A Guidebook for the Preparation of STI for SDGs Roadmaps

Draft for Consultation

An Input to the Fourth STI Forum, New York

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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, DESA, UNCTAD and UNESCO

Note: this draft builds on the discussions at four Expert Group Meeting (in NY, Tokyo, Brussels and Nairobi) but is incomplete, before documentation of early roadmap pilot experiences and analysis of international partnerships for STI for SDGs, in the background papers, to inform further modifications to the main texts and recommendations.

For easier access to first-time readers, the draft omits detailed annexes that include analytical underpinnings. Annex and (annotated outlines of) background papers as prepared so far will be separately published through TFM website.

IATT plans to finalize the Guidebook toward July or September. The final product will contain a short Executive Summary, which can serve as a stand-alone brochure, accompanied by several background papers elaborating on key topics included in Chapter 2 and 3.

Written comments and feedback to this draft, upon discussions through STI Forum, will be most welcome and should be addressed to Naoto Kanehira (nkanehira@worldbank.org) and Carl Dahlman (carl.dahlman@gmail.com).
# Table of Contents

Chapter 1. Introduction

1.1 Background and Objective

1.2 Concepts and Definitions

1.3 Rationale of STI for SDGs Roadmaps under National Policy Contexts

1.4 Need for Strengthened International Partnerships on STI for SDGs

1.5 Structure of the Guidebook

Chapter 2. Towards National STI for SDGs Roadmaps

2.1 Institutional Set-up

2.2 The Framework

2.3 The Core Inputs

2.4 The Six Steps

Chapter 3. International Partnerships for STI for SDG Roadmaps

3.1 The Landscape of Global Innovation System and International STI Flows

3.2 How the International Community can Help

3.3 What Governments Need to Do

3.4 What Donor Countries Need to Do

Chapter 4. Conclusions

4.1 Key Messages

4.2 Reflections and Remaining Challenges

4.3 Moving Forward

References
Chapter 1. Introduction

1.1 Background and Objective

Science, Technology and Innovation (STI), both technological and non-technological, leads 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. The role of STI in economic and social progress not only requires appropriate infrastructure, resources and capabilities to produce new inventions but also the capacity of individuals, communities, and companies to apply and absorb them. It is only by understanding and supporting the whole process of technological and innovative development, diffusion, and readiness of its final recipients to accept, own and implement change that we can strive to achieve sustainable and inclusive growth.

Accordingly, the 2030 Agenda, unanimously adopted at the United Nations Sustainable Development Summit in September 2015, positioned STI as key means of implementation of the Sustainable Development Goals (SDGs), and launched the UN Technology Facilitation Mechanism (TFM). The Annual Multi-Stakeholder Forum for Science, Technology and Innovation (STI Forum) has been the main fora for TFM to discuss topics of common interests of Member States and STI stakeholders in the context of the 2030 Agenda.

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” (para 119). In the 2017 STI Forum, participants highlighted that the STI roadmaps and action plans are needed at the subnational, national and global levels, and should include measures for tracking progress. These roadmaps incorporate processes that require, evaluating what is working and not working, and producing continual revisions that create a real learning environment.

This Guidebook is addressed to interested national and local governments, agencies and institutions that wish to use roadmaps as a policy tool to harness STI as means to achieve SDGs. It can also be of interest to the stakeholders taking part in the dialogue that is an essential part of the whole process of design, implementation and monitoring of STI for SDGs Roadmaps and to the wider public that wants to advance global and national SDG agendas and observe the progress. The guidebook focuses on the design stage of the Roadmaps, while showing that the design underpins effective implementation and monitoring.

The guidance included in this publication should be treated as general advice that always needs to 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 the development and implementation of the roadmaps.
1.2 Concepts and Definitions

STI. Science, technology, and innovation are three different domains, each affiliated 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. Governments typically have a responsible ministry for science policies and funding agencies administering research programs.

- **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. Yet, broader actors in industries and governments’ line ministries disseminate, adopt or adapt existing technologies, such as for agriculture, health, infrastructure and environmental purposes.

- **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 is largely a private undertaking by industries and entrepreneurs, farmers and individuals who device better ways of producing or using goods and services.

In the past, innovation used to be seen as a linear process to turn scientific discoveries into commercial applications of new technologies. From policymakers’ perspective, the respective fields of science, technology and innovation were typically considered as highly specialized domains, left to experts oftentimes facing challenges in political, administrative and budgetary environments, as well as inherent uncertainties and long timeframes, or with STI being regarded in some developing country contexts as unaffordable “luxury.”

Today, policymakers’ understandings of STI and approaches to STI policies have matured (as reflected in the rest of this Guidebook). Many governments have cross-ministerial mechanisms, such as national STI councils or commissions, conducive for multi-stakeholder dialogues, planning for coherent STI policy mix, and coordinating and interfacing with implementation of sectoral policies. Yet, in many countries, STI policy focus is still transitioning from predominantly economic objectives towards achieving a closer integration with broader social and environmental aspirations in line with the SDGs.

**STI for SDGs.** In the context of the SDGs, TFM’s work on STI has involved four broad deliberations.

- **STI for or as individual Goals/Targets.** 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 Agenda 2030 language, science, technology or innovation is formally agreed as means or ends for 12 (out of the 17) Goals, and 26 (out of the 169) Targets\(^1\). Addis Ababa Action Agenda (AAAA) has more than 20 commitments for STI. More broadly, STI Forum discussions have shown that STI can contribute to virtually every single 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 the understanding of inter-linkages across multiple SDGs for policymakers to pursue synergies or manage trade-offs (such as between economic and environmental goals). Systemic gender disparity in key STI actors in

\(^1\) Not all of these Targets are accompanied by corresponding metrics under the Global Indicator Framework. For full list of STI explicitly reflected to Agenda 2030 languages, see the background paper.
STEM fields, beyond Targets under Goal 5, have been recognized as a key issue to be addressed. Traditional knowledge held by indigenous communities is 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 at UN deliberations, a broader set of issues needs to be examined, to facilitate capacity development and materialize the full potential of STI contributions toward 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 around displacing jobs, undermining the advantage of most developing countries in unskilled labour and exacerbating inequalities within and between countries.

STI Forums have enriched the discussions, while the breadth and depth of the inter-related issues have presented challenges in identifying practical courses of actions to maximize opportunities and mitigate risks. Meanwhile, the reflection on the state of SDGs have made it clear that ‘business as usual’ is not an option, and 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, STI for SDGs Roadmap has been proposed as a useful approach to strengthen country ownership and elevate the policy debate on STI for SDGs, informing on the areas of common interests among UN Member States, strengthening complementarities of UN system initiatives on STI in a demand-driven manner, and effectively facilitating relevant national and international efforts.

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

- **Goal-driven** by ensuring alignment with the Agenda 2030 and a strategic focus on contributing to accomplishment of the SDGs
- **Informed by evidence, experiences and prospects**, through retrospective STI ecosystem diagnostics or policy reviews, analysis of country-specific challenges or priorities in achieving the SDGs and assessment of critical contributions of STI, practice-based peer learning among countries, and/or foresight exercise on technological changes and their socioeconomic impacts.
- **Localized** and taking into account the specific contexts at different territorial levels.
- **Focused and prioritized** where the possible impact of public and private intervention can be highest.
- **Action-oriented**, through specifying granular challenges and solutions, (re-)allocating budgetary or other resources, building policy and implementation capacities as necessary, improving predictability and incentivising key stakeholders’ contributions, and with explicit mileposts.
- ** Appropriately financed** so that the specific actions can actually be implemented as planned rather than remain as aspirations or statements of objectives.
- **Owned by key actors** through multi-stakeholder engagement in design and implementation.

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2 Concerns often discussed at UN and other international forums also relate to ethical, security (both cyber and physical, such as autonomous weaponry) and human rights aspects, not necessarily within the SDGs scope.
• **Coherent** through adequate governance structure, reflecting sector specific deep-dives in line with national development priorities, considering synergies and trade-offs, and strengthening foundational or enabling STI environments through policy and institutional reforms.

• **Dynamic**, based on learning and course correction through definition of mileposts and measures of success, monitoring and evaluation of progress, and informing necessary adjustments including international efforts.

The diversity of the stakeholders involved in deliberations so far on STI for SDGs roadmaps has caused the challenge of the ‘tower of babel’ problem, namely the absence of a shared framework and language across these different professional communities – scientists, technologists, innovators rooted in public, private, academic, and civil society organizations. In response, **this guidebook is meant to provide common language and step by step advice** for the practical policymaking and communication purposes.

### 1.3 Rationale of STI for SDGs Roadmaps under National Policy Contexts

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 SDG goals and targets by 2030 and to ensure that the three dimensions of sustainability are properly addressed (Box 1.1).

STI for SDGs Roadmaps are not created in a vacuum. Most countries already have or are developing their research, development and innovation infrastructures and capabilities. A systematic assessment and exchange of national and international experiences have so far been limited, though, in developing and implementing policies, action plans and strategies on STIs specifically for SDGs using systemic and consistent frameworks.

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

1. **National development plan.** Many countries have developed some type of national plans (occasionally framed as a growth strategy) with varying levels of detail as well as usefulness.

2. **National science, technology, and innovation (STI) plans**, which are also varying 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. Other times they are more closely related to national development plans.

3. **National SDGs plans.** Since the global agreement on the UN 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 guiding development cooperation in line with the SDGs.
Box 1.1 Why Focus on STI for SDG Roadmaps?

Human progress has been based on advances of science, technology and innovation. This was clearly seen with the dramatic increases in growth and productivity with 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 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 take into account social and environmental aspect in development strategies as reflected in the SDGs goals. We are also entering a new period characterized by the rapid development and convergence of emerging technologies in the physical, digital, and biological spheres which many are calling a fourth industrial revolution (WEF 2016). These emerging technologies and their convergence offer tremendous opportunities and 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 the technology from developed countries to rapidly catch-up. However, that large productivity gaps still remain indicates that it is much more complicated.

Historically some countries, such as Japan and Korea, have been very successful at technological catch-up and have become technology leaders themselves through the use of STI as part of their development strategies. This involved explicit STI strategies including development of their science base, human and institutional capital, and effective government policies working closely with the private sector. Developing countries such as China and India have been explicitly including STI in their development strategies and achieving rapid growth and now also focusing on inclusiveness and environmental sustainability.

Developing countries need to put in place effective strategies to use STI to further their economic and social development to reach the SDG goals. They need to take advantage of technologies that already exist, as well as to make effective use of the potential offered by new emerging technologies and to mitigate the risks they present. That is why developing effective STI for SDG roadmaps is so critical and why the highest levels of government need to be involved in developing and implementing these strategies.

These three generic, yet distinct types of plans may or may not have any areas of overlap. The focus of this guidebook is how to encourage the greater use of STI to help meet the SDGs in all three types of plans—the intersection of the three circles. The basic proposition is that STI can accelerate the achievement of SDGs if it is properly integrated into plans to reach the SDGs.
Figure 1.1: STI for SDGs Roadmap as an intersection of three types of national plans

STI for SDG 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 that they have with other planning documents to avoid duplication and reduce waste—i.e. to maximize the opportunities for convergence among the three circles.

