector, as will be developed in the next section.

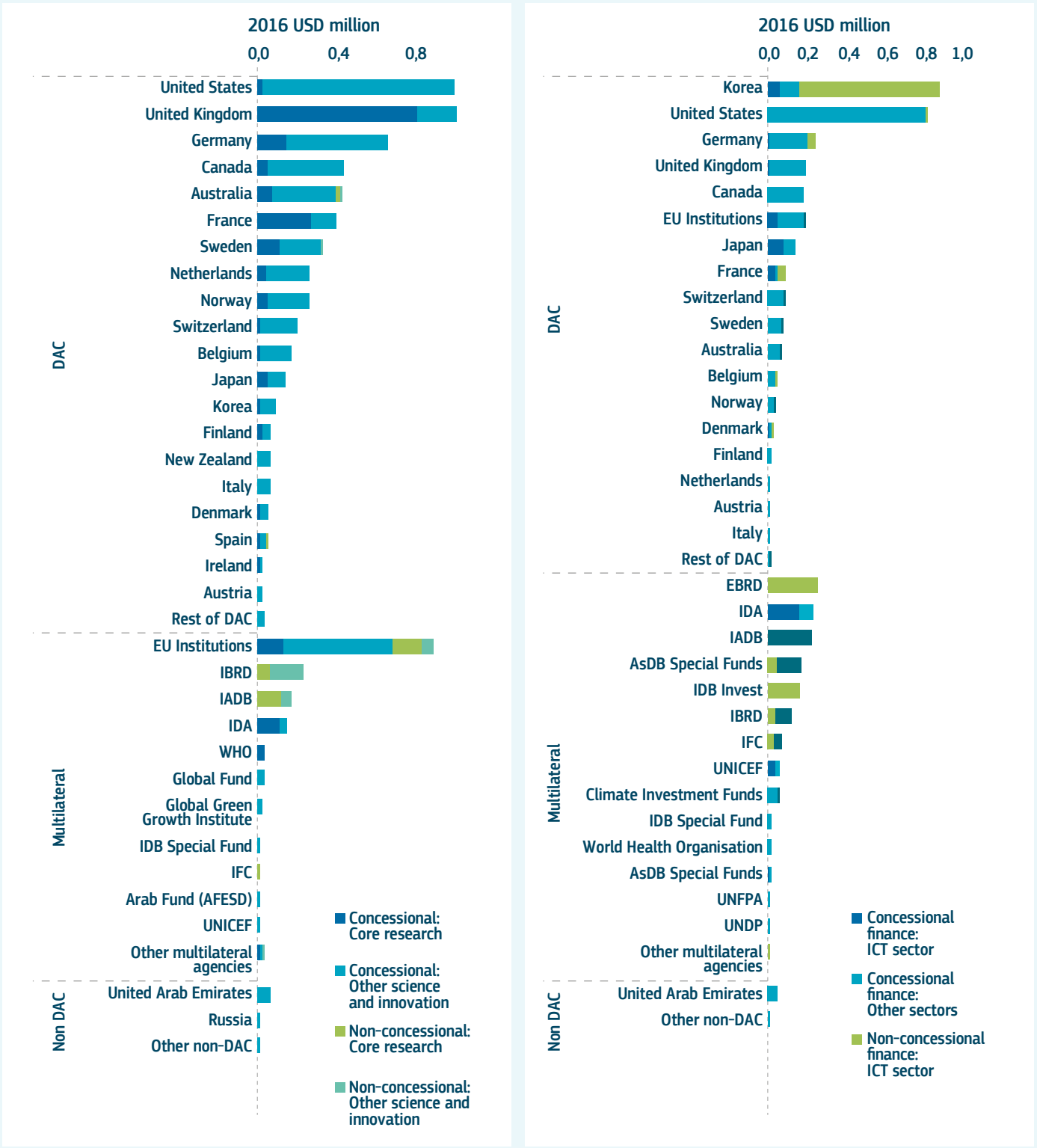
- STI cooperation is more focused on pushing the boundaries of knowledge and performing R&D than on building country capacity to use STI for the SDGs, which is relatively small compared to international collaboration among advanced countries.[53] However, the STI community can potentially play a highly significant role under all pillars. This is very forcefully argued in the Global Sustainable Development Report 2019 (Independent Group of Scientists, 2019; see also ***Box 2.2***), which emphasizes in particular the need for the scientific community to go much further in developing new science and technology to take advantage of synergies among the Goals, and to manage trade-offs and address negative impacts. The role of the STI community under Pillar 3 is limited by the difficulty in brokering coalitions to take on large-scale challenges, due to problems relating to scale, limited finance and workable governance arrangements.

- SDG cooperation on STI, such as the United Nations TFM, has not been able to achieve much under any of the pillars, despite the clearly articulated need to harness STI to achieve the SDGs. This is largely because of its limited funding to boost the flow of existing knowledge, broker concrete collaborations to create new STI, or build country capacity beyond some training, methodologies and policy advice. However, it has a potentially highly significant role in brokering global STI coalitions to address grand SDG challenges, through its advocacy and convening power (see ***Annex 1***). This is an area that will be addressed in the next chapter.

- The private sector plays a very important role in delivering under the second pillar, through its role in creating and transferring knowledge and technologies through market activities, including foreign direct investment, R&D, sale of intellectual property and sale of manufactured products and business services. Typically, however, market incentives do not necessarily assure inclusive outcomes for the most marginalized groups. The private sector has a weaker role in building country capability to use STI for the SDGs, although multinationals often build the absorptive capacities of small and medium enterprises and improve management practices through supply chains and contracts, strengthen key elements of the national innovation system such as research centres, and develop STI-related training programmes at universities. The private sector is very weak on the third pillar, because almost by definition there are problems with incentive due to lack of appropriability, high risk and complexity. However, more recently, the private sector has been realizing that it has a critical and major role to play in achieving the SDGs, as illustrated by a major initiative launched in January 2020 (see ***Box 3.1***), showing that there is great potential for governments to work together with the private sector and the scientific and NGO community to boost and broker STI for the SDGs.

The next section will focus on what governments can do to make effective use of ODA, as well as to leverage more STI activities by other key actors in the international community.

53 *Since most of these activities are non-market, it is harder to quantify the actual volume of R&D focused on developing countries and less on STI for SDGs. Details in the Background Paper.*



ABBREVIATIONS: *DAC, Development Assistance Committee; IBRD, International Bank for Reconstruction and Development; IADB, Inter-American Development Bank; IDA, International Development Association; IDB, International Development Bank; IFC, International Finance Corporation; AFESD, Arab Fund for Social and Economic Development; EBRD, European Bank for Reconstruction and Development; AsDB, Asian Development Bank.*

Figure 3.5: *Sources and content of STI in ODA supporting science and innovation (left panel) and technology (right panel): disbursements in 2016 prices*

Source: Ericsson and Mealy (2019)

Box 3.1

New private sector initiative on unlocking technology for the SDGs

The World Economic Forum (WEF) is one of the institutions hosting multi-stakeholder initiatives to systematically onboard private sector efforts to address global challenges. Its key initiatives to engage industries, international development partners and governments of developed and developing countries, and to integrate technology development/deployment with investments, policy reforms and other complementary measures, include the New Vision for Agriculture and the Water Resources Group (for case studies, see Background Paper).

At its Annual Meeting in 2020, WEF launched a new initiative called Frontier 2030 - a New Fourth Industrial Revolution for Global Goods Platform, with an accompanying report. The report analysed over 300 Fourth Industrial Revolution technologies that could make contributions to meeting the SDGs. However, they found that there were significant barriers and risks to scaling these applications. The barriers include "poor data access and quality, a lack of basic infrastructure, an inadequate governance and policy environment, upskilling and reskilling needs and – in particular for public goods-focused solutions – a lack of viable business models and commercial incentives for scaling" (p.7). The basic argument is that business as usual is not an option for achieving the SDGs by 2030 and that "a gearshift is urgently needed, from the current race to deploy new technologies for short-term growth and private gain to a more long-sighted and principled approach that actively manages and harnesses the role technology can play for humanity and the environment" (p.29). The report argues that the private sector has a critical role to play, in partnership with government, the scientific community and civil society, in developing and scaling the technologies to facilitate achievement of the SDGs, and in managing the downside to that technological revolution – from security and control risks to socioeconomic risks such as job displacement, and even unintended environmental risks. They identified eight "enablers needed to continually accelerate innovation and investment into new solutions that help tackle our grandest challenges, and to create viable markets for those solutions in the long term":

1. Responsible technology governance: from "do no harm" to "principled and positive impact"
2. Leadership: leadership to mobilize commitments and standards
3. Partnerships: collective action and collaboration
4. Public policy: policies and regulation for the Fourth Industrial Revolution
5. Finance mechanisms: stimulating the Fourth Industrial Revolution for good market solutions
6. Breakthrough innovation: shaping an innovation agenda to tackle the most pressing social and environmental challenges
7. Data and tools: new models for data collaboration scaled for Global Goal impact

8. Skills: upskilling, reskilling, interdisciplinary talent and collaboration

They issued a call to action for tech sector executives and government leaders, advocating "coordinating, mobilizing and tracking commitments, and action, around a collective mission to accelerate and realize technology's potential to tackle the Global Goals" and organizing vital pathways that also help different stakeholders recognize the respective and complementary roles that each needs to play to change business as usual (WEF, 2020).

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3.4 What donor country and pilot country governments can do

Donor country governments

It has become clear to the international development community that more effective use of innovation is critical to achieve the SDGs, in light of the needs and limited financial resources. An upcoming report by the Development Cooperation Directorate of the OECD (2020) found "at its best, the innovation work DAC donors have led and supported involves the fusion of new technologies and technical advances with new business models and organizational approaches, and efforts to reform and transform institutions, norms and political context." It argues that "this kind of innovation ... is the best pathway for achieving the SDGs and other global commitments." However, it found that the efforts are fragmented and that not enough is being done to make innovation a major driver of development assistance. It urges DAC members and other development organizations to support innovation "as a centrally important and cross-cutting strategic capability," and to "[harness] ... this capability courageously and systematically in pursuit of the most pressing and complex development and humanitarian goals."[54]

In the language of this Guidebook, this includes more efforts to build, boost and broker STI activities for attainment of the SDGs. Donor country governments – not just those from developed countries, but also developing country governments with strong STI capabilities and development assistance programmes – can undertake various initiatives to improve the use of STI in developing countries to help them achieve the SDGs.[55]

These include three areas:

- Improve the coherence and effectiveness of the STI components in the ODA assistance they provide to developing countries
- Leverage the broader STI supply beyond what they do through direct ODA, by providing incentives or otherwise facilitating market and non-market channels
- Create international coalitions of STI actors to take on grand challenges

Improve the coherence and effectiveness of the STI components in ODA assistance

The World Bank took a detailed look at the disbursement of STI-ODA intersections in 2017 by the five largest donors: United States, Germany, UK, Japan and France (Kanehira and others, forthcoming 2020). Based on this analysis, and the one by OECD (Ericsson and Mealy, 2019), concessional finance for STI is estimated to range from $10 billion to over $20 billion per year, representing six to ten per cent of total concessional finance by DAC members, multilateral organizations and other countries, according to the Background Paper on international STI collaboration. Data on these ODA for STI programmes and activities are not very well reported, shared or analysed; there is an urgent need to build up a robust and comprehensive evidence-based mechanism for coordinating within and across donor countries, to capitalize on respective comparative advantages and achieve greater impact and improved outcomes.[56]

54 *See more details in Background Paper on international STI collaboration for the SDGs*

55 *Triangular cooperation, where a developed country helps finance the transfer of relevant technology and innovation from one developing country to another, is also an important element, particularly for grassroots and other inclusive and frugal innovations that commonly originate in developing countries.*

56 *Further analysis of the coherence of action across countries is needed to overcome barriers.*

Donor country governments also need to think strategically about what makes the most sense for them in supporting STI for the SDGs in developing countries. Currently, STI support from donor countries to developing countries is highly fragmented.[57] More systematic efforts are needed to enable donors to understand what different ministries and agencies are already doing in this area. The joint European Union programmes, open to international research and innovation collaboration, can provide a good example of such an activity.[58] There are different country models of STI-related ODA assistance. The Background Paper provides a brief overview of those of the five largest donors (United States, Germany, UK, Japan and France). There are advantages and disadvantages to each of these variants.

Donor countries should consider their national strategic foreign policy and competitiveness interests, as well as their STI strengths and capabilities, as the basis for defining the objectives and scope of their contributions to STI for the SDGs in developing countries. In addition, donor countries may find it useful to undertake public expenditure reviews of the efficiency and effectiveness of the STI components in their ODA.[59]

It is likely that their interests would be better served if they were to develop more strategic and better integrated activities across government departments/agencies and with other agents in their national innovation systems, as well as with other countries, and be more systematic about developing their country's contributions.

Leverage the country's broader STI supply to build and boost STI in developing countries

Donor country governments can also try to leverage the broader supply of STI from their countries. While ODA is just a fraction of the total STI elements a country supplies to developing countries, it can be leveraged if countries are able to use it strategically to influence the broader country supply of STI. Unfortunately, most donor country governments have little systematic knowledge of how the private sector, universities, think tanks, NGOs, professional associations, diaspora networks or individuals are supplying STI inputs to developing countries.

To develop more effective assistance and leverage STI inputs to accelerate achievement of the SDGs in developing countries, it is important to know who in the country is doing what, and to understand what drives them, what they are accomplishing, and how they could be organized to have greater impact. This assessment is fundamental to developing a realistic vision of what can be accomplished, what role the government could play, and how it is to be done. This requires consultation within the government as well as with relevant stakeholders in the country, such as the private sector, academia and civil society, as their involvement will be important for formulating and delivering the initiatives.

As previously noted, the private sector is the main agent in the generation and global dissemination of technology and innovation. While it is primarily motivated by its own profit-making interests, it does undertake STI activities that can be relevant to achieving the SDGs, where it finds profitable opportunities (e.g. more energy-efficient and alternative energy technologies, lower cost health services, cures for diseases, lower cost sustainable shelters). Moreover, it responds to regulations and incentives and other instruments that the government can use to influence its activities. There are therefore opportunities to try to influence private sector contributions to STI for the SDGs, such as carbon pricing on fossil fuels, and regulations on emissions and other environmental "externalities".

57 *The efforts of many agencies as well as of multilateral development banks are also very fragmented even with-in the agencies, and especially across institutions. This is an endemic challenge that should be addressed in the context of developing international STI for SDGs roadmaps.*

58 *The European Union and its Member States are the world's major donors of development aid.*

59 *The World Bank has developed a guidebook for undertaking public expenditure reviews for STI within a country (World Bank, 2014), which may provide some useful insights into how donor countries can review the effectiveness of the STI components in their ODA.*

Innovative public procurement can also have an important role in generating new solutions.

Likewise, governments can influence the activities of NGOs, academics, researchers and citizens through a wide range of policy instruments other than direct finance, as summarized in ***Table 2.2***. Thus, there is room for governments to encourage other agents to deploy STI efforts towards the SDGs, including activities directed at the specific challenges of developing countries.

On the government side, this will necessarily involve the ministries of foreign affairs, development, science and technology, telecommunications, industry and commerce, finance and many others, as well as relevant agencies and committees of congress or parliament and the head of government. It should also involve the mass media to build public support for the plans, and take into account the STI needs of developing countries that the government aims to assist. The specific Goals and targets should be set after considering the different approaches, to reflect what is politically and economically feasible.

Leveraging activities being done by other agents or institutions in the country includes providing incentives to increase the STI support they give, such as matching research grants and scholarships, co-funding technical assistance, or underwriting some of the risks in financing such ventures. It also includes non-financial levers, such as providing leadership and coordination for activities in the country supporting greater STI inputs to help developing countries achieve the SDGs.

Stakeholder consultation should be held to create consensus and ensure buy-in from different actors in developing a detailed plan of action. This should set out clear goals and priority actions, including the responsibilities of the different agents, financing, special incentives, etc. Governments have many policy instruments, including direct action through their ministries, agencies and special programmes, tax and incentive systems, awareness campaigns and moral suasion, and coordinating the actions of others.

The government should identify what is required to improve leverage through each of these routes. This is related to how much political support there is at the highest levels of government, not only to make more effective use of the STI assistance that is already being provided, but also whether there is an appetite for increasing support, and even taking a global leadership role in developing some relevant technology or innovation. However, even making effective use of the existing overall budget requires some political capital, because there are always entrenched vested interests in retaining ongoing programmes. It also requires coordination across different ministries and programmes, and developing processes to accomplish this, as well as some lead agency or point of contact at a high level of government such as the Head of State or Cabinet Office.

As in the case of receiving country STI for SDGs Roadmaps, those for donors should have clear provisions for monitoring and evaluation of results, as well as periodic readjustments in light of what works and what needs to be improved or changed. For this to happen, it would also be useful to consider formally monitoring these specific STI for SDGs Roadmap activities as part of ODA peer review mechanisms (such as through the Development Assistance Committee of the OECD). It would also be helpful to set up a peer learning mechanism to share approaches and best practices among donor countries, including non-DAC members active in this area such as China, India, Brazil and South Africa.

The roadmaps should identify direct government financing, as well as what is expected from other actors in the country and from other international donors and the recipient countries themselves. It should also identify concrete monitorable milestones over specific time periods.

Broker international coalitions of STI actors to take on grand challenges

Beyond what donor governments can do to coordinate their own country's STI supply to developing countries, they should also consider creating inter-

national coalitions of STI actors to address grand challenges. As has been clearly articulated in the Global Sustainable Development Report (2019), there is an urgent need for more concerted scientific effort to address the synergies and particularly the trade-offs among SDGs, as well as some of the global trends that may negatively impact achievement of the goals, such as climate change, increasing inequality and environmental degradation. Many of these global challenges are beyond the capability of any one country to address. They require large-scale efforts by many countries and multiple stakeholders, working individually and collaboratively towards shared goals. Examples of areas requiring this type of global effort include the transition to sustainable development, the eradication of some endemic diseases, and solving the challenges of the energy/water/food nexus, particularly in poor countries.

There have been historical examples of such international collaborative effort, such as the Green Revolution and vaccines against HIV/AIDS (see Background Paper). These are impressive achievements that have had a tremendous global impact in improving sustainable development. What is very sobering, however, is that it took decades to create the coalitions and to develop the science and technology that led to the breakthrough innovations and improved outcomes. It is important to learn from those experiences in order to speed up this process to tackle global challenges, including new ones such as the potentially negative social and environmental impact of disruptive technologies.