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

1.4 Need for Strengthened International Partnerships on STI for SDGs

Few countries alone will be able to achieve the SDGs with business as usual. Continuation of current pace of poverty reduction (SDG 1, Target 1.1) is likely to leave 23% of African population below the poverty line by 2030\(^3\). Effective use of STI may change the trajectory and accelerate progress toward the future we want, particularly if developing countries are able to develop effective STI for SDG roadmaps. However, 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 toward the SDGs.

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.

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\(^3\) World Bank, Poverty and Shared Prosperity Report 2018
International partnerships on STI for SDGs can be strengthened in the following three ways, from narrower to broader in their scopes:

- **Support governments** to design STI for SDGs roadmaps, through capacity building, diagnostic inputs, peer learning, engagement facilitation and other technical and financial assistance.
- **Enable countries** to achieve SDGs with more and better creation, adoption and diffusion of STI inputs (i.e. implementation of STI for SDGs roadmaps) through market and non-market channels.
- **Strengthen mechanisms** for gap analysis, collective action, financing, progress tracking and policy learning toward optimal use of STI to fill the critical gaps in global sustainable development.

This guidebook reviews a landscape of global flows of STI, associated opportunities and challenges in the context of SDGs, and provides an initial set of guidance on how developing and developed countries can participate in and benefit from international partnerships.

**Figure 1.2: Business as Usual will leave Africa Further Behind**

1.5 **Structure of the Guidebook**

Subsequent to the introduction, Chapter 2 of the guidebook provides step-by-step guidance to development and implementation of national STI for SDGs Roadmaps. This chapter targets 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 or collective actions 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 toward stepping up efforts on STI for SDGs through the next cycle of SDGs follow-up and review.
Chapter 2. Towards National STI for SDGs Roadmaps

The objective of this chapter is to provide a conceptual framework and propose step-by-step guidelines for the development of national STI for SDGs roadmaps.

2.1. Institutional Set-up

STI for SDG 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 taskforce 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 actor within them.

Figure 2.1 Intersection of Development, STI and SDG Plans and Key Actors

Ideally, the process would be coordinated at the highest level by the President’s Office or 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 of using STI to accelerate the achievement of some specific SDG goal may be led 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 SDG roadmaps requires interaction across a broad range of actors from different parts of government, academia, industries, entrepreneurs, civil society, development partners, and other stakeholders.

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4 This chapter has benefitted from extensive oral and written comments received during expert group meeting in 2018 and 2019.
Box 2.1: An Early Pilot Experience on National STI for SDGs Roadmap

As part of UN’s Global Pilot Program for STI for SDGs Roadmaps, Kenya has recently launched an interagency committee to develop and implement STI for SDGs Roadmaps. The promising characteristics of Kenya’s approach include:

- **Institutional arrangement integrating supply and demand sides of STI for SDGs.** The pilot is owned by National Treasury, State Department for Planning, jointly with 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 interagency committee invites contributions by line ministries, such as Ministry of Agriculture, Ministry of Health and Ministry of Industry.

- **Policy frameworks.** The STI for SDGs roadmap is building on Kenya’s SDG Roadmaps (under Treasury), STI Policy (ongoing finalization at Ministry of Education), to contribute to the current administration’s Big Four Agenda and aligned in scope with Africa’s continental strategy on Digital Transformation (African Union).

- **International partnerships.** The pilot design is supported by diagnostic inputs and capacity building from UN agencies, such as by World Bank on effectiveness and efficiency of government’s STI policies, programs and budget as well as incoming development cooperation as related to STI; and UNESCO on assessment of STI system functioning in the context of Treasury’s and county governments’ SDGs gap analysis at national and subnational levels, and gender inclusive STI policy implementation. These diagnostics are envisaged to stimulate dialogues among policymakers, academia, private sector and civil society towards collective visioning and planning to orient policy actions to improve STI system’s contributions to fill the critical gaps in achieving the targeted SDGs.

The first phase of Kenya’s roadmap pilot will focus on technology innovations that enhance agricultural productivity for Food Security, and 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 and contribute to the attainment of targets of several SDGs. The aim of this first phase is to launch implementable action plans over the coming 6 months, supported by the African Center of Technology Studies (ACTS) as a knowledge carrier to codify and disseminate lessons to other African countries.

As part of the initial consultations, World Bank and Government of Kenya organized a digital agriculture start-up competition event in March, synergizing with 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 onboarding younger or new generation policy practitioners; and the need to strengthen domestic scientific community’s voice in the face of challenging policy choices.

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

Regardless of the starting place, this chapter presents a framework and outlines a six-step process that should be undertaken in planning the STI inputs into a specific SDG goal or target. It should be kept in mind that the attainment of any given SDG goal may require many different technologies and innovations and that the STI component is just one of the many elements 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 SDG roadmap is a stand-alone document, whether it is part of a national development plan or sectoral development plan or STI plan that also targets SDGs. Chapter 3 outlines the steps that both receiving countries and donor countries should consider in developing international partnerships using STI to help the achievement of the SDGs in developing countries.  

2.2. The Framework

Figure 2.2 presents a stylized framework for developing STI for SDG roadmaps as a series of six sequential steps, plus a set of three core inputs which are depicted in the hexagon in the center 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 SDG roadmaps for implementation
6. 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 have to be continually updated based on the evaluation of what is and is not working, as well as considering new developments that may affect what is possible (including, the development of new technologies). That 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 policy makers think and work their way systematically through the key elements that have to be taken into account to harness the potential of STI to reach the goal earlier or more efficiently. The steps that are outlined are for a single SDG goal or target. A similar exercise would need to be done for other SDG goals or targets that the government decides to tackle. As noted before, the STI for SDG roadmap does not necessarily have to be independent or self-contained. The STI for SDG roadmap should actually be a key element of a national development plan or a sectoral development plan that the government is undertaking. It may also be part of a STI plans where the focus is on how STI can help accelerate the attainment of a specific SDG or a set of goals. The key is that the roadmap is a systematic approach to how STI can be used to accelerate achievement of the goal and coordinate implementation. Annex 2.1 provides an illustrative table of contents of what a STI for SDG roadmap would contain.

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5 A companion background paper for this chapter summarizes different country diagnostic methodologies and tools for gaps and needs assessment, and provides analysis of initial voluntary national STI for SDG roadmaps as well as of the international STI system and its relationship to national roadmaps.
Figure 2.2: Process flow of six key steps in the development of STI for SDG roadmaps

Key Inputs:
- Stakeholder consultations
- Expertise
- Data & evidence base

1. Define objectives and scope
2. Assess current situation
3. Develop vision, goals and targets
4. Assess alternative pathways
5. Develop detailed STI for SDG roadmap
6. Monitor, evaluate, and update plan

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

In addition, it is important to take into account that there are three levels to the framework. One is the subnational level, since roadmaps have to be tailored to the specific local context. 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 is the national level, which is the main focus of this chapter. It assumes that this already aggregates the inputs from the subnational levels which would follow a similar step by step process. The third is the international level which will be developed in the next chapter.

2.3. The Core Inputs

Although the three core inputs are quite obvious, many roadmaps are developed without sufficient attention to them.

Stakeholder engagement

Although the way stakeholder consultations are done may vary across countries depending on the type of political system and on how top-down or bottom-up their policy decision process is made, it is an important input for virtually all the steps because of the need to get stakeholder perspectives and to try to get stakeholder alignment. The broader the scope of the plan, the greater the need to involve stakeholders to receive input on their needs and priorities. In addition, the consultation process can help to align conflicting interests and get greater buy-in from different stakeholder for implementation and monitoring.
An important risk that needs to be guarded against is that the process of roadmap development may be captured by vested interests. These may be particular groups within government as well as 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.

**Expertise and experience**

Expertise, including on scientific, technical, and 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, including on political aspects, is also very important in developing the vision, goals, and targets. It is also fundamental for developing the specifics of the STI input into the SDG roadmap, including who does what, how much will it cost, what capabilities are required by the agencies or individuals in charge of different aspects, what milestones should be set at what point in time, etc. It is also critical for monitoring progress on the implementation of the plan, and even more for evaluating what is working or not, what are the main obstacles, how they can be overcome, and how the plan should be updated in light of changes in the context as well as the development of new technologies. International experts and assistance from international institutions with experience in analyzing SDG gaps and the role of STI in helping to accelerate them can play a very useful role here and should be factored into the roadmap process.

On the expertise side there is also the risk that the process can be captured by particular lobbies who potentially see the roadmaps as a pathway for resourcing specific projects of technology development projects. 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**

Data and evidence base refer 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 the implementation of the plan is going both in terms of inputs and outputs, and what specific indicators should be monitored. It also includes qualitative information on all of the above as well as information on what are obstacles or problems in implementation, etc. It also includes information of 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 analyzed to develop, implement, and monitor the roadmap. In many developing countries data is poor or not available. For this reason, one of the first activities that may need to be built into the development of the roadmap is data collection and the capability to assess that data. This need to be supplemented by domestic and foreign expert judgement on relevant domestic data and international data and global trends relevant to the country. It should also be noted that with the advent of increasing digitalization of all kinds of information as well as better geospatial mapping tools, it is possible in many instances to use new digital
data to provide some of the information that may not be readily available through conventional methods. In addition, it is necessary to develop systems to integrate multiple data streams and to channel the data aggregates to decision makers at different levels. Organizing efforts to systematically collect, analyze this data is an area that can be developed as part of the international section of this guidebook.

2.4. The Six Steps

Step 1. Define objectives and scope

What is the objective of the roadmap?

STI for SDG roadmaps can have many objectives regardless of whether they are stand-alone documents or whether they are part of other planning and implementation documents (Box 2.2). Is the objective of this roadmap primarily to help build consensus on a vision or is it ready 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 greater advocacy. But even if it is the latter, it is still necessary to involve those who are expected to be part of the implementation, or who will be affected by the roadmap in the discussions in order to align actions and get buy-in. The process of developing the roadmap and building stakeholder alignment is often one of the most valuable aspects of roadmaps as it helps the consideration and integration of perspectives and involvement of institutions and agents that are critical for successful implementation.

The organization developing the roadmap also needs to consider various practical details such as ensuring leadership commitment, appointing a steering committee whose members have knowledge and authority to make decision regarding the scope and boundaries of the exercise, as well as how broadly to consult and the types of organizations and experts who are expected to participate in the development of the plan. Ideally the whole process should be endorsed and led by the highest level of government. Box 2.2 presents a rationale for why developing STI for SDG roadmaps should be of interest to the President’s Office, and Ministries of Finance and of Planning.

What is the scope?

Is this a national STI for SDG 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 mission-oriented exercise? Is the scope a broad set of SDG goals, or is it focused on a single SDG goal, or sector? (See background paper for useful references to sectoral roadmaps such as agriculture, education, energy, environment, health, ICT, oceans, STI, and water.) Or, is it part of a multi-country regional roadmap, in which case it will require coordination

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6 See, for example, the presentation by Xu Zhengzhong on 11/27/2088 at the 3rd EGM in Brussels. See also UNCTAD (2017b), which describes how digital tools such as big data and artificial intelligence can be used to support foresight analysis.