Brokering coalitions of interested stakeholders requires:

- Convening international workshops to define the challenge(s) to be addressed and to assess the baseline and objectives
- Designing and building partnerships that bring together the different competencies required to map out possible pathways towards a solution
- Designing appropriate governance structures and key instruments for coordination, financing, monitoring, progress evaluation and direction/redirection
- Designing the ecosystem of other agents and institutions (e.g. government agencies, entrepreneurs and firms, NGOs, extension agents, input suppliers, community organizations, financing agents) that are required to get the technology to the ultimate beneficiary
- Awareness raising, stakeholder engagement and strategic communication to influence consumer choices with SDG-informed alternatives

The main lessons in brokering successful international coalitions to undertake collaborative programmes for global technological public goods are the following:

- Clear definition of the challenge(s) and of the role of STI
- Exploration of alternative pathways and solutions to the challenge(s)
- Realistic assessment of the costs and potential benefits of different pathways in the short, medium and long term
- Clear mechanisms for stakeholder engagement and long-term commitment (this requires a clear understanding of the incentives and rewards for different stakeholders to engage and stay engaged; these may be not just monetary, but social and reputational)
- Adaptive mechanisms for tracking progress and adjusting work programmes, stakeholder engagement and collaborative arrangements in light of what is or is not working
- Thinking beyond the development of technology to the design of the ecosystem that is necessary to deliver benefits to the ultimate beneficiary

A promising example of this kind of effort is a global coalition to bring some of the benefits of the digital revolution to Africa – the Digital Economy for Africa Initiative (summarized in ***Box 3.1***).

While it only addresses some of what is needed to help Africa take advantage of the digital revolution, it is noteworthy for its ambition: $25 billion investment plus $25 billion mobilized from the private sector, to provide some of the key elements including digital infrastructure, digital skills, digital platforms, digital financial services and digital entrepreneurship. It involves collaboration between regional organizations, multiple governments, various United Nations agencies and multilateral development banks, private companies and philanthropic agencies.

There are other incipient attempts to create international STI coalitions to address other SDG-related goals, such as the elimination of plastic pollution in the marine environment, low carbon energy, and climate change adaptation in cities. It will be important to distil some lessons from them in order to move towards developing international STI for SDGs Roadmaps to tackle some of the grand challenges of the SDGs.

What receiving country governments need to do

The discussion in this chapter has shown the great need – as well as the tremendous potential – for the international community to do more to leverage STI to accelerate achievement of the SDGs, and especially to help developing countries. As has been highlighted, one great challenge is weak STI capacity in developing countries. However, the challenge is not just in weak human and physical infrastructure and limited resources. As noted in the last section of ***Chapter 2***, it also involves the mindset and the policy and regulatory frameworks in developing countries. Addressing this will involve the following.

- Building endogenous potential and excellence in STI with the aim of having a partner role in global alliances.
- Being more open and proactive in acquiring, adapting, deploying and using existing global technology and innovation.
- Keeping more up to date with global developments in technology and innovation, particularly disruptive technologies that may offer strong potential but also carry risks.
- Conducting foresight analysis of the potential and risks of new disruptive technologies that may impact them, and how to best take advantage of the positive aspects and mitigate or adapt to the negative aspects.
- Strengthening their broad innovation systems to be able to assess and participate in the global innovation system and develop new technology and innovations relative to their needs.
- Thinking in terms of the whole innovation deployment system and including the role of the private sector and civil society (both domestic and international), in order to translate technology and innovation into actual practice and at scale to make a difference.
- Thinking also in terms of how they can benefit from regional STI arrangements that can provide some economies of scale and sharing of relevant experience, as well as how to raise awareness of some of the major challenges they face, where more international STI support would be very helpful.

Box 3.2

African Digital Transformation Strategy

Digital innovation is creating unprecedented opportunities for Africa to grow its economy, create jobs and transform people's lives. With the aim of ensuring that every African individual, business and government is digitally enabled by 2030, the African Union, with support from the World Bank Group and many other partners, has embarked on an ambitious journey. Digital Economy for Africa (DE4A) will help countries to accelerate progress, bring high-speed, affordable connectivity to all, and lay the foundations for a vibrant digital economy.

The African Union is developing a Digital Transformation Strategy, and the World Bank Group, together with AU Member States and many other partners, is developing an Action Plan. This takes a multi-tiered approach to five foundational elements of the digital economy: digital infrastructure, digital skills, digital platforms, digital financial services and digital entrepreneurship. Partners include the African Union Commission, Regional Economic Communities (RECs) and regional institutions (e.g. East African Community, West African Economic and Monetary Union/Central Bank of West African States, Economic and Monetary Community of Central Africa, Smart Africa, African Development Bank). They also include bilateral partners and philanthropic agencies (e.g. Bill & Melinda Gates Foundation, UK, France, Germany, Norway, Japan), United Nations agencies (e.g. United Nations Economic Commission for Africa, International Telecommunication Union) and the private sector (e.g. GSMA, Google, Microsoft, Alibaba).

Achieving the goal of digitally connecting every individual, business and government requires ambitious and easy-to-understand targets under each of the five foundational pillars of the digital economy to help catalyze and concentrate action, as shown below. Diagnostics are being undertaken to develop a detailed digital scorecard to set more granular targets.

DIGITAL INFRASTRUCTURE	DIGITAL SKILLS	DIGITAL PLATFORMS	DIGITAL FINANCIAL SERVICES	DIGITAL ENTREPRENEURSHIP
• Universal Internet network coverage • Affordable Internet for all at less than 2% of GNI per capita • Interim Milestone Doubling broadband connectivity by 2021	• All 15 year old students with basic 'digital skills' competencies • 100,000 graduates in advanced digital skills programs annually	• Doubling of Online Services Index rating for all Governments • All individuals are able to prove their identity digitally • At least 50% of the population regularly uses the Internet to access Government or Commercial services	• Universal Access to Digital Financial Services • Africa-wide payments infrastructure/ platform in place	• Tripling the number of new digitally-enabled businesses created annually • Financing for Venture Capital to reach 25% of GDP

Indicative Targets for Digital Economy for Africa

CHAPTER 4.

Conclusions and Next Steps

4.1 Key messages

This Guidebook introduced a step-by-step approach for policymakers to develop and implement national STI for SDGs Roadmaps, and to participate in and benefit from international partnerships to harness STI potential to achieve the Global Goals and leave no one behind. The Guidebook is also designed to address the "Tower of Babel" problem by introducing a set of common languages. Given the current state of data, and the constantly evolving understanding about needs and potential supply of STI, the underlying analysis has necessarily been very preliminary. However, it has attempted to outline what is possible and the kinds of thinking, strategizing and planning that need to be done, both nationally and internationally. As a result, this first edition of the Guidebook promotes a common approach and develops coherent frameworks to examine gaps, evaluates synergies and trade-offs through a joint effort, and prioritizes actions in order to strengthen national STI systems. The overall message is that governance, institutional arrangements and participatory processes are critical, in aligning on visions, assigning accountabilities, and shaping ownership by stakeholders.

The Guidebook has also demonstrated that there is tremendous potential, as well as urgency, to leverage STI to help developing countries attain the SDGs. However, the focus and the financial resources to optimize and exploit this potential are not yet there. Therefore, an important next step is to discuss how developed countries and the donor community can do more to make this happen. On the financing side, discussions are already beginning on how to increase financing for STI for the SDGs (***Box 4.1***). These discussions should be continued and expanded to include how support from the international community can be more coherent and effective.

When the international community embraced the SDGs as a global ambition just five years ago, the pace of digital technological change at the frontier of science and innovation was not as prominent and global in its reach. Hence, it is important to consider resetting the SDG trajectory and the means of achieving them, in light of recent progress and heightened awareness of opportunities and risks. Building on historical lessons and current emerging practices, STI for SDGs Roadmaps can contribute to formulating new solutions to old and nascent challenges.

The United Nations system, through the TFM, will stand ready to work with all United Nations Member States in cultivating communities of practitioners and partners and fostering a learning environment to test and improve the approaches as proposed in this Guidebook, apply the methodologies to country-specific STI for SDGs Roadmaps, learn from experiences to further refine the Guidebook, and potentially initiate or stimulate more fit-for-purpose international partnerships.

4.2 Global Pilot Programme on STI for SDGs Roadmaps

As an initial step in pursuing the above objectives, during the United Nations High-level Political Forum (HLPF) on Sustainable Development in July 2019 the United Nations Inter-agency Task Team on STI for the SDGs (IATT) launched the Global Pilot Programme on STI for SDGs Roadmaps with a group of five pilot countries. Under the programme's first phase, IATT will support the design and implementation of roadmaps in Ethiopia, Ghana, India, Kenya and Serbia. In addition, the European Commission's Joint Research Centre and Japan have joined the Global Pilot Programme to strengthen international partnerships on STI for SDGs Roadmaps. The final results will be presented at the Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs in 2021.

The five countries (as all other countries) are different in terms of their SDG gaps and STI capabilities, as mapped in ***Figure 4.1***. Low SDG index scores for some countries, compared with their peers at a similar level in the Global Innovation Index (e.g. Mali, Ethiopia, Uganda, India and the United States), indicates that innovation capability does not automatically ensure good SDG performance. The latter requires commitment, good strategy, effective policy, financing and good implementation capability. Hence the importance of developing effective roadmaps, in the context of national development priorities in line with the SDGs.

Table 4.1 characterizes the state of the STI for SDGs Roadmaps in the five pilot countries[60] at their initial stages. While the countries vary significantly in terms of preparation status, as well as the analytical, consultative and planning activities already undertaken, early lessons and opportunities for peer learning are as follows.