7 The UN Technology Facilitation Mechanism has an extensive reference list for developing roadmaps, which includes not only UN agencies but other international and bilateral agencies. The full list of references as of end December 2018 is reproduced in the Background Paper.

8 For more guidance on initial planning and preparation see TEC (2013).
among the country governments participating, as well as with the bilateral or multilateral agencies, international private sector, and NGOs involved?

Box 2.2: Objectives of Roadmapping

Roadmaps can be used for a variety of purposes relevant for policy process:

- **Vision building**: Building a long-term vision of desired future expressed as statements and images of desired and plausible futures. (e.g. TIFAC 2035 Technology Vision in India, ICC’s Green Economy Roadmap)

- **Exploration of innovation and technology pathways**: Exploration and assessments of alternative technology, innovation or policy pathways to achieve a vision, often expressed as scenarios. (e.g. energy roadmapping by CSIRO in Australia).

- **Technology advocacy**: Technology and innovation advocacy supporting technology areas or specific technologies within specific areas, often including research and innovation agendas with priority technology areas (e.g. SPIRE in the EU, Forest products industry roadmap in the USA).

- **Stakeholder alignment**: Building or strengthening stakeholder alignment to support the vision and technology, innovation or policy pathways. (e.g. ICC’s Green Economy Roadmap, Forest products industry technology roadmap in the USA).

- **Support for policy design and planning**: Providing support for design and planning of policy portfolios or programs by elaborating selected technological and innovation pathways, often using milestones and quantitative targets (e.g. Japan’s New Low Carbon Energy Plan, EU SET-PLAN, RISEnergy in Sweden)

- **Support for policy implementation**: Providing support for implementation and management of ongoing policy programs or other initiatives. (e.g. EU SET-PLAN and underpinning roadmaps, Jamaica’s National Energy Policy 2009-2030, Power Africa by USAID).

Roadmaps often strive for multiple objectives. The choice of objectives and design of roadmaps are situated in a specific context in which the roadmapping process is conducted. It depends on factors internal (e.g. institutional capacity, competences and interests of the owner or owners of the exercise) and external to the process (e.g. maturity of the policy agenda on the national and international level, the stage of the relevant policy processes, alignment among local and international stakeholders).


This is something that those developing the roadmap need to consider carefully. Broad roadmaps 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 expertise and actors with different technical skills and capabilities. For example tackling SDG 2 to eliminate poverty may involve improved seeds, other inputs such as irrigation and fertilizer, training in the use of new technological inputs, better systems of food storage and distribution, better marketing systems, improved government
targeting of food supply or cash grants to get the food to poor persons who may not be able to buy food, better information on health and nutrition, better education and skills, better jobs, etc.

What specific SDG goals and objectives are targeted?

Because the 17 SDG goals are so broad and cover so many targets it is important for countries to think carefully on which they will prioritize. Presumably, this will have been done in their national development plan, but it can be supplemented in separate STI for SDG roadmaps. Various international agencies are creating methodologies to help countries identify where they have the greatest SDG gaps as well as where there are possible synergies. For the SDG gap analysis, benchmarking assessments such as those by the Bertelsmann Foundation and the Millennium Development Institute may serve as useful reference.

Given the broad range of SDG goals and the need to prioritize, it is also critical to consider to what extent there are potential synergies and tradeoffs among the SDG goals. The International Council for Science has developed a mapping of linkages among SDG goals 2, 3, 7, and 14 and is piloting this with the International Network for Government Science Advice (INGSA) in Jamaica. In addition, the Millennium Institute’s Integrative model for Development Goals Strategies (iSDG) simulates the consequences of a variety of policies influencing SDGs individually and concurrently. Other useful tools include the Rapid Integrated Assessment Tool developed by UNDP, and the SDG Accelerator and Bottleneck Assessment Tool developed by UNDP, which help developing countries identify key areas that can trigger positive effects across SDGs. (see Background Paper to this chapter for more details.)

Once the specific goals and objectives are identified, what will be the sources of knowledge and expertise that will be needed to turn those goals into actionable plans? This will be very important for steps 3-5. As noted earlier, this 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 the wider planning of SDG agendas and national development or sectoral development plans - then the alignment can occur more naturally. The objective of developing STI for SDG roadmaps is to offer concrete steps that can accelerate the achievement of SDG goals in whatever planning process countries have for achieving SDG goals by harnessing innovation potential and taking advantage of technological opportunities.

Most countries have begun to articulate SDG goals as part of their plans, but few have outlined what the role of STI will be in reaching those goals, or even more generally, how the goals will be met. It is also important to consider how STI for SDG 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 that was undertaken for the preparation of this guidebook it is clear that there is scope for much more integration across the different plans (see Background paper to this chapter). This closer integration has the potential to

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leverage resources and actions, as well as to improve the efficiency and effectiveness of the actions considered in the various plans.

Step 2. Assess current situation

What is the current situation regarding the targeted SDG goal(s) and objectives?

Developing a baseline of the country’s current situation regarding the targeted SDG goal(s) is critical for developing a successful roadmap because it is necessary to know where a country is in order to set realistic goals. This involves assessing not only SDG gaps, but STI gaps and most specifically how STI can contribute to the acceleration of closing the SDG gaps.

There are various methodologies which help to identify SDG gaps. These include Bertelsmann and SDSN (2018), OECD (2017), Millennium Institute (2018). However, it is also necessary to assess what are the challenges to making significant improvements on the goals. This requires expertise on the specifics of the country’s economic, social, and environmental situation as well as on what technologies are in use, how widely diffused they are, and what other technologies can 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. The World Economic Forum’s Global Competitiveness Report benchmarks countries on 12 pillars, several of which are very relevant for innovation. The UNESCO Institute of Statistics is working on thematic STI indicators in 6 areas: STI framework conditions and governance, infrastructure for STI, human capital for STI R&D and other S&T activities, innovation processes and outputs, and knowledge exchange and transfer.

To benchmark countries STI systems there are also various methodologies. These include UNCTAD’s STIP Review Framework, UNESCO’s Global Observatory of Science, Technology, and Innovation Policy Instruments (GO-SPIN), OECD STI Policy Reviews, The World Bank public expenditure reviews on science technology and innovation (See the Background Paper). The EU is promoting Smart Specialization Strategy for which it has developed very useful diagnostic methodologies to analyze a country’s or region’s situation and develop concrete strategies which have now been implemented in many regions, including in countries outside the EU.

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10 The UN has an online database of the UN family’s repository of actions, initiatives and plans on the implementation of the 2030 Agenda and the sustainable development goals (SDGs). It is available at: https://sustainabledevelopment.un.org/content/unsurvey/index.html.
11 There are also several useful benchmarking indicators of a country’s competitiveness (WEF,2018), and innovation capability (WIPO, Cornell and INSEAD 2018),
12 https://www.globalinnovationindex.org/Home
13 The World Economic Forum’s Global Competitiveness Report provides indicators relevant for international competitiveness in the context what they call the fourth industrial revolution ( http://gcr.weforum.org/)
14 The GO-SPIN launched a very useful electronic platform to assess countries national innovation systems. It is available at: https://en.unesco.org/go-spin.
15 For details on the diagnostic tools and their application see their online platform at: http://s3platform.jrc.ec.europa.eu/
An important dimension of assessing a country’s current situation involves progress towards gender equality as per SDG 5 which has implications for the STI for the SDG roadmaps both as an input and an output.\textsuperscript{16}

**What resources are available or can be made available to meet those goals?**

It is also important to assess whether resources available match the needs and the level of ambition 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 this roadmap? What additional resources can be obtained by the government for this task? How can resources from the private sector, NGO, 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 in government, the private sector, the NGO sector and civil society have to be developed to implement the plan? What support can be obtained from abroad? What twinning and training arrangements may be possible? What skills development need to be included in the roadmap? This is a complex piece of work. To accomplish this, countries should take advantage of technical expertise that can be supplied by various international agencies including many from the UN system (such as UNCTAD, UNESCO, UNDP, WIPO), multilateral financial institutions (such as the World Bank, Asian Development Bank, African Development Bank, InterAmerican Development Bank, European Bank for Reconstruction and Development, etc.), bilateral country programs 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 pragmatic considerations of time availability and the willingness of stakeholders to participate. Nevertheless, regardless of what methodology is chosen, or even if no formal methodology is chosen, some of the key questions that need to be considered include the following.

**What is the vision?**

Developing a credible vision for advancing the attainment of SDG goals also requires that the political leadership of the initiative understands the current situation and can provide goals that are realistic in terms of resources, capabilities, technologies/innovations, and time line to reach the objective(s).\textsuperscript{17}


\textsuperscript{17} While developing vision has been put as the third step, it could just as easily been put as a fourth step after more work has been done on the alternative technology/innovation pathways. This illustrates the iterative nature of developing roadmaps.
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 depends on where advancing on specific SDG goals chosen fits into the overall strategy, resources, and capabilities of the country and the extent to which a greater STI input can accelerate the attainment of that SDG goal. It will also depend on the 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 the commitment of high-level stakeholders, and the extent to which they are involved in the governance of the implementation of the roadmap. The success in getting stakeholder ownership will also depend on the process through which the vision is developed. Visions generated through broad consultation processes are likely to get 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 consensus. This is an important trade-off that needs to be considered.

Approaches for developing visions include foresight workshops, alternative futures, horizon scanning, scenarios, and others. 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 assist policy makers and relevant stakeholders develop plausible narratives for alternative futures and to think through systematically about likely implications for the country’s future. That helps to set out the goals and to open up an out-of-the box discussion of a future state that normally may not be considered. Once a consensus emerges about what policymakers want that state to be, they can begin to develop pathways of how to reach that state with an STI for SDG roadmap. Some countries also set up specialized agencies or institutions that help to assess future trends and how they may affect what a country has to do. In addition, some of the UN 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 (3-4 years), medium (5-8 years) and long-run (8-12 years to 2030)?

The time path for meeting different goals and targets also needs to be developed as part of the vision. If not here, they need to be spelled out in further detail in step five of the roadmap.

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Step 4. Assess alternative pathways

This is perhaps the most critical step for creating an STI for SDGs roadmap because it is the phase for explicit consideration of STI inputs towards accelerating the achievement of SDG goals. This is also where current STI for SDG roadmaps are weakest, particularly in developing countries. Part of the reason is that most available STI for SDG roadmaps 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 an important argument can be made that innovation covers a broader space than pure research for scientific or technological purposes as it includes new ways of producing goods and services which may be non-technical.

Table 2.1 presents a comprehensive overview of innovations, ranging from incremental process improvements to system innovation (OECD 2015) as well as grassroot, pro-poor, inclusive and frugal innovation. Different types of innovation are needed to make technologies work in different local contexts. For example, if the focus is placed on diffusing existing well tested technology, say, solar energy, there may be still a need for a great deal of innovative activities to apply it. Organisational innovation may be needed to work out suitable business models to make it economically feasible considering socio-economic profile of future customers. Product innovation may be needed to adapt existing technology to the local context (e.g. design of roof tops, climate and other natural conditions, regulatory requirements, including standards). There will be always a need for innovation if technology is new to the country or locality where it is to be applied. In addition, as noted in the introduction, there needs to be an equal, if not greater focus on non-technological aspects of innovation, including on alternative business models, organizations, delivery systems and social aspects, including barriers to using new technologies.

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19 This conclusion is also reached by a review of STI roadmaps. See Carayannis, Grebeniuk and Meisner (2013), International Energy Agency 2015), and Miedzinski, McDowall and Fahnestock (2018).
20 One perspective on transformative innovation is the notion of system innovation (Geels 2005, OECD 2015).
21 Grassroot innovations are 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 to highlight them and to scale up their dissemination, In India the Honeybee Network has developed an extensive database and support network for identifying, highlighting and disseminating grassroot innovations.
22 Pro-poor, inclusive, and frugal innovation refers to innovations that have been designed to address the needs of poorer, marginalized population. The 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, low cost solar stoves for rural communities. For more examples see some of the innovations presented at the Global Solution Summit in June 2018 before the third STI Forum in New York (www.globalsolutionssummit.com).
Table 2.1 Innovation is Diverse: The Man Faces of Innovation for the SDGs

<table>
<thead>
<tr>
<th><strong>Product and service innovation</strong></th>
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</thead>
<tbody>
<tr>
<td>• 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)</td>
</tr>
<tr>
<td>• Innovative products</td>
</tr>
<tr>
<td>o New products that provide value to users because of their features</td>
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<tr>
<td>o Inexpensive, durable, repairable, re-usable, recyclable, biodegradable materials and products with enhanced accessibility and reduced environmental impact</td>
</tr>
<tr>
<td>• Innovative services</td>
</tr>
<tr>
<td>o Business to Business (B2B): New services which reduce the cost or time, or improve the quality of processes of production, management or distribution</td>
</tr>
<tr>
<td>o Business to Consumer (B2C): Provision of new services that meet needs of consumers at lower costs or provide them faster or more efficiently</td>
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<tr>
<th><strong>Organizational (institutional) innovation</strong></th>
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<tr>
<td>• New ways of organizing the production of goods or delivery or services that reduce the costs, or time, of producing and delivering them</td>
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<tr>
<td>• Better ways of managing the production of goods or services or their delivery, which can increase efficiency, quality, or accountability for new objectives such as pollution control, waste reduction, corporate social responsibility, inclusiveness.</td>
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<tr>
<th><strong>Marketing innovation</strong></th>
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<tbody>
<tr>
<td>• Faster delivery or lower cost of marketing products and services, including for example through social media and other internet-based platforms, as well as product differentiation with eco-labels, fair-trade labels or labels ensuring that the production process of products has respected human rights</td>
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<tr>
<td>• Science-based campaigns and awareness raising, for example on water and sanitation, sustainable consumption</td>
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<tr>
<th><strong>Business model innovation</strong></th>
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<tbody>
<tr>
<td>• New ways of organizing businesses and their products and services, for example using internet-based platforms to match supply and demand of goods (such as Amazon) or services such as personal transport services (Uber and Lyft) or short term apartment rentals (such as Airbnb) without owning any assets</td>
</tr>
<tr>
<td>• Changes in value proposition and product-service systems of companies (e.g. circular economy business models, including product sharing and functional sales)</td>
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<table>
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<tr>
<th><strong>Pro-poor, inclusive innovation and frugal innovation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Various types of innovation designed to address the needs of poorer, marginalized groups</td>
</tr>
<tr>
<td>• Affordable products from the informal sector that have a potential to reduce lifecycle-wide 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)</td>
</tr>
<tr>
<td>• Products designed or redesigned to reduce their cost and complexity (become modular but can still be high-tech) while retaining their core functions.</td>
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<tr>
<th><strong>Grassroots innovation</strong></th>
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<tbody>
<tr>
<td>• 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.</td>
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<tr>
<th><strong>Social innovation</strong></th>
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<tbody>
<tr>
<td>• New collaborative arrangements with social and environmental benefits (e.g. supply chain innovations rewarding primary producers, energy cooperatives, repair cafes, eco-villages)</td>
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<tr>
<th><strong>System innovation</strong></th>
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<tbody>
<tr>
<td>• System changes underpinning a number of mutually reinforcing innovations, often implemented by many organizations, which together have a potential to transform functional systems delivering key services to societies, such as health, water and food, or mobility:</td>
</tr>
<tr>
<td>o Circular economy approaches changing waste management systems (integrated approaches to collection, sorting, processing and disposal)</td>
</tr>
<tr>
<td>o Integrated solutions to urban systems (e.g. multimodal mobility systems).</td>
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</table>

Figure 2.3 presents three archetypes of technologies/innovation in terms of their relative importance for STI for SDG roadmaps in developing countries, existing technologies/innovations, emerging technologies/innovations, and new technologies/innovations which have yet to be developed.

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 technologies/innovations as well as emerging technologies/innovations. This is why they are in the broader bottom parts of the pyramid in Figure 2.3. The potential of new technologies/innovations yet to be developed is being 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 expect that even if they are developed, they could be broadly disseminated. Currently, only a few developing countries (such as China, India, Russia, Brazil, and some others) 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 the international STI for SDG roadmaps chapter. For developing countries, the key will be how to be able to acquire, disseminate and use those new yet to be developed technologies.

**Figure 2.3: Pyramid of Relative Relevance of Different Technologies/Innovations to Achieve SDGs**

What technologies exist to help attain those goals?

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

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23 See for example OECD (2014) and Ciera and Maloney (2017)
A key issue is how developing countries can access those technologies, considering that 68% of the population in low income countries and 61% of that in lower middle-income countries live in rural areas (WDI 2018). Moreover, more than two thirds of the labor force in low income countries and roughly 40% of that in lower middle-income countries is still engaged in agriculture, most of it in subsistence farming. For smallholder farmers and low-income population, grassroots innovation, frugal and pro-poor innovation offer ways for narrowing this innovation gap. And for these types of innovations one of the major challenges is how to adapt, scale up and deploy available technologies.

There are multiple channels for obtaining existing technology. These include obtaining technology through direct foreign investment, importing capital goods and components that embody the more efficient technology, licensing technology, technical assistance purchased through arms-length market transactions or provided as part of bilateral government technical assistance packages or the dissemination work of NGOs or professional societies, 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 that technology is to be disseminated within a country, across different regions, and different actors.

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

It must be kept in mind that technology is just one of many inputs required to actually have an impact in use. 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 are to benefit from them. For example, to disseminate medical technologies/innovations, such as vaccines, requires a system of health providers. Also, something as simple as oral rehydration therapy, essential to reduce mortality because of dehydration from diarrhea, requires not just a few cheap chemicals, but trust by the target population in the providers, as well as clean water, which is usually not easily available in the communities where the problem is most endemic. Figure 2.4 is a schematic representation of some of the key components of the technology/innovation deployment system.

Technology can involve existing technology which is ready for dissemination. However, new technology often has to be applied in prototypes and tested before it is 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. Therefore, more steps would be required within the technology box, but they are not represented here in order not to overly clutter 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 and alternative energy systems for electricity generation, such as wind farms or solar energy
systems. Increasingly, a good ICT infrastructure of fiber 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.

**Figure 2.4: Technology is Just One Element of the Deployment System Required to Reach Beneficiaries**

[Diagram showing the components of technology deployment system: Technology, Complementary inputs, Supporting infrastructure, Ultimate beneficiary, Delivery mechanisms, Entrepreneurship and skills, Finance]

Source: Authors

Developing and deploying a technology 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 typically require some sort of tangible collateral before they are willing to make loans. New start-ups almost by definition do not have much 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 finance to buy the product or service, so it will also be necessary to address how that financing can be extended. 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 repayments.  

Deploying the technology/innovation also requires entrepreneurship. Someone – be it a company, a nongovernment organization, or a government agency – needs to take the initiative to roll out the technology to the ultimate beneficiaries. For technologies that are new to the target environment there is often some risk that the technology will not work without some 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 the technology requires skills, including not only basic literacy, but often specialized technical skills, such as how to use the internet or new applications.

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Box 2.3: Some Relevant Insights from the 2018 Global Solutions Summit

Five key points came out of the Global Solutions Summit held in NYC June 4th, 2018 just before the UN 4th STI Forum. The summit brought together entrepreneurs around the topic “From Lab to the Last Mile: Technology Deployment Business Models for the SDGs.”

1. Useful concept of the “global last mile challenge.” This was not the conventional geographic concept related to proximity to the grid, but the challenge of getting existing technologies relevant to the attainment of critical SDG goals 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. Achieving the latter required strengthening local social capital to share assets and information and promote self-help approaches, and linking communities and local networks with government and formal institutions.

2. Scaling up challenge. While 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, and had reached thousands, and even hundreds of thousands of poor people, it is clear that this is not sufficient to reach the hundreds of millions of people who can be helped. What is required is a way to radically scale-up and massively implement these successful innovative solutions to help achieve SDG goals.

3. Building an efficient and effective deployment ecosystem. In order to scale up and replicate successful business models to deliver SDG solutions for delivering these solutions requires an ecosystem involving technical, financial, human capital, supply chains, infrastructure, political support, entrepreneurship and innovative business models and delivery systems, and financing. This entails a two-pronged strategy. First, developing a platform “so that the disparate elements of the ecosystem can find each other and join forces more easily,” such as through online platforms. Second, “building 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 from billions to trillions to developing new innovative financial conduits necessary to deliver this finance in smaller increments. Private business, NGOs and social enterprises are developing some of these innovative conduits via traditional and non-traditional banking systems as well as by using new fintech solutions to reach the last mile customers as well as to channel resources to intermediaries who in turn deliver the goods or services to the last mile customers through small service fees.

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 SDG roadmaps have to address the income constraint. There is a feedback loop from extending basic SDG services to communities and the income that is generated for them to be able to buy these services. Some NGO organizations have realized this and have expanded their role from technology suppliers to income generating market access programs. This also requires building social capital which is time consuming. This needs to be factored into programs to help achieve the SDG goals.

An important implication of these findings is that, discussions of STI for SGD need to also focus on the non-science components of the technology deployment ecosystem.

Deploying technology also requires a delivery system (See Box 2.3). For commercial technologies this is typically through private firms which have an incentive to deploy the products or services because they make some profits from such sales. For social technologies 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 technologies (such as in the health area, or when a new agricultural technology is proposed to a subsistence farmer), the delivery system needs to obtain the trust of the users before it will be accepted.

What emerging technologies may help to 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 having to build central power stations and an extensive grid system to provide electricity to communities without electric service, 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 much faster in time than through the expansion of traditional wire-based telephone or cable service. Similarly, new water purification technologies using advanced Nano-technology membranes or other new technologies may make it possible to provide water to rural communities more cheaply than by extending more expensive conventional water supply systems.

However, it must also be kept in mind that some disruptive technologies, such as automation and robotics, 3-D printing, and new materials, may also have negative impacts on growth and development prospects of developing countries. Automation and robotics may wipe out the low labor cost advantage of developing countries which has given them possibilities for producing labor intensive manufactured produces. 3-D printing may also lead to displacements and reshoring of global supply chains which have provided an entry point for developing countries into manufacturing. New materials and synthetically produced foods may reduce the exports of metal and commodity crops that have been critical for developing countries’ exports and growth. In addition, some of the emerging technologies such as Nano and bio-technologies may have negative side effects, including bio and environmental hazards.