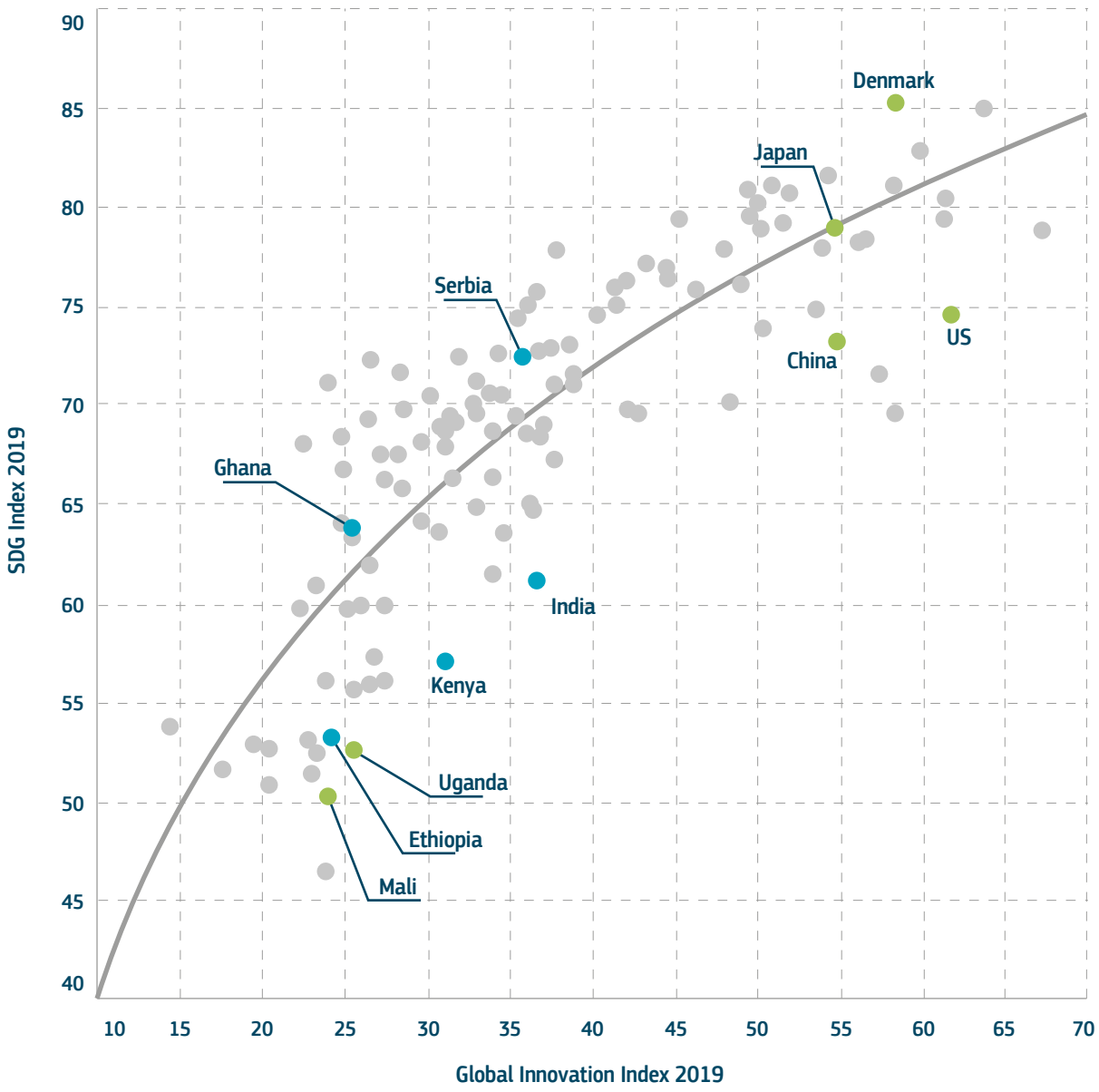
Institutional arrangement. In some countries, a single ministry is responsible for piloting roadmaps, while other countries have instituted interministerial coordination and consultation structures, supported by policy think tanks (e.g. ACTS in Kenya, RIS in India, CSIR-STEPRI in Ghana, National Smart Specialisation Team in Serbia). This is not to say that the presence of a coordination structure is either a precondition for policy coherence or a predictor of achieving intended outcomes, given the variance in relevant contexts (e.g. political and administrative cultures, degree of high-level ownership, or influence and resources at the discretion of the responsible ministry or ministries/agencies). However, countries may want to consider intra-governmental institutional arrangements conducive to broader stakeholder engagement and cross-sectoral alignment, to best harness STI in line with national development plans and the SDGs.

Policy planning cycles. Countries have different planning cycles (whether for national development, STI or the SDGs). This indicates there may be varying extents to which underlying policy frameworks are fully established or updated to serve as an anchor in piloting roadmaps (and so that roadmaps can be grounded in a robust administrative momentum which survives political cycles that may have shorter timescales). Alternatively, in some countries, STI for SDGs Roadmaps – depending on their scope and ownership – can be useful inputs to the next cycle of broader policy planning.

Scope and approaches. Given the diversity of underlying SDGs gaps, STI capabilities and national development priorities, the scope and contents of STI for SDGs Roadmaps also vary. There is tension between the depth of "deep dives" and the breadth of a systemic approach (i.e. addressing trade-offs, harnessing co-benefits, turning vicious into virtuous cycles), as evident in the case of Kenya. In fact, pilot countries are in the driver's seat in identifying national demands for assistance. While IATT does not intend to provide a "cookie cutter solution", the United Nations and other supporting partners could be in a position to assist pilot counterparts who are constrained by availability of resources, and often facing capacity and bandwidth constraints, and report back on harmonized methodologies with lessons and good practices. This pilot programme intends to demonstrate the United Nations system-wide approach to advancing harmonization and synergies in the area of STI.

STI digital integration or complementarity. Conceptually, there is no doubt that there are large overlaps (in policy issues and relevant stakeholder groups) between "science, technology and innovation" and "digital economy/digital transformation", and that both require coherent and effective policy responses to maximize opportunities and mitigate risks in achieving the SDGs. However, in practice, both national and international entities are pursuing these agendas in a silo approach and non-coordinated manner. This is in terms of the institutional arrangement and the scope/approach (either as a result or as a cause). It would be a missed opportunity if the roadmap were to fall into a silo, either in the pilot

60 *Country-specific contexts, progress and considerations for successful outcomes are being documented in pilot country case studies (IATT, 2020).*



NOTE:
Blue dots are the pilot countries; green dots are some outliers as reference points.

Figure 4.1: *Five pilot countries in terms of the SDG Index vs. Global Innovation Index*

Source: Compiled based on indices in Independent Group of Scientists (2019); Cornell University, INSEAD, and WIPO (2018).

country or supporting partner sides, and not take advantage of synergies between the two.

International dimension. Pilot plans also vary in terms of addressing subnational, national and international levels of roadmaps, from a solely domestic/national focus to a willingness to contribute internationally (e.g. India). International partners (e.g. Japan, European Union) are already supporting roadmap pilots, and there are promising emerging initiatives with broader multi-stakeholder cooperation (e.g. Japan-India-Africa trilateral cooperation among policy think tanks; scaling up the European Union-supported Global Pilot Network; private participation spearheaded by the Toyota Kenya agreement; active discussions about contributions by academies of sciences in pilot and partner countries). To produce greater collective impact, IATT and other partners may be in a position to proactively engage pilot counterparts in raising the level of ambition and identifying opportunities to produce positive international spillovers.

Policy learning for acceleration at scale. Only two of the ongoing pilots, India and Serbia,[61] have put monitoring and evaluation systems in place or considered learning and feedback mechanisms as an explicit component of their STI for SDGs Roadmaps. As noted in the Guidebook, this is a critical step because the implementation of the roadmaps is essentially a learning exercise, where it will be important to monitor and evaluate what is being done in order to make adjustments and corrections during implementation. Furthermore, given the scale and urgency of the challenges we face, policy learning is critical, not only at the country level but internationally – requiring a harmonized approach to monitoring and evaluation for national STI for SDGs Roadmaps, and mechanisms for collective learning and course correction.

IATT presented interim updates from a few pilot countries at the 2020 HLPF and full results of the first phase of the programme will be presented at the 2021 HLPF. To support individual country pilots, analyse and cross-fertilize emerging experiences and lessons, and stimulate and galvanize international support, IATT will continue to work with current and prospective partners to help achieve the intended results through the pilot programme and beyond.

4.3 Moving forward

In response to strong interest expressed by countries participating in the deliberations so far, IATT[62] together with its partners is committed to piloting and scaling the adoption of country-level roadmaps, codifying and disseminating lessons learned, and strengthening international cooperation accordingly. Based on further consultations and analysis, the next phase of the intersessional work programme on STI for SDGs Roadmaps may include the following components.

- **Intensify joint support for pilots:** IATT agencies to strive to secure additional resources, onboard United Nations country teams, engage new United Nations and other interested partners and stakeholders, and align with countries' aspirations and constraints according to the respective pilot plans.