Thus, it will be important to constantly scan the horizon for the potential positive or negative impact of emerging and new technologies. This means that the assessment of alternative roadmaps also has to take into account what special regulations or compensation programs need to be put in place to protect the populations who are negatively affected by the rapid dissemination of emerging technologies. Regulation may include increased security and privacy protection measures. Programs include both skill retraining as well as better systems of social protection.

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

This 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, cheap organ replacement), water (cheaper desalination and water treatment...
technologies) and other areas can open new more cost effective ways of meeting some of the SDGs. Therefore, it is important to consider what is the potential of these possible new technologies and how the country should position itself to take advantage of them.

What alternative innovation pathways are there to reach those goals?

Because there can be different ways of using science, technology and innovation to meet some of the SDGs, it is useful to explore different pathways. These 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 as well as organizational capabilities required to effectively diffuse it at the country or regional level need to be considered, allowing an overall comparison of these different routes.

It is also important to appraise the distributional impacts of these pathways, considering their impact on gender, different age groups, ethnic groups, as well as territorial aspects. These impacts can be positive or negative and need to be considered in making the decision of what pathway to take. It will also imply the needs to have specific policies to offset some of the negative impacts on some groups. It is likely that some technology/innovation routes will be more effective for reaching some particular population. For example, for electricity, conventional centralized power grid technology may be more cost effective for dense urban populations, while others 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. And this would probably need not just local, but global expertise.

It is generally expected that successful new technologies 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 eventually are replaced by newer technologies. Attention has to 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, such as the trust and acceptance of the technologies by the users, needs to be taken into account. Ideally, for each technology/innovation pathway the following should be considered in evaluating it: capability of the different agents involved in getting the service to the users including firm capabilities when they are the main delivery agents, the capabilities of government or NGO organization and community organizations when they are the main delivery agent, physical and digital infrastructure requirements, complementary inputs, financing, and government policy making and delivery capability, and the relative costs of using the different technological routes.

The choice of innovation pathways in STI roadmaps needs to consider existing STI capabilities and the extent to which they are aligned with the SDGs. Put simply, different types of innovation needed to accomplish the SDGs in different contexts require different capabilities from firms and other actors to be successfully implemented, scaled and diffused. For example, if one of the priority goals is to provide a 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 infrastructures in the country. The focus on STI capabilities needed to address specific challenges is important as they may considerably differ between various topics, actors,
technology areas, economic sectors and regions. This appraisal allows to better tailor policy intervention in STI to address the SDGs while making sure that policy portfolios are catered for the specific policy context.

Step 5. Develop STI for SDGs roadmap

Step 5 is focused on developing STI for SDGs roadmap indicating 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 and aligned with the 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 a full account of the evidence and deliberations in the preceding steps.

The process should result in a roadmap document – a long-term action plan. The document needs to build on the preceding steps. It should introduce key findings of the baseline analysis and give an account of the roadmap deliberation process, especially on how the roadmapping process considers different voices and interests in elaborating and comparing alternative STI pathways.

The action plan should introduce:

- Key challenges and vision of STI for SDGs roadmap
- Objectives, concrete targets and milestones of the roadmap and explain how they link with key strategic documents of the country
- Description of selected innovation pathways and technology areas, explaining how the roadmap tests alternative approaches and 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
- Expected timeline of implementation considering 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 an inclusive governance of the roadmap, as well as
- Monitoring and evaluation system allowing to track progress in the roadmap implementation.

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 SDG goals will be developed by government. However, given the nature of the SDGs, the government is not always the key actor or even the most important actor. For some, such as quality of education, clean water and sanitation, peace and 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 others, such as decent work and economic growth, industry innovation and infrastructure, affordable and clean energy, it will be the private sector that will roll out the services or undertake the activities that will help attain the goals. For others, such as no poverty,
zero hunger, good health and wellbeing, it will be a wide variety of actors, including non-government actors and civil society. Therefore, policy makers need to think of 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 adequate policy mix?

For this policy makers need to develop an appropriate policy mix and instrument portfolios. 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, as well as on 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 the investments in innovation needed to accomplish the SDGs. This includes changes to the country’s regulatory regime as well as specific instruments aimed at encouraging or supporting desired activities.

Table 2.2 outlines some general regulatory levers and policy instruments relevant for STI for SDG roadmaps. Changes to the regulatory regime are primarily to open the economy to global knowledge inflows, but also to 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. It also includes dealing with the challenges of emerging technologies such as new forms of unfair competition facilitated by proprietary digital platforms, data ownership, privacy, and security, and these can apply across low income as well as high income countries.

Policy instruments providing support can be grouped into three broad types:

- **Adoption and use of existing and emerging technologies.** In most low-income countries production and services are done by very small informal firms in manufacturing and services, and subsistence agriculture. They have limited knowledge of existing technologies that could improve the production and delivery of better goods and services that can help meet the SDG goals. Innovation is largely indigenous or grass roots, although there may be a small modern sector. Thus, the key focus is not so much to encourage research, but to encourage the use of existing technology and the scale up grassroots innovation. Therefore, the instruments are aimed at providing technological information and innovation dissemination, strengthening management capability and skills upgrading, and improving the basic national quality infrastructure.

- **Adaptation of existing and emerging technologies and innovations.** This is typically more relevant for countries at the middle level of technological development and 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 supply and the needs of firms and society, and the commercialization of adapted technology.

- **The third is for more ambitious creation of new technologies and system wide innovations.** It is typically more relevant for countries with more advanced technological capabilities and productive sectors and includes support for more ambitious and transformative system innovation. The focus
here is to help mitigate the risk as well as to encourage more collaborative approaches to big challenges.

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 the different types to support different kinds of innovations. Even countries at low levels of technological development may find the need to use policy instruments in the second or even the third type 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 and adapt advanced emerging technologies, including digital technology systems, to local conditions. Likewise, even advanced countries may need policies in the first type to help small and medium enterprises use existing new technology.

Table 2.2: Illustrative Regulatory Levers and Policy Instruments for STI For SDG Roadmaps

<table>
<thead>
<tr>
<th>Regulatory framework levers</th>
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<tbody>
<tr>
<td>• Trade and foreign direct investment policy to encourage entry and use of technologies that can help reach SDG goals, including a good business environment that encourages investment and innovation</td>
</tr>
<tr>
<td>• Prices that reflect economic costs (i.e. carbon pricing; removing subsidies on carbon-based fuels, etc.)</td>
</tr>
<tr>
<td>• Regulations for the challenges of the digital economy including, unfair competition, privacy, security,</td>
</tr>
<tr>
<td>• Reskilling and social protection legislation and institutions to help persons negatively affected disruptive technology</td>
</tr>
<tr>
<td>• Regulations and institutional arrangements underpinning gender equality in STEM and research</td>
</tr>
<tr>
<td>• Product and process standards and certification for safety, health, social and environmental goals</td>
</tr>
<tr>
<td>• Intellectual property regulation and incentives (such as purchases of licenses) to encourage use and diffusion of technologies helpful for the attainment of SDG goals</td>
</tr>
<tr>
<td>• Rules and regulation for development of venture capital and other finance relevant for new technologies that can help reach SDG goals</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Instrument to absorb and use relevant technology and innovations</th>
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</thead>
<tbody>
<tr>
<td>• Public awareness campaigns and outreach activities to support use of technologies for SDG goals</td>
</tr>
<tr>
<td>• Business advisory services to build up management capability and help increase productivity, and attainment of safety, health and environmental standards and gender equality</td>
</tr>
<tr>
<td>• Technology extension services to demonstrate and diffuse new technologies relevant for SDG goals, including scale-up and dissemination of indigenous and grassroot innovations</td>
</tr>
<tr>
<td>• Technology centers to help solve firm problems related to the SDGs by using relevant new technologies</td>
</tr>
<tr>
<td>• National quality infrastructure including metrology, standards, testing, and quality control and awareness programs on the importance of using these services to meet quality, health and environmental goals</td>
</tr>
<tr>
<td>• Supplier development programs to help firms integrate into domestic and international value chains</td>
</tr>
<tr>
<td>• Vouchers for firms to contract specialized technical assistance to use relevant new technologies</td>
</tr>
<tr>
<td>• Tax incentives or grants to first (pioneer) firms to use relevant new technologies</td>
</tr>
<tr>
<td>• Development of firm clusters to generate economies of scale and agglomeration for learning about and effectively using (and developing) relevant new technologies</td>
</tr>
<tr>
<td>• Skills upgrading and training programs to use new technologies including digital technologies</td>
</tr>
<tr>
<td>• Tax incentives or low interest loans to firms or individuals to use products with technologies that help address SDG goals (such as for installation of high efficiency furnaces or purchase of electric vehicles)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instruments to adapt new emerging technology and innovations</th>
</tr>
</thead>
</table>

29
The choice and design of STI policy instruments to support the selected pathways has to consider existing policy and institutional capacity to deploy and implement specific instruments and portfolios. This 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 delivery mechanisms or design features of instruments to make them feasible and avoid implementation.

Adapting STI policy mix to existing STI capabilities does not need to limit the ambition of STI policy for SDG roadmaps. Governments have a great deal of flexibility in selecting combinations 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 design and implementation of policy portfolios which gradually build up the capacity of STI system to respond to key societal challenges. Roadmaps can create learning-by-doing environments in which governments in a close collaboration with stakeholders appraise, co-design and gradually improve STI policy mix so 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 over what time period? This involves spelling out the role of different government ministries and agencies that may be involved as well as the relation between the central government and subnational governments. This includes determining how the activities of the different government agencies will be coordinated. But who or what agency is to coordinate government activities also needs to be decided considering what power or leverage that agency will have to effectively carry out the coordination. To make this work and have real traction, it is necessary to get all the relevant stakeholder on board to commit to their respective responsibilities (see

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**Instruments to develop new technologies**

- Technology development grants and subsidized loans for technologies relevant to help with SDG goals
- R&D vouchers for firms to contract research to help deliver better goods and services for the SDGs
- R&D tax incentives or grants to firms to adapt technology relevant for the SDGs
- Technology transfer offices in universities and research centers to commercialize technology
- Business incubators to support technology start-ups in areas relevant for SDG goals
- Grants for science and engineering training abroad as well as developing strong domestic universities

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Source: Authors
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?*

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 fulfill 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 have a roadmap that can be implemented. To build up domestic capabilities, developing countries can try to get technical support from international institutions, develop twinning arrangements for capacity building with bilateral agencies as well as 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 very 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 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.

**Step 6. Monitor, evaluate, and update plan**

*What monitoring 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, on what parameters, and with what frequency?