- **Foster learning environment:** orchestrate multi-tier engagements for experience sharing, such as through tracks led by United Nations regional commissions and/or other regional bodies (e.g. ASEAN, African Union Commission, European Union) and participated in by current and prospective pilot countries. Cultivate communities of practitioners and networks of knowledge (e.g. policy think tanks in pilot countries) to codify and disseminate emerging lessons. Address evidence and data gaps

61 *In the case of the Smart Specialisation Strategy approach followed by Serbia, monitoring and evaluation systems are necessary elements for the roadmap.*

62 *For more details about IATT, See:* ***https://sustainabledevelopment.un.org/tfm#un***

Table 4.1

Five countries participating in the Global Pilot Programme for STI for SDGs Roadmaps

		KENYA	GHANA
LEAD AND OTHER INSTITUTIONS INVOLVED		■ Treasury, Dept of Planning ■ NACOSTI, ACTS ■ Line ministries (Education, Science and Technology, Foreign Affairs, ICT, Agriculture, Industry)	■ Ministry of Environment and STI ■ CSIR-STEPRI
UNDERLYING POLICY FRAMEWORKS		■ Kenya Vision 2030 ■ MTP III 2018-2022, Big Four ■ STI Policy, Research Priorities ■ Digital Economy Blueprint	■ Agenda for Jobs 2017-2021 ■ CPESDP 2017-2024 ■ National STI Policy 2017
SCOPE AND OBJECTIVES OF ROADMAP		■ Big Four Agenda (agriculture, health, manufacturing, housing) ■ Agro-processing and ICT as an initial focus	to be determined
APPROACH TO PILOT		■ Sectoral deep dive, target-driven (100% food and nutrition security by 2022) ■ R&D and adoption/diffusion ■ Aiming for an East Africa regional model	■ Build on technology incubation centres ■ Aim for investment proposals and institutional strengthening
TIMEFRAME AND KEY MILESTONES			to be determined
PARTNERS (DESA: THE SECRETARIAT)	IATT FOCAL	■ World Bank (STI PERs) ■ UNESCO (SAGA, GO-SPIN)	■ UNESCO ■ World Bank
	UN, OTHERS	■ Private partnership (Toyota)	■ OECD
		Possible EU-ACP, African Union Commission, RECs,	

KEY ABBREVIATIONS: *[Kenya] NACOSTI, National Commission for Science, Technology and Innovation; ACTS, African Center for Technology Studies; MTP III, Mid Term Plan III; SAGA, STEM and Gender Advancement. [Ghana] CSIR-STEPRI, Council for Scientific and Industrial Research – Science and Technology Policy Research Institute; CPESDP, Coordinated Programme of Economic and Social Development Policies. [Ethiopia] GTP III, Growth and Transformation Plan III. [India] NITI Aayog, National Institution*

ETHIOPIA	INDIA	SERBIA
■ Ministry of Innovation and Technology ■ Ministry of Science and Higher Education	■ Office of the Principal Scientific Adviser ■ NITI Aayog, Ministry of External Affairs, RIS ■ National Coordination Committee	■ Ministry of Education, S&T; ■ Coordinating Interministerial Working Group (WG) and cooperation with national Agenda 2030 Group ■ WGs for priority domains led by business and academia, Statistics Office, Patent Office; National Analytics team (academia-led)
■ GTP III 2015-2020 ■ STI Policy 2012	■ Strategy for New India@75 ■ STI Policy 2013	■ EU Accession Process and Smart Specialisation ■ New STI and industrial policy under Prime Minister ■ Agenda 2030
SDG 8 (Job creation)	■ Agriculture, energy, water, health; align with key initiatives (e.g. Doubling of Farmers' Income, JAM Trinity) ■ Strong international focus – Africa and Far East	■ defined Smart Specialisation priority domains and horizontal actions ■ creative industries; food for the future; machines and production processes of the future; ICT
■ Sectoral: build on 24 technology roadmaps	■ International, national and subnational levels (Lighthouse India, cooperative federalism) ■ Data/dashboard to be substantiated through STI PER inputs	■ work at national level, with subnational and international dimension ■ mix of deep dives and horizontal activities
	■ First six months (in India) ■ End first year (AfDB AMs?) ■ End second year (in New York)	■ adoption of S3 (February 2020) and a detailed roadmap (October 2020)
■ UNCTAD (STIP Review) ■ World Bank, UNESCO	■ World Bank (STI PERs) ■ ESCAP	■ UNIDO
■ UNDP, UNIDO	■ OECD ■ UNDP	■ EU JRC (RIS3)
Japan-India-Africa cooperation		

for Transforming India; RIS, Research and Information System for Developing Countries; JAM Trinity, Jan Dhan-Aadhaar-Mobile trinity; AfDB AMs, African Development Bank Annual Meetings; ESCAP, United Nations Economic and Social Commission for Asia and the Pacific. [Serbia] RIS3, Research and Innovation Strategies for Smart Specialisation.

to support the development of monitoring and evaluation systems.

- **Initiate or stimulate international STI partnerships:** use pilots as tangible entry points to galvanize multi-stakeholder forums, for matching collective actions to address identified common challenges and developing pipelines/portfolios of partnerships with the private sector, donor countries and STI stakeholders.

- **Mainstream STI in broader SDGs work:** apply the six entry points in the Global Sustainable Development Report – 1) human well-being and capabilities, 2) sustainable and just economies, 3) food systems and nutrition patterns, 4) energy decarbonization and universal access, 5) urban and peri-urban development, and 6) global environmental commons – for STI for SDGs roadmaps in existing or new pilot countries, if countries desire.

- **Solidify multi-year programme of work:** define intermediate and final outcomes to be demonstrated by 2020 and 2021 STI Forums, and align with pilot counterparts to work backwards and use milestone events to pace and accelerate the roadmap exercise. Plan for the second phase pilot cohort, with appropriate timing for useful lessons to be generated from the first phase, while ensuring current momentum can be sustained (and over 20 countries remain interested). Define longer-term objectives, such as addressing the current fragmentation of international support activities, by using critical mass demands through roadmaps and convening donors and research funders.

- **Mobilize resources:** build the case for multilateral pooled resources to support both individual pilots and collective programme delivery/expansion, and align with interested and willing donors.[63]

TFM started as voluntary efforts by IATT member agencies, without additional resources. Its work on STI for SDGs Roadmaps has evolved as one of most tangible deliverables over the last two years. This has been made possible through hard work by pilot and other interested countries, technical and intellectual contributions from institutional partners and participants of the series of Expert Group Meetings, and seed funding contributions and championship by Japan and the European Commission. Co-leads of the IATT Sub-Working Group on STI roadmaps, namely the World Bank, DESA, UNCTAD and UNESCO, welcome interested partners and countries to join forces to further promote this promising and meaningful work.

63 *Donors may contribute to the existing Sustainable Development Trust Fund at DESA, to relevant trust funds at other agencies, or to trust funds relevant to STI; or consider a more coordinated funding mechanism.*

Box 4.1

Global discussions on financing STI for SDGs

World leaders are advancing parallel deliberations on STI for SDGs and Financing for SDGs, creating a promising space for STI policymakers and stakeholders to work more closely to demonstrate a case for efficient and effective financing of STI for SDGs.

On the STI front, the G20 under the Japanese presidency, through the Development Working Group (DWG), acknowledged that multi-stakeholder engagement is essential for unleashing STI potential, and reached consensus on the Guiding Principles for the Development of STI for SDGs Roadmaps. The principles touch on the structure of roadmaps, the role of government, promotion of knowledge sharing, international cooperation and other elements to consider. The work of the G20 DWG and TFM on STI for SDGs Roadmaps proceeded in a mutually informing and reinforcing manner, recognizing that the Guiding Principles represent political consensus on "why" STI for SDGs roadmaps, whereas the Guidebook prepared by IATT explores "how" to formulate roadmaps. In coordination with the DWG, the G20 Digital Economy Task Force (DETF) deliberated on a plan for action towards the SDGs through digitalization, focusing on Africa and least developed countries, to share the benefits of digitalization and leave no one behind. Following the G20 Osaka Summit in June, Japan hosted the seventh Tokyo International Conference on African Development (TICAD7) in August 2019, where STI for SDGs Roadmaps was a key topic for discussions with African leaders.

On the financing front, TFM and its partners from the scientific community have pursued a multi-stakeholder approach to the funding of STI for SDGs, such as through the Funders' Roundtable at the sidelines of the STI Forum 2018. At the Financing for Development Forum in 2019, the United Nations announced the creation of a Global Investors for Sustainable Development Alliance, to be officially launched in September 2019. The Forum also discussed the "triangle of technology, the SDGs, and financing" as a crucial new arena requiring attention and the deployment of financing. In addition, the United Nations Inter-agency Task Force on Financing for Development has been tasked with supporting countries' efforts to operationalize integrated national financing frameworks (INFF). These are a planning and delivery tool to finance sustainable development at the national level. INFFs are a tool to operationalize the Addis Ababa Action Agenda at the national level, in conjunction with international cooperation at the global level. The roll out of the INFFs started in July 2020.

Informing G20 deliberation on development finance, the Eminent Persons Group on Global Financial Governance, in its report in 2018, recommended implementing the system-wide reorientation in development finance. The aim was to achieve complementarity among multilateral, regional and bilateral institutions, and to establish a clear system of metrics to track impact and value for money. This would involve building effective country platforms, owned by governments, to enhance contributions from all development partners, including the private sector. In response, Finance Ministers, through the Development Committee communiqué in April 2019, urged the World Bank Group "to continue to work closely with public and private partners including international financial institutions and the UN, on the most pressing development challenges". They noted that

"heads of state will gather in September for the UN summit focusing on climate, universal health coverage, SDGs, financing for development, and small island developing states" and underscored the importance of "the potential of multilateral development banks working as a system to improve their response to common challenges, including through a coordinated country platform approach" (paragraph 12).

STI for SDGs Roadmaps, if adequately formulated and implemented, may constitute a tangible element in approaches to such country platforms, by enhancing complementarity among national and development partner efforts.

Source: Ministry of Foreign Affairs of Japan, presentation at the Fourth Expert Group Meeting on STI for SDGs Roadmaps, Nairobi, April 2019; the Boards of Governors of the Bank and the Fund on the Transfer of Real Resources to Developing Countries, April 2019.

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ANNEX 1

Technology Facilitation Mechanism in the 2030 Agenda for Sustainable Development

The United Nations Technology Facilitation Mechanism (TFM) was established by the Addis Ababa Action Agenda to support the implementation of the Sustainable Development Goals (SDGs) and launched through the 2030 Agenda for Sustainable Development in September 2015. From the outset, the Division for Sustainable Development Goals (DSDG) at DESA continued to serve as Secretariat for the Inter-agency Task Team on Science, Technology and Innovation for the SDGs (IATT) and for the group of high-level representatives of the scientific community, the private sector and civil society (10-Member Group) appointed by the Secretary-General to support the TFM. The two groups mobilize experts from within and outside the United Nations system to advance the SDGs through science, technology and innovation (STI) in various contexts. Since 2015, both groups have been coordinated and supported by DESA/DSDG (2015 to present), the United Nations Environment Programme (2016-2017) and UNCTAD (2018 to present).