*Who will do the evaluation?*

This 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.
Box 2.4: Engaging the Private Sector to Use STI more Effectively to Attain SDG goals

The private sector is driven primarily by the search for profits and responds to market signals and the policy environment. It may also be bounded by limited information on market opportunities relevant for reaching some SDG goals, as well as by incomplete knowledge of technologies and innovations that could provide profitable ways to provide goods and services towards that end. Policy makers, on the other hand, tend to focus their attention on providing goods and services to reach SDGs goals which may not be economically attractive to the private sector and which it will therefore not engage in. Policy makers need to understand this disconnect and seek ways of engaging the private sector’s contribution towards leveraging STI to accelerate the achievement of SDG goals. They also have to understand that the private sector is very 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 great capabilities and global reach. They have to target their strategies and policies to 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 instruments (e.g. direct financial support to technology adoption) to measures supporting industrial clusters and innovation networks in areas relevant for SDGs (see Table 2.3 overviewing policy instruments). Incentives can be introduced by 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 on market opportunities and technologies (such as by market fairs; agricultural, industrial, and service extension services and demonstration project, business incubators, science or industrial parks, etc.) to help achieve SDG goals, as well as training for entrepreneurs and workers to use relevant technologies and innovations.

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

As strategic long-term 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 a highest potential for the SDGs. By developing a shared vision and innovation pathways, the roadmapping process can help to identify concrete barriers and incentives needed to prioritize and scale up STI investments conducive to economic, social and environmental sustainability.

The baseline analysis underpinning STI for SDGs roadmapping can help identify positive and negative incentives provided by many policy instruments deployed across different areas by different ministries. It can help to create a systemic perspective on the role of public policy for setting up a coherent incentive regime which encourages and rewards STI investments for the SDGs. This requires a collaborative approach engaging various ministries, private sector and other relevant stakeholders guided by a shared vision and action plan.

It is important that changes to incentive regimes are designed in a systemic way and introduced in a coordinated matter to minimize the risk of rebound effect. Changing incentive regimes is likely to meet with opposition from actors who may lose economic or political power because of the proposed direction of change. It is, therefore, key to ensure sufficient political backing for the roadmap process and build alignment of actors around the vision to ensure that the proposed changes are credible and can be implemented in practice.
What mechanisms will there be for continuous horizon scanning for changing sub-national, national, and global and conditions?

These include not just scanning for changing subnational, national and global conditions which may affect the plan such as trade wars, the impact of more frequent extreme weather, wars, or other disruptions. In addition, since technology is such an important factor in the STI for SDGs roadmaps, there needs to be a mechanism for tracking the potential impact of new technologies that may open up new opportunities or pose new challenges. 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.

Annex Table A.5 in the background paper provides some examples of key global trends that merit monitoring because of their potential positive or negative impacts on countries which may affect their ability to meet their SDGs. 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 (Lopez-Portillo 2018). This has included consultations with foreign and domestic technology experts as well as extensive consultations with leaders in various industries as well as with civil society. This will be an important input into Mexico’s STI for SDG roadmap.

How will the 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 rarely is an explicit mechanism to learn from the evaluations of what is working or not working to adjust the roadmap. In some countries, progress of plans is reviewed on an annual basis. In others, reviews are undertaken every 3 to 4 years. This requires treating the roadmap as a dynamic process that needs to be adjusted in light of performance as well as changes in domestic and foreign context and technology.

The framework has to be built into existing policy processes and practices. It needs to include credible and effective feedback mechanisms which ensure that lessons from implementation are heard and acted upon. The framework can benefit from an on-going collaboration with local, national and international stakeholders who can support collection of data as well as share relevant evidence and methodological approaches.

A useful mechanism that can help here is to set up “learning platform” (or “community of practice”) developed for the roadmap, which can build on the current Voluntary National Review process of countries’ reporting on plans and progress on the SDGs. This would make the roadmap more than just an action plan. It would turn the roadmap into a learning mechanism bringing together various ministries and stakeholders and international experience.
Chapter 3. International Partnerships for STI for SDG Roadmaps

The objective of this chapter is fourfold. The first is to provide a brief overview of the landscape of the global innovation system and STI flows. The second is to summarize some of the key ways through which the international development community can help developing countries use STI to accelerate the attainment of SDG goals.

The third is to outline what developing country governments could do to leverage global STI inputs into their plans for achieving the SDG goals. The way that most countries tap global STI inputs for their SDG goals 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 SDG goals.

The fourth is to outline what governments in donor countries could do to increase the leverage of STI inputs in their international development assistance programs to help developing countries achieve their SDG goals. In most donor countries the provision of STI inputs for helping developing countries achieve their SDG goals faster is very fragmented and uncoordinated. The objective of this fourth section is to outline some of the issues that donor country governments should consider leveraging global STI inputs to help developing countries achieve their SDG goals faster.

3.1 The Landscape of Global Innovation System and International STI Flows

Figure 3.1 is a schematic of the relationship between the global STI system and the national innovation system of a country. On the supply side it is useful for expositional purposes to distinguish between science on the one hand, and technology and innovation, on the other, because they involve different actors and mechanisms. That said, since these two sub-systems are closely interconnected, improving the interface between them will help tackle societal goals more effectively.

Since the agreement on the SDGs in 2015, there has been an international trend to incorporate the SDG goals more explicitly into the innovation system of countries. In general, there is more awareness of the need to go beyond the traditional focus on economic growth and competitiveness to include greater attention to inclusiveness and sustainability which are part of the focus of the SDGs. There is also a greater focus on mission-oriented research, some of it on issues relevant for the SDGs (OECD 2018).
Figure 3.1: Positioning the National Innovation System to Benefits from International Supply and Address SDG Demands

Adapted from Ciera and Maloney (2017).
However, not enough is being done to support STI for the SDG needs of developing countries.

- UN TFM has conducted two rounds of “mapping” on UN System’s STI support to developing countries. Key observation from the first was fragmentation and the need for better coordination. Based on the inputs from 20 UN agencies, the second mapping estimated around 2,600 full-time staff equivalents, $1 billion annual budget and $120 billion stock of resources for recipients, without collective mechanisms to identifying needs, gaps and priorities and track progress.

- OECD has assessed intersections of STI and ODA to tackle grand challenges context of SDGs. Bilateral, multilateral and philanthropic, concessional and non-concessional sources of funding totaling approximately $20 billion annually, but the analysis of cooperation mechanisms, governance, policy practices and learning concluded that the current system of STI cooperation is unfit to tackle global challenges of the 21st century.

Figure 3.2 summarizes an analysis from Annex 3.1 on the global innovation system in the background paper, on countries’ national innovation system and global STI flows. The bulk of technology transfer occurs through private transactions, especially through direct foreign investment and trade (including capital goods, components, services, and technology licensing). A smaller but important part is done through non-market transactions. These include government-to-government development aid with STI components; STI related aid provided by philanthropic organizations, NGOs and civil society; knowledge and technology transferred by communities of practice, professional associations, diasporas, and education and travel; and STI related assistance provided by UN agencies.

**Figure 3.2: Distribution and Significance of STI Flows to Developing Countries**

<table>
<thead>
<tr>
<th>Distribution of STI flows, by country income groups</th>
<th>Relative significance of STI flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>HIC</td>
</tr>
<tr>
<td>GDP</td>
<td>17%</td>
</tr>
<tr>
<td>S&amp;T journal articles</td>
<td>62%</td>
</tr>
<tr>
<td>FDI net inflow</td>
<td>72%</td>
</tr>
<tr>
<td>Manufactured goods import</td>
<td>70%</td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>75%</td>
</tr>
<tr>
<td>Outgoing students in tertiary education</td>
<td>75%</td>
</tr>
<tr>
<td>Business service import</td>
<td>80%</td>
</tr>
<tr>
<td>Payments for use of IP</td>
<td>84%</td>
</tr>
<tr>
<td>Used International bandwidth</td>
<td>87%</td>
</tr>
</tbody>
</table>

For the international community, there is a large role in improving the market and non-market intermediation mechanisms to provide capacity building (for governments, the private sector, and civil society). On the supply side, this may involve actions to increase information about what is available and how it can be deployed. On the demand side, it can help developing countries become more strategic and capable planners and users of knowledge and technology. It can also improve global STI governance to organize coalitions and build partnerships to create new knowledge relevant for the needs of developing countries to accelerate the attainment of the SDGs.

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25 An Overview of UN Technology Initiatives, IATT 2015; and Landscape of Science, Technology and Innovation initiatives for the SDGs, IATT 2017

26 Connecting ODA and STI for Inclusive Development, OECD 2019 (forthcoming); and International Co-operation in STI for Grand Challenges, OECD 2019 (forthcoming)
Figure 3.3 taken from the analysis in Annex 3.1 presents a stylized summary assessment of the supply and demand for STI support for specific SDG Goals.27

**Figure 3.3: Demand and Supply for STI Support for SDGs**

This mapping results in five broad clusters, each distinguished by specific questions for follow-up action:

- **High STI demand, high STI support from private sector, UN and others**: goals 2,3,7.
  What will it take to scale up these activities?
- **High STI demand, moderate STI support (largely UN and general public)**: goals 8,9,12.
  What policies and investments could be deployed to engage and mobilize the private sector?
- **High STI demand, scarce or limited STI support**: goals 14,15,16.
  What policies and instruments can mobilize public and private resources to use STI to support these SDG?
- **Moderate/low STI demand, moderate/limited largely public STI support**: goals 4,11,6,13.
  What policies and instrument can mobilize more demand and supply of STI inputs for these goals?
- **Low STI demand, scarce STI supply**: goals 1,5,10
  What can be done to create more awareness of how STI can help accelerate the achievement of these goals and mobilize public and private actions to address acute gaps?

It should be emphasized however, that STI can have an indirect effect on all the goals, even those in the last category.28 For example, to the extent that STI can provide more opportunities for growth and employment and increased agricultural productivity, and education, it will help to reduce poverty. More international finance will be needed to help developing countries attain their SDG goals. The scale of the flows of STI related ODA flows is small relative to STI related market flows (see Annex Table A3.2). However, the potential of STI related ODA flows to strengthen the take-up of STI to help developing countries attain the SDG goals is enormous. To realize this potential, the

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27 This figure is preliminary and meant as illustrative and to stimulate thinking and discussion- see annex in background paper.
28 See for example INGSA (2017).
international community has to allocate more ODA towards STI programs and to be more strategic in how these limited resources can be leveraged to that end. It should also be kept in mind that given the wide differences in country conditions and needs, as well as the wide range of measures that can be taken, it is critical to differentiate approaches according to the functioning and readiness of markets, as well as the roles of international organizations, ODA, and other means to address market failures (e.g. signaling, coordination, externalities, capacities, etc.) and other obstacles.

It is also important to note that emerging technologies bring new opportunities but also big challenges for developing countries to achieve the SDG goals. This puts added urgency to developing effective STI for SDG roadmaps in developing countries.

Opportunities and Challenges of New Emerging Technologies for Developing Countries

There are a large number of both existing and emerging technologies that present many opportunities to help developing countries meet the SDG goals. 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, 3-D printing), nanotechnology, new materials and biotechnology (OECD 2017). Moreover, there is increasing convergence in these technologies, largely facilitated by advances in digital technologies. This is speeding up the rate of technological change as well as the way research and innovation are done (OECD 2018). As argued in Chapter 2, many new technologies are already available and offer opportunities for leapfrogging as well as for reducing the cost of providing better goods and services and how they are delivered and used. Rapid advances will continue and open up even more livelihood and welfare opportunities for people in developing countries.

However, the rapid advances of these emerging technologies also raise many challenges.

1. Developing countries 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 labor alone, as labor 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 will reduce demand for developing country exports of agricultural products and raw materials.
4. Besides the loss of jobs from competition from advanced countries, the new technologies may reduce the net demand for labor although they may create new job opportunities. This means that there will not be enough jobs for the growing labor forces in most developing countries (especially in Sub-Saharan Africa and South Asia) which can lead to increased social instability.

29 These include: smart energy grids, off-grid energy technologies (such as more cost effective solar and wind power), new HIV treatments, new vaccines, new preventive medicine technologies, smart drugs targeted at specific problems, artificial limbs, gene enhanced seeds to make crops more disease and drought resistant as well as to increase productivity and the nutritional content food, porous membrane water desalination, automated factories (which combine automation, robotics, digitalization of processes from design to operation, maintenance and after sales servicing—often called industry 4.0), digitally enabled education, fintech, e-government services, cell phones with increasing capabilities and broadband internet connectivity, etc. The issue for many of these is how to support their wider diffusion. The challenge is that often key parts of the diffusion ecosystem such as skills, finance and delivery agents are not sufficiently available in developing countries.

30 For more detailed discussion see Hallward-Driemeier (2018), Pathways for Prosperity (2018a and 2018b) and OECD (2017 and 2018).
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. Many complex issues are being raised by the advance of digital technologies, yet developing countries are at a disadvantage by not being at the center of global discussion of how to deal with them. These include the issues of data ownership (critically important as data has become a critical new asset for competitiveness), data privacy, data security, the advantages that captive data gives to giant global data players (such as Facebook, Google, Amazon, Baidoo, Tencent, credit card and finance companies), cross border data flows, and the regulatory and governance issues raised by the new forms of competition enabled by first mover advantage in internet based platforms.

Developing countries need to strengthen their STI capabilities and use their entrepreneurial potential to take advantage of these opportunities, while anticipating and building response capacity of how to deal with these challenges. For both dimensions, it is important that they strengthen their national innovation systems, including their physical and soft infrastructure and the policy and regulatory capability. They need to develop policy and institutional capacity and inclusive governance mechanisms to critically assess and prioritize their STI needs. They also have to improve the flexibility of their economies to take advantage of the opportunities, at the same time ensuring that the social (rising unemployment, and the shortage of new productive jobs) and environmental costs of restructuring are considered and mitigated. Initiatives to improve (sub-)regional integration by systematically upgrading cross-border STI systems and capabilities are likely to gain greater attention in coming years, notably in Africa. For all developing countries, this also places immediate urgency on strengthening systems of training and retraining as well as policies for improving inclusiveness and mechanisms for social protection to help people who lose or cannot get jobs. These are all areas that need to be taken into consideration in helping developing countries make more effective use of STI for SDGs.

3.2. How the International Community can Help

There are many ways that the international community can support market and non-market mechanisms to supply STI elements to accelerate the achievement of SDG goals. Besides strengthening market and non-market mechanism for the supply of existing STI elements, it can strengthen capabilities in developing countries to use STI for SDG goals, as well as create demand and supply of new STI solutions, and use ODA to leverage STI for SDGs.

A. Support market mechanisms for increasing the supply of existing STI elements

- Increasing the information about existing commercially available technologies and technology services suppliers can reduce the cost or improve the efficiency of attaining SDG goals in developing country conditions. This is relevant because often developing countries do not know what STI elements are available. Similarly, commercial suppliers may not be aware of the latent demand for their goods and services. Overcoming information asymmetry implies need for supply and demand information systems and virtual platforms or marketplaces. Many private ones already exist, but there is room for the international community to improve online provision of these services. An initial start has been made through the online platform supported by the UN’s Technology Facilitation Mechanism, but this needs to be strengthened and expanded.
- Increasing efforts to make more effective use of advances in technology and innovation in projects with multilateral finance in developing countries, and to the extent possible, all projects by publicizing successful examples to demonstrate the benefits of more effective
use of STI for such projects. Another mechanism is using public procurement to solicit innovative ways to deliver better goods and services more cost effectively to address SDG needs.

- Increasing the overall volume of finance available for development projects that make more effective use of STI to meet SDG goals by greater use of blended finance for this purpose. This essentially requires using grant money and soft loans from ODA to take the first level of risk in projects in order to make them more attractive to private finance\textsuperscript{31}.
- Promoting the use of alternative financing mechanism for STI projects such as crowdfunding and social investment funds.

B. **Support non-market mechanism for increasing the supply of existing STI elements**

There are many non-market channels for the use of STI to accelerate the achievement of SDG goals. An important non-market channel is government-to-government assistance, especially for services related to the functions of government such as government services, education, health, security, etc. Many others are carried out as part of ODA. Others are carried out independently of ODA by other agents, including NGOs, philanthropic organizations, universities, research networks, communities of practice, etc. But governments and ODA related agencies can also help to encourage these non-market transfers.

Some of the opportunities for increasing collaboration in science are:

- Bringing students, scientists, and engineers to study and get experience in high income countries or by having professors and students from advanced countries teach local students face to face or through various digital media, such as Massive Online Open Courses (MOOCs), YouTube videos, podcasts, and computer-based learning systems.
- University collaborations in teaching STEM subjects and cooperation in research.
- Bilateral and international collaboration of public research institutes and researchers on joint interdisciplinary research programs focused on sustainability challenges.

Some of the opportunities in technology and innovation include:

- Supporting and increasing open data systems for scientific and technical publications and databases, for example by launching an African Open Science Platform.
- Transferring frameworks, tools, methodologies, and technical assistance to help policy makers in receiving countries develop STI for SDG roadmaps (see background paper for some examples).
- Developing communities of practice and other networks for sharing approaches and experiences.
- Improving the effective use of limited funds available for STI for SDGs by assisting countries undertake public expenditure reviews on STI for SDGs.

C. **Strengthen the capability of developing countries**

- Developing STI planning capacity in developing countries (in government, the private sector and civil society organizations) to search, acquire, adapt, and disseminate technology and innovations. This may be an area where international assistance can have the most

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\textsuperscript{31} See BSDC, \url{http://s3.amazonaws.com/aws-bsdc/BFT_BetterFinance_final_01192018.pdf}
immediate impact. However, this is not simple training but education, technical assistance and hands-on experience and twinning arrangements.

- Training policy makers in how to develop, implement, monitor, evaluate and improve STI for SDG roadmaps. This includes education, technical assistance, twinning arrangements, design workshops, and sharing of experience across countries.
- Training scientists, engineers, entrepreneurs, managers, venture capitalists, etc. in technology and innovation through education, foreign training, work and research experience and twinning arrangements.
- Supporting the strengthening of STI-related infrastructure in developing countries (e.g. R&D labs, metrology standards and quality control systems and institutions, science parks, technology transfer agencies, accelerator labs, technology business incubators, etc.). Priority should be given to developing shared infrastructures inviting collaboration between public and private sectors, across sectors, and whenever feasible, across countries.
- Supporting international experimental STI projects co-developing and demonstrating innovative approaches and projects, and social and business practices with high impact potential on the SDGs. The lessons learned from these pilot projects should be shared internationally.
- Increasing STI-related technical assistance in projects of international development finance institutions, ODA and commercial lending for more systematically leveraging STI to help achieve the goals (STI for SDG roadmaps).

**D. Support demand and supply of new STI for SDGs**

This has three levels:

- Challenge-led mission-oriented research and innovation. Examples include: Gates Foundation Grand Challenges in health and education, X Price Grand Challenges, Horizon 2020 (EU) Grand Challenges, Grand Challenges Canada, and UK.

- Develop coalitions to create technology global public goods in areas that can help the achievement of important SDGs, particularly those where there are big gaps in demand and supply (see annex for brief summaries of some historical examples such as the Green Revolution, Vaccines against HIV Aids), as well as some ongoing programs tackling large developing country challenge such as PEPFAR (USAID led international program to eliminate AIDs), Feed the Future (US-government-wide program to reduce hunger, malnutrition and poverty through STI initiatives) and the international consortium to reduce ocean plastics; see Box 3.1 for a new global initiative in the making for supporting the digital economy in Africa.

- Build partnerships to strive for a better STI policy integration towards a global STI system that enables collaborative STI efforts for SDGs. This is the ambitious goal of developing a new global STI system as a global public good. Examples of what could be done are the ITU’s AI for Good A key challenge is that cross-national research efforts are inherently difficult to orchestrate and finance. An analysis of data from national science funding councils found that only 11% of projects funded in 2015 were related to any of the 17 SDG goals. Moreover, international cooperation occurred in only 2% of these projects. Therefore, international cooperation for the SDGs represents only 0.2% of all STI projects (OECD 2017 and 2018).

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The main lessons for assembling successful international coalitions to undertake collaborative programs for technology global public goods are the following:

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

Therefore, using coalitions of interested stakeholders require:

- Convening international workshops to develop the challenge to be addressed and to assess the base line and the 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, costing, monitoring and progress evaluation, and direction/redirection
- Designing the ecosystem of other agents and institutions (such as government agencies, entrepreneurs and firms, NGOs, finance, extension agents, input suppliers, community organizations, financing agents, etc.) 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

Examples of some areas that would benefit from such global public good collaborations are:

- SDG goals identified in Figure 3.3 of the background note which are handicapped by low demand for STI and scarce supply SDG goals 1 (no poverty), 5 (gender equality), 10 (reduced inequalities)
- Multiple areas related to climate change and green economy (notably low-carbon energy)
- Health (see recently launched anti-microbial resistance R&D hub33)
- Safe water
- Marine (including blue economy)
- Electricity for all
- Green chemistry (e.g. work on safe chemicals)

E. **Use ODA smartly to leverage STI for SDGs**

There is scope for increasing the focus and level of STI in overseas development assistance. According to a first ever assessment of statistics for the Development Assistance of the OECD, just 5% of overall development assistance from OECD countries finances STI activities (OECD 2017). A more detailed look at the assistance of the five largest donors (U.S. Germany, UK, Japan and France—see background paper) suggests that it may amount to 10%. These ODA-for-STI programs

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are not very well-informed of activities by others and lack a robust mechanism for coordinating within and across donor countries to capitalize on respective comparative advantages for greater impact and improved outcomes.34

3.3 What Governments Need to Do

Figure 3.4 summarizes three levels that national government need to take into account in developing their STI for SDG roadmaps. The SDG goals are attained at the local level so effective plans need to include input from the local level. Implementation plans for STI for SDG roadmaps also need to reach to the local level, as has already been emphasized in Chapter 2. However, STI for SDG maps also have to explicitly consider the international dimension. This includes how they will draw on and make effective use of international supply of STI inputs, methodologies and approaches, data and evidence based good practices, technical assistance, and finance. That is the focus of this section.