Throughout both the intergovernmental negotiations on the post-2015 development agenda, and the preparatory process in 2014 and 2015 for the Third International Conference on Financing for Development, Member States clearly indicated that the development, transfer and dissemination of technology, along with strengthening the scientific and technological capabilities of all countries, represent key elements of the Means of Implementation (MoI) for the 2030 Agenda for Sustainable Development.

Paragraph 70 of the 2030 Agenda for Sustainable Development launched a Technology Facilitation Mechanism (TFM) in order to support the implementation of the SDGs. The TFM was first established by the Addis Ababa Action Agenda, which was agreed at the Third International Conference on Financing for Development held in Addis Ababa, Ethiopia, in July 2015.

It was decided that the Technology Facilitation Mechanism (TFM) will be based on a multi-stakeholder collaboration between Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders and will be composed of:

- United Nations Inter-agency Task Team on Science, Technology and Innovation for the SDGs (IATT). IATT will draw on existing resources and work with the ten representatives (10-Member Group) appointed by the Secretary-General to support the TFM. This group, appointed for two years at a time, is drawn from civil society, the private sector and the science and technology community.
- Collaborative Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum)
- Online platform

The diagram below summarizes the key mechanisms on STI and maps the main channels for engaging multi-stakeholders in the United Nations process.

The creation of the TFM was of historic significance, as it brought substantive STI discussions back to the United Nations Headquarters in New York, after decades of political gridlock over intellectual property rights and technology transfer issues. Over the past three years, the TFM has explored a new multi-stakeholder model of work for the United Nations system, which has so far engaged 42 United Nations entities, more than 100 expert staff of the United Nations system, and thousands of scientists and stakeholders to facilitate STI for the SDGs. The TFM's STI Forum also holds a special role, as it reports formally to the High-level Political Forum on Sustainable Development (HLPF) in support of its formal review of SDG progress and its explicit function to "strengthen the science-policy interface".

In its meetings, the IATT has regularly reflected on its work direction, and on the relationship to participating United Nations system entities and to the TFM 10-Member Group. At the same time, UNCTAD (as the Secretariat for the Commission on Science and Technology for Development), the United Nations Regional Commissions, Inter-agency Task

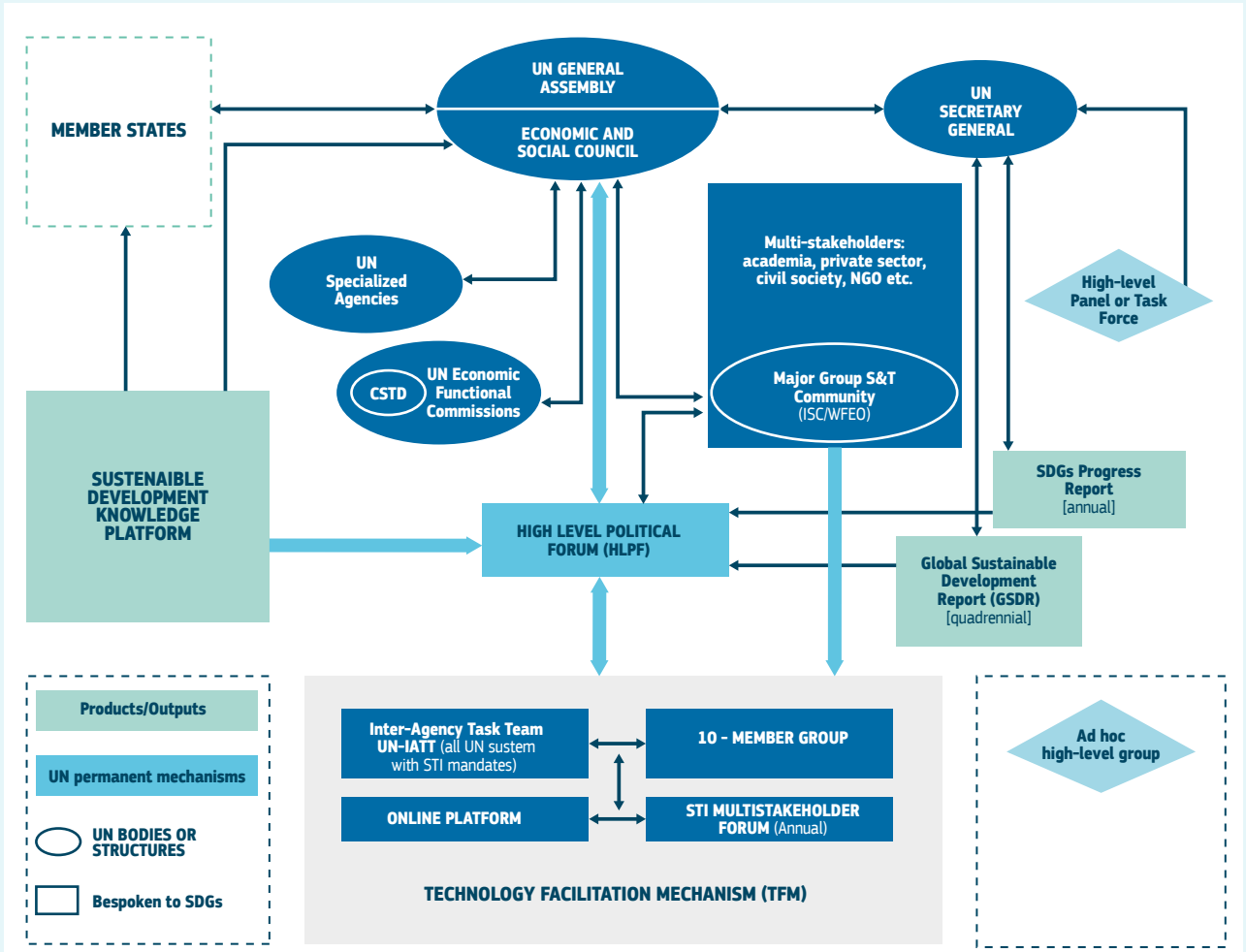

Diagram: *Mapping key mechanisms on STI under the 2030 Agenda*

Source: DESA/DSDG adopted from InterAcademy Partnership (IAP) Report on Improving Scientific Input to Global Policymaking with a Focus on the UN Sustainable Development Goals, 2019: ***https://www.interacademies.org/50429/SDGs_Report***

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Force (IATF), UNEP, World Bank, UNESCO, WIPO, ITU, FAO and many other participating United Nations system entities have issued documents on trends and policy options and proposed findings on STI in their areas of expertise. In addition, several organizations beyond the United Nations system have started cooperating and contributing to work on the TFM.

One significant achievement of the IATT is this joint Guidebook on STI for SDGs Roadmaps and its Operational Note, currently being piloted in five countries: Ethiopia, Ghana, Kenya, India and Serbia.

ANNEX 2

STI as explicit in 2030 Agenda language

GOAL	TARGET	LANGUAGE	RELEVANCE
1	1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, **appropriate new technology** and financial services, including microfinance	Outcome: Tech
2	2.a	Increase investment, including through enhanced international cooperation, in rural infrastructure, **agricultural research and extension services, technology development and plant and livestock gene banks** in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	MoI: Sci / Tech
3	3.b	Support the **research and development of vaccines and medicines for the communicable and non-communicable diseases** that primarily affect developing countries, provide **access to affordable essential medicines and vaccines**, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all	MoI: Sci / Tech
4	4.3	By 2030, ensure equal access for all women and men to affordable and quality **technical, vocational and tertiary education**, including university	Outcome: Sci (edu)
	4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including **technical and vocational skills, for employment, decent jobs and entrepreneurship**	Outcome: Sci (edu)
	4.b	By 2020, substantially expand globally the number of **scholarships** available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in **higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes**, in developed countries and other developing countries	MoI: Sci (edu)
5	5.b	Enhance the use of **enabling technology, in particular information and communications technology**, to promote the empowerment of women	MoI: Tech
6	6.a	By 2030, expand international cooperation and capacity-building support to developing countries in **water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies**	MoI: Tech
7	7.a	By 2030, enhance international cooperation to facilitate **access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology**	MoI: Tech
	7.b	By 2030, expand infrastructure and **upgrade technology for supplying modern and sustainable energy services for all** in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	MoI: Tech
8	8.2	Achieve higher levels of economic productivity through **diversification, technological upgrading and innovation**, including through a focus on high-value added and labour-intensive sectors	Outcome: Inno
	8.3	Promote development-oriented policies that support productive activities, decent job creation, **entrepreneurship, creativity and innovation**, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	Outcome: Inno

GOAL	TARGET	LANGUAGE	RELEVANCE
9	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of **clean and environmentally sound technologies and industrial processes**, with all countries taking action in accordance with their respective capabilities	Outcome: Tech
	9.5	Enhance **scientific research, upgrade the technological capabilities of industrial sectors** in all countries, in particular developing countries, including, by 2030, **encouraging innovation** and substantially **increasing the number of research and development workers per 1 million people** and **public and private research and development spending**	Outcome: Inno
	9.a	Facilitate **sustainable and resilient infrastructure development** in developing countries through enhanced **financial, technological and technical support** to African countries, least developed countries, landlocked developing countries and small island developing States	MoI: Tech
	9.b	Support **domestic technology development, research and innovation in developing countries**, including by **ensuring a conducive policy environment** for, inter alia, industrial diversification and value addition to commodities	MoI: Inno
	9.c	Significantly increase **access to information and communications technology** and strive to provide universal and affordable access to the Internet in least developed countries by 2020	MoI: Tech
12	12.a	Support developing countries to strengthen their **scientific and technological capacity** to move towards more sustainable patterns of consumption and production	MoI: Sci/Tech
14	14.3	Minimize and address the impacts of **ocean acidification**, including through **enhanced scientific cooperation** at all levels	Outcome: Sci
	14.4	By 2020, effectively **regulate harvesting and end overfishing**, illegal, unreported and unregulated fishing and destructive fishing practices and implement **science-based management plans**, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	Outcome: Sci
	14.5	By 2020, **conserve at least 10 per cent of coastal and marine areas**, consistent with national and international law and based on the **best available scientific information**	Outcome: Sci
	14.a	**Increase scientific knowledge, develop research capacity and transfer marine technology**, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	MoI: Sci/tech

GOAL	TARGET	LANGUAGE	RELEVANCE
17	17.6	Enhance **North-South, South-South and triangular regional and international cooperation** on and access to **science, technology and innovation** and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a **global technology facilitation mechanism**	MoI
	17.7	Promote the **development, transfer, dissemination and diffusion of environmentally sound technologies** to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	MoI
	17.8	Fully **operationalize the technology bank and science, technology and innovation capacity-building mechanism** for least developed countries by 2017 and **enhance the use of enabling technology, in particular information and communications technology**	MoI
	17.16	Enhance **the Global Partnership for Sustainable Development**, complemented by multi-stakeholder partnerships that **mobilize and share knowledge, expertise, technology and financial resources**, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	MoI

STI commitments in Addis Ababa Action Agenda (AAAA)*

National STI Policy Framework

- adopt **science, technology and innovation strategies** as integral elements of our **national sustainable development strategies (§119)**
- craft **policies that incentivize** the creation of new technologies, that incentivize research and that support innovation in developing countries **(§116)**

Scientific Research and Education

- scale up **investment in science, technology, engineering and mathematics education (§119)**
- consider using **public funding to enable critical projects** to remain in the public domain and strive for **open access to research** for publicly funded projects, as appropriate **(§118)**
- enhance **technical, vocational and tertiary education and training**, ensuring **equal access** for women and girls and encouraging their participation therein, including through international cooperation **(§119)**
- enhance cooperation to strengthen **tertiary education systems** and aim to increase **access to online education** in areas related to sustainable development **(§119)**
- increase the number of **scholarships** available to students in developing countries to enrol in higher education **(§119)**

Industry and Innovation Systems

- consider setting up **innovation funds** where appropriate, on an open, competitive basis to support innovative **enterprises**, particularly during research, development and demonstration phases **(§118)**
- encourage knowledge-sharing and the promotion of cooperation and partnerships between stakeholders, including between **Governments, firms, academia and civil society,** including linkages between **multinational companies and the domestic private sector** to facilitate technology development and transfer, on mutually agreed terms, of knowledge and skills **(§117)**
- promote **entrepreneurship**, including supporting **business incubators (§117)**
- promote **social innovation** to support social well-being and sustainable livelihoods **(§116)**
- recognize that **traditional knowledge**, innovations and practices of **indigenous peoples** and **local communities** can support social well-being and sustainable livelihoods, and reaffirm that indigenous peoples have the right to maintain, control, protect and develop their **cultural heritage**, traditional knowledge and traditional cultural expressions **(§117)**

Technologies Supporting Specific Development Outcomes

- promote the development and use of **information and communications technology infrastructure**, as well as capacity-building, particularly in least developed countries, landlocked developing countries and small island developing States, including rapid **universal and affordable access** to the Internet **(§114)**
- encourage the development, dissemination and diffusion and transfer of **environmentally sound technologies (§120)**
- support developing countries to strengthen their scientific, technological and innovative capacity to move towards more **sustainable patterns of consumption and production** through science and technology **(§120)**
- increase scientific knowledge, develop research capacity and transfer **marine technology** ... in order to improve **ocean health** and to enhance the contribution of **marine biodiversity (§121)**
- step up international cooperation and collaboration in science, research, technology and innovation, including through public-private

and multi-stakeholder partnerships, and on the basis of common interest and mutual benefit, focusing on the needs of developing countries and the achievement of the sustainable development goals **(§120)** [for example, research and development in **vaccines and medicines**, including relevant initiatives such as Gavi **(§121)**; preventive measures and treatments for the **communicable and non-communicable diseases (§121); earth observation (§121); rural infrastructure (§121); agricultural research and extension services and technology development (§121)**; increase scientific knowledge, develop research capacity and transfer **marine technology (§121)**]

- further facilitate accessible technology for **persons with disabilities** [and] promote access to technology and science for **women**, **youth** and **children (§114)**

Supportive international arrangements

- enhance international cooperation, including **ODA**, in these areas, in particular to **least developed countries, landlocked developing countries, small island developing States, and countries in Africa** [and] encourage other forms of international cooperation, including **South-South cooperation (§120)**

- recognize the importance of adequate, balanced and effective protection of **intellectual property rights** in both developed and developing countries in line with **nationally defined priorities** and in full respect of WTO rules **(§116)**

- commit to strengthening **coherence and synergies** among science and technology initiatives within the United Nations system **(§122)**

- established a **Technology Facilitation Mechanism** to support the sustainable development goals **(§123)**

- operationalize the **Technology Bank for Least Developed Countries** by 2017 **(§124)**

***** *Grouping of the commitments and bold texts are by the Author for the analytical purposes of this paper*

ANNEX 3

Overview of the main methodologies to support STI for SDGs roadmaps

METHODOLOGICAL STEP/ *ORGANIZATION*	SMART SPECIALISATION *(EU JRC)*	STI POLICY REVIEWS *(OECD)*	STIP REVIEWS *(UNCTAD)*
DEFINE OBJECTIVES AND SCOPE	Systemic approach: STI in the context of economic, societal and environmental challenges	Modular approach: focus on collection, analysis, reporting and dissemination of STI policy data	Systemic approach: STI in the context of economic, societal and environmental challenges
ASSESS CURRENT SITUATION	Based on existing policy frameworks; requires inter-institutional cooperation. Quantitative and qualitative analysis of economic, STI and SDG indicators	Detailed analysis of STI performance in the macroeconomic context and societal needs. Quantitative STI indicators plus in-depth analysis of specific sectors	STI policies instrumental for economic growth and development. Wide collection of qualitative data supported by overviews of literature and quantitative analyses
DEVELOP VISION, GOALS AND TARGETS	Vision for sustainable socioeconomic development of territories developed jointly by external and internal stakeholders	Vision developed individually by each country based on the analysis and recommendations	Synergic vision for transformative change developed jointly by internal and external stakeholders
DIALOGUE AND CONSULTATION WITH STAKEHOLDERS	Entrepreneurial Discovery Process requires permanent involvement of public and private sector, academia and civil society in development, implementation and monitoring of the strategy and associated activities	Stakeholders are interviewed during the fact-finding missions. International community involved in reviews	Multiple stakeholders involved in the STIP review process
ASSESS ALTERNATIVE PATHWAYS	Foresight and similar exercises recommended, although not obligatory	**Countries can develop scenarios for enhancement of the national STI ecosystem**	Technology foresights are strongly recommended
DEVELOP DETAILED STI FOR SDGs ROADMAP DOCUMENT	Clear intervention logic required, with implementation action plan, policy mix and instruments, and financing instruments	Not explicit, recommendations provided	Specific guidance is provided on implementation, policy instruments and financial instruments
MONITOR EVALUATE AND UPDATE PLAN	Monitoring and evaluation frameworks are essential in S3 approach, with clearly defined metrics and indicators	Monitoring and evaluation considered very important but not included. Post-review analyses are possible on request	Monitoring and evaluation frameworks are strongly recommended, and additional support is possible on request

Source: Matusiak (2020)

GO-SPIN *(UNESCO)*	**SIIG** *(UNIDO)*	**TIP** *(TIPC)*	**PERS IN STI** *(WORLD BANK)*
Modular approach: focus on STI governance, explicit and implicit STI policies, legal frameworks, policy instruments and indicators	Sectoral approach: focus on STI component in industrial policy; includes social inclusion, economic competitiveness and environmental protection	Systemic approach using innovation to address societal, economic and environmental challenges	Modular approach: main focus is on STI policy expenditure and its impact
Description of the political, economic, social, cultural and educational contextual factors; analysis of explicit STI policies, policy cycle and STI organizational chart; study of R&D and innovation indicators	Based on existing development plans and strategies. Includes in-depth quantitative and qualitative analyses of the industrial landscape in the context of the country's development goals	Based on wide qualitative process and review of existing policies. Uses case study approach and learning histories	Quality of public spending on STI and R&D is assessed, based on a mix of qualitative and quantitative indicators, with the objective of understanding how governments can spend better on STI or how they can improve the impact of STI expenditures on economic development
Looks at impact of existing STI policies, based on a survey enabling creation of country profiles with comprehensive assessments of STI policies	Vision developed individually by each country with wide participation by stakeholders	Wide vision for transformative change achieved through STI policies and other elements of systemic change	The PERs can result in the development of vision for change DIALOGUE AND CONSULTATION WITH STAKEHOLDERS
Internal and external stakeholders involved in providing the survey responses and discussing the results	Stakeholders are involved in a participatory policy-making process throughout the policy cycle	Wide stakeholder participation, including local and grassroots innovators	Stakeholder involvement is part of data collection, in the form of interviews, access to data, etc.
This step can be included but is optional	Possibility of developing scenarios for industrial policy	Foresight and future studies activities are considered valuable but optional	Based on the analysis, the team discuss different options
Methodology provides an overview of STI policy instruments but does not prescribe specific solutions – they can be developed at country's request	Developed individually by governments but based on recommended policy instruments	Strong focus on experimentation. The policy mix is a part of TIP development and guidance can be provided on financing	Assessment results in a set of recommendations that support stronger alignment of innovation policy instruments with national development objectives, improved quality and higher efficiency of instruments used, and an evidence-based framework to track results and map expenditure to outputs and outcomes
The regularly updated country profile can be a useful monitoring tool	Monitoring and evaluations are a part of the methodology	Monitoring and formative evaluation are required with the focus on learning and improvement	M&E is a core part of the methodology. A unique feature of PER in STI is the inclusion of impact evaluations in the effectiveness stage.

ANNEX 4

Summary of key lessons learned from the Global Pilot Programme on STI for SDGs Roadmaps

The United Nations Inter-agency Task Team (IATT) launched the first phase of the Global Pilot Programme on Science, Technology and Innovation for SDGs Roadmaps with an initial group of five pilot countries. Under this first phase, roadmaps have been piloted in Ethiopia, Ghana, India, Kenya and Serbia (see table below). In addition, the European Union and Japan have joined the Global Pilot Programme to strengthen international partnerships on STI for SDGs roadmaps. These pilots have been implemented using the guidance in the draft Guidebook for the Preparation of STI for SDGs Roadmaps.

To date, more than 20 countries have expressed interest in joining the programme. They will be accepted onto the programme as resources become available to support their participation. The most common challenge, experienced by all countries, has been achieving stakeholder involvement and active participation. The pilot countries that are doing relatively well have succeeded in involving several ministries and agencies, and in creating platforms for effective coordination and collaboration among governments and between governments and other stakeholders. A related challenge has been ensuring a focus on SDGs in the development of national plans and the STI for SDGs Roadmap. The second major challenge has been the availability of current data and relevant expertise to perform the assessment to develop priorities. In addition to COVID-19, another common problem that has slowed preparation of the roadmaps is the lack of a specific budget to develop – and more importantly to implement – the STI for SDGs Roadmap.

FIVE COUNTRIES PARTICIPATING IN THE GLOBAL PILOT PROGRAMME ON STI FOR SDGs ROADMAPS

	ETHIOPIA	GHANA
Leading Ministry / Ministries	Ministry of Innovation and Technology (MINT) is lead agency; Ministry of Science and Higher Education (MOSHE) later joined the roadmap initiative. Working on modalities of collaboration.	Ministry of Environment, Science, Technology and Innovation (MESTI) and CSIR-STEPRI (policy research institute). Technical oversight committee co-chaired by President's SDG Advisory Unit and National Development Planning Commission. Involves Ministry of Finance, Ministry of Planning, etc.
Objectives and Scope	Effort so far has been based on Science Technology and Innovation Policy (STIP) Review concluded in 2019. Key SDGs that appear as planned targets are 1, 2, 3, 8 and 10.	Stakeholder consultation meeting in December 2019 and first meeting of Technical Task Team prioritized SDGs 1, 2, 4, 6, 7, 8, 9, 10 and 13. SDGs 3 and 5 will also be considered.
Assessment of Current Situation	Has been done as part of the STIP Review; Included collection of data and knowledge on development situation of country, status of national innovation system including 22 sectoral technology roadmaps.	Largely based on STI Eco survey; SDG baseline report 2018; Additional STI situational analysis ongoing, including desktop research by University College of London MSC student team as part of partnership with UNESCO.
Alternative Technology Pathways	Discussion so far has focused on preparing an implementation plan covering several of 22 sectoral technology maps prepared for Ethiopia.	Focusing on university-based technology incubators working on emerging technologies.
Timeframe and Key Milestones	COVID-19 delayed process of preparation.	**Assessment studies of current situation of policies, strategies, implementation plans: March-August 2020** ■ Sensitization of key stakeholders: January-December 2020 ■ Preparation of the STI Roadmap for the SDGs by the Technical Task Team, with support from a consultant and research assistance team: July-December 2020 ■ Mobilization of resources, implementation of programmes/projects/activities, monitoring and evaluation: January 2020 - December 2030
Execute, Monitor, Evaluate and Update Plan	Not yet applicable	Not yet applicable. Ministry of Monitoring and Evaluation is part of the Technical Task Team and is involved in process.
IATT Focal point	UNCTAD	UNESCO

	INDIA	KENYA	SERBIA
	Office of the Principal Scientific Advisor to the Prime Minister and NITI Aayog (main government policy think tank)	State Department of Planning (within National Treasury) and National Commission for Science, Technology, and Innovation (NACOSTI) within Ministry of Education; in partnership with Ministries of ICT, Foreign Affairs, Agriculture, and Industry, and supported by African Center for Technology Studies (ACT)	STI for SDGs Roadmap being developed by two WGs: Interministerial WG on Smart Specialisation and Industrial Policy, led by Prime Minister's Cabinet, and Interministerial Group for Agenda 2030 (26 Ministries) under the lead of Minister for SDGs. The Roadmap is operationalized by the Ministry of Education, S&T; Participation by multiple ministries, private sector and academic community.
	Focusing on SDGs 2, 3, 6, 7 and 17 (due to India's strong STI capability and interest in partnering with developing countries)	Main objective is plan for implementation of STI policy and support for delivery of President's Big Four Agenda, which focuses on agriculture, manufacturing, health and housing, and therefore includes SDGs 1, 2, 8 and 9.	Serbian STI for SDGs Roadmap is to be detailed action plan for the Serbian Smart Specialisation Strategy (4S), with the main goal of fostering socioeconomic development and transformation based on six knowledge-intensive priority sectors (food, creative industries, manufacturing, ICT, key enabling technologies, energy). SDGs include 2, 7, 8 and 9.
	Detailed R&D assessment at subnational and national level (2019); NITI Aayog constructed SDG India Index for 13 of 17 SDGs on set of 62 priority indicators in 2018; In 2019, it was updated with 100 indicators covering 54 targets across 16 Goals except SGD17; Mapping of some key sectors completed.	Used indicators from various international and national databases on SDG gaps and country situation; Is undertaking STI Public Expenditure Review aiming to promote R&D and technology adoption and diffusion with increased efficiency and effectiveness.	4S plan involved detailed assessment of economic, innovation, and research potential of Serbia; EC JC supported mapping of 17 SDGs, statistical baseline analysis and identification of STI inputs focused on specific SDG goals; After this analysis SDGs 3, 4 and 12 are under discussion as an additional priority.
	Analysis of alternative technologies being done as part of development of roadmap.	Within SDG 2, focused on increasing productivity and income for smallholders and technologies for maize, rice and potatoes; methodology being tested for maize.	Entrepreneurial Discovery Process framed the discussion of alternative targets and solutions; this is documented in separate workshop reports.
	Deep dives into specific programmes are next step; monitoring and evaluation platforms planned. IATT Workshop with Japan held June 2020.	Team will expand scope and hold consultations to identify what technologies can be delivered, mobilize resources and incentivize private-sector participation.	Detailed STI for SDGs Roadmap will have detailed indicators and timeframes. Expected to be completed by end 2020. Progress has been slowed due to the COVID-19 crisis.
	Not yet applicable, but planning includes monitoring and evaluation and strategic decision system	Not yet applicable as plan is still under preparation.	Not yet applicable, but 4S includes the outline of the monitoring and evaluation system, which will be further developed in the STI for SDGs Roadmap based on input, output and outcome indicators.
	World Bank	World Bank	EU JRC, UNIDO

	ETHIOPIA	GHANA
Challenges/Problems/Lessons	Challenges: **1.** lack of specific budget for the implementation of the STI for SDGs Roadmap (UNCTAD has been able to mobilize some support for the preparation), **2.** establishing a smooth mechanism for collaboration across stakeholders that would ideally be involved in preparation of the roadmap **3.** COVID-19 crisis has slowed the whole process	Challenges: **1.** involving broad range of stakeholders for definition of priorities **2.** better alignment of STI policies with sectoral priorities **3.** interministerial cooperation key to avoiding duplication **4.** capacity building in STI governance
Detailed Roadmap	Under preparation; so far implementation plans have only been prepared for 3 of the 22 technology roadmaps	**Under preparation**

Source: IATT, 2020.

	INDIA	KENYA	SERBIA
	Challenges: **1.** obtaining updated data **2.** coordination among agencies **3.** COVID-19 crisis has slowed progress	Challenges: Inadequate data for baseline of SDG targets or to link government programmes to SDG targets. Lessons: **1.** importance of Technical Committee to provide guidance **2.** need for external support to develop STI for SDGs Roadmaps due to limited skills and funding **3.** need for increased stakeholder consultation **4.** most difficult and expensive step is assessing alternative technology pathways	Challenges: lack of sufficiently disaggregated data; building trust and involving stakeholders; overcoming government silos; getting focus on SDGs; balance between setting strategy and actual implementation. Lessons (keys for success): **1.** mobilizing own funding for implementation of 4S, with additional EU funding **2.** formation of permanent public-private dialogue platform for involvement of high-level stakeholders **3.** winning approval of PM
	Under preparation but various interventions ongoing in agriculture, digital connectivity, health, energy, e-governance, tinkering labs, digital ID, digital banking and health insurance. Also, PM has announced eight major innovation missions.	Under preparation, but team has identified needs and gaps along six agricultural value chains, and current gaps in STI system.	Under preparation. Detailed STI for SDGs Roadmap will be the action plan for 4S; will focus on specific actions to achieve the prioritized SDGs, and include monitoring, financing and implementation system.

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