Figure 3.4 Three levels of STI For SDG Roadmaps

To a large extent getting access to and using global STI resources and expertise is intermediated by a country’s national innovation system (Figure 3.2). Assessing the capacity of the country’s national innovation system 35 to acquire, adapt, deploy and use global STI to help attain the SDG goals has various dimensions:

- 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.36

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34 More analysis of the coherence of action is needed across countries to overcome barriers.
35 There are several useful methodologies for doing reviews of a country’s national innovation system. See for example the OECD Innovation Policy Reviews, UNCTAD’s Framework of STI Review (2019), and the World Bank’s Public Expenditure Reviews in Science, Technology and Innovation: A Guidance Note (2014). The steps proposed here are 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 SDG goals it chooses.
36 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.
• Assess how well the national innovation system is drawing on relevant global STI inputs. What types of inputs is it getting or not getting 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 necessary 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 are the main players in the creation and dissemination of technology and innovation, what policy or other barriers may there be for attracting relevant foreign investment? Similarly, are there regulatory or policy barriers to accessing foreign science and technology databases because of policy restrictions? In addition, it is important to assess the adequacy of the country’s social policies. Emerging technologies can offer many opportunities, but they also can 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 help with environmental sustainability require a favorable policy environment for them to work. For example, proper pricing of water and energy, good regulation and charges against environmental pollution, etc.

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

The government should also consider priority areas where elements of STI can most usefully be obtained from abroad and what that requires in terms of changes to the national innovation system. There may be options which require fewer international inputs, but this may mean longer lead 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 is important because some STI roadmaps for the attainment of specific SDG goals may work at cross purposes with others. Open consultations with stakeholders can identify some of these trade-offs and help identify problems, complemented by input from technical experts on alternative ways to deal with some of these trade-offs and constraints.

Explicit consideration should be given as to what is expected in the short run (next 1-2 years) versus the medium term (3-4 years), and long run (more than four years).

• Interventions that may be possible in the short run are getting better access to information about what is available internationally; changing policies and regulations that may constrain that access, high impact training and awareness building among policy makers and key actors in the non-government sectors; 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, many preventive medicine practices and vaccines as opposed to more expensive treatment, etc. This should also

37 Annex 3.3 to the background paper has a brief summary of the broad approach the five largest donor countries have to STI in their ODA. Developing country governments also need to actively explore how they may get more coordination and synergy from the STI activities of different UN agencies and other actors on the supply side of STI.
include how to strengthen the ability of local researchers and research institutions to participate in international programs that are developing technologies relevant to attaining SDG goals.

- Programs that can be launched in the medium term (3-4 years) are strengthening key infrastructural elements as well as the broader innovation ecosystems that will be necessary to mobilize and deliver STI elements that can contribute to accelerate the SDG goals targeted in the country, strengthening some key STI infrastructure institutions than can help deploy relevant knowledge to meet the SDG goals, etc.

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

Considerations should be given to how the country’s STI for SDG roadmap can draw on regional initiatives such as the African Union’s plans for science and technology and the SDG goals, and digital transformation of Africa. There can be important economies of scale in addressing some STI for SDG issues that cross national boundaries such as sharing of data and experiences of good practice, training program, 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 which require concerted global action such as developing new vaccines for tropical diseases, new technologies to help adapt and mitigate 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 to trigger a concerted response from the international STI supply system.

3.4. What Donor Countries Need to Do

Donor country governments also need to think strategically about what makes the most sense for them in supporting STI for SDGs in developing countries. Currently, the support for STI from donor countries to developing is very fragmented. More systematic efforts are needed for donors to understand what different ministries and agencies are already doing in this area. There is even less systematic knowledge of how the private sector, universities, think tanks, NGOs professional associations, diaspora networks or individuals are supplying STI inputs to developing countries. The OECD has done an initial mapping of STI-related ODA support to developing countries (OECD 2019, forthcoming).

Donor countries need to consider their national strategic foreign policy and competitiveness interests as well as their STI strengths and capabilities as the basis for defining their objectives and scope of their contributions for STI for SDG roadmaps in developing countries. There are different country models of STI related ODA assistance. Annex 3.3 to the background paper provides a brief overview of those from the five largest donors: U.S., Germany, UK, Japan and France. All of these variants have their own pros and cons.

Donor countries may wish to consider whether 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 to be more systematic about developing their countries’ contributions.

To develop more effective assistance in providing STI inputs to accelerate the achievement of SDG goals in developing countries, it is important to know who in the country is doing what, to understand what drives them, what they are accomplishing, and how they could be organized to
have greater impact. This assessment is fundamental to develop 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 on the initiatives.

On the government side, it will necessarily involve the ministries of foreign affairs, development, science and technology, telecommunications, industry and commerce, finance, etc., 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. It should also take into account the STI needs of developing countries that the government aims to assist. The specific goals and targets should be set after addressing the different approaches in light of what is politically and economically feasible.

There are many things that policy makers can do to more effectively support the systematic use of STI inputs to accelerate the achievement of SDG goals in developing countries. These include:

- Increasing its ODA to support STI inputs. This includes reallocating resources from some other ODA activities to STI initiatives, as well as, when possible, increasing overall ODA resources to provide more support to STI in developing countries.

- Leveraging activities being done by other agents or institutions in the country. This includes providing incentives to increase the STI support given by other agents or institutions in the country such as matching research grants, scholarships, co-funding technical assistance, underwriting some of the risk in financing such ventures; as well as providing leadership and coordination of activities in the country supporting greater STI inputs to help developing countries reach the SDG goals.

- Taking or sharing a lead role in developing global coalitions and partnerships to develop global STI public goods for helping the attainment of SDGs. Example include initiatives such as PEPFAR and Feed the Future led by the U.S. government, or Disaster Preparedness led by Japan (Annex 3.3 to the background paper) and the Digital Moonshot for Africa where a coalition of countries, companies, and international institutions working with the African Union are taking the lead (Box 3.1).

The government should identify what is required to improve leveraging 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 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 keeping ongoing programs. It also requires coordination across different ministries and programs and setting up processes for accomplishing that, as well as some lead agency or point of contact at a high level of government like the head of state or cabinet office.

As in the case of receiving country STI for SDG 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, it would also be useful to consider formally monitoring this special STI for SDG roadmap activities in the peer review mechanisms of ODA assistance in the Development Assistance Committee of the OECD, as well as 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 government should hold stakeholder consultations to create consensus and get buy-in from the different actors to develop 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 its ministries, agencies, and special programs; tax and incentive systems, awareness campaigns and moral suasion, and coordinating the actions of others.

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

**Box 3.1: African Digital Transformation Strategy and ‘Moonshot’**

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 the support of the World Bank Group and many partners, has embarked on an ambitious journey—a “moonshot” that will help countries 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, with AU Member States and many partners, is developing a ‘Moonshot’ Action Plan, taking a multi-tiered approach to the five foundational elements: digital infrastructure, digital skills; digital platforms; digital financial services and digital entrepreneurship. Partners include the African Union Commission, Regional Economic Communities and regional institutions (e.g. EAC, WAEMU/BCEAO, CEMAC, Smart Africa, AfDB), bilateral and philanthropic agencies (such as Bill & Melinda Gates Foundation, UK, France, Germany, Norway, Japan), UN agencies (UNECA, ITU) and the private sector (such as GSMA, Google, Microsoft, Alibaba).

Reaching the goal of digitally connecting every individual, business and government requires ambitious and easy to understand targets in 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.

**Figure: Indicative Targets for Digital Economy for Africa ‘Moonshot’**

<table>
<thead>
<tr>
<th>Digital Infrastructure</th>
<th>Digital Skills</th>
<th>Digital Platforms</th>
<th>Digital Financial Services</th>
<th>Digital Entrepreneurship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal Internet network coverage</td>
<td>All 15 year old students with basic “digital skills” competencies</td>
<td>Doubling of Online Services Index rating for all Governments</td>
<td>Universal Access to Digital Financial Services</td>
<td>Tripling the number of new digitally-enabled businesses created annually</td>
</tr>
<tr>
<td>Affordable Internet for all at less than 2% of GNI per capita</td>
<td>100,000 graduates in advanced digital skills programs annually</td>
<td>All individuals are able to prove their identity digitally</td>
<td>Africa-wide payments infrastructure/platform in place</td>
<td>Financing for Venture Capital to reach 0.25% of GDP</td>
</tr>
<tr>
<td>Interim Milestone: Doubling broadband connectivity by 2021</td>
<td></td>
<td>At least 50% of the population regularly uses the Internet to access Government or Commercial services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: AUC’s Presentation at the Fourth Expert Group Meeting on STI for SDGs Roadmaps in Nairobi, April 2019, and All Africa Digital Economy Moonshot event at the Spring Meetings of World Bank Group and IMF, April 2019.
Chapter 4. Conclusions

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 potentials to achieve the global goals and leave no one behind. The guidebook is also meant to address the ‘tower of babel’ problem by introducing a set of common languages. Given the current state of data and the constantly evolving knowledge of needs and potential supply of knowledge, 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 have to be done both nationally and internationally. Overall, governance, institutional arrangement and participatory process 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 SDG goals. However, the focus, and financial resources to make to exploit this potential is not there yet. 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 there is already the beginning of a discussion of how to increase financing for STI for SGDs (Box 4.1). This should be continued and expanded to include how the support of the international community can be more coherent and effective.

When the global community embraced the SDGs as a global ambition just four years ago, the pace of technological change ‘at the frontier’ of science and innovation was perhaps not as prominent and global in its reach. Hence, it is important to consider resetting the SDG trajectory and 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 Roadmap is proposed to contribute to new solutions to new challenges.

UN System through TFM will stand ready to work with Member States to cultivate communities of practitioners and partners and foster a learning environment to test and improve the approaches as proposed in this guidebook. An important next step is to test the usefulness of this guidebook by applying the methodologies to country specific STI for SDG roadmaps, to learn from the experience in developing and implementing those roadmaps, and to use those lessons to further refine the guidebook to make it a better planning and implementation tool. TFM recently launched the Global Pilot Program for STI for SDGs Roadmaps for this purpose. TFM’s Online Platform will help by providing information on technology and innovation, country experiences, and sources of expertise.

4.2. Reflections and Remaining Challenges

Discussions through the inter-sessional work on STI for SDGs roadmaps and early engagement with pilot countries highlighted several remaining challenges:

- While the global progress toward the SDGs is far off track, the pace of technological changes, among other changes in economies, societies and environments, is very rapid and can be disruptive. For the new challenges for which policy responses and their outcomes are yet to emerge, and there are no “good practices” to simply disseminate and replicate. Countries and the international community need shared sense of urgency and agile response and learning mechanisms.
- Despite greater awareness on STI for SDGs and increasing multi-stakeholder/multidisciplinary deliberations, the current system of international STI cooperation is not adequate. Financing for
STI for SDGs, including PPP and blended finance, is not yet sufficiently available for directing and catalysing necessary investments and actions at scale.

- Analyses of STI needs and gaps have been so far limited in informing the most critical actions at national and international levels, exacerbated by inadequate availability of data and evidence in many developing countries, and lack of adequate theory of change connecting STI to SDGs, both with tremendous breadth and complexity.

Building on emerging country experiences and international practices, we need stepped-up approaches, including a revamped TFM mandate/deliverables, adequate financial resources, and global collective leadership.

4.3. Moving Forward

[this section is to be further developed / refined upon STI Forum discussions]

In response to strong interest expressed by countries participating in the deliberations so far, UN IATT38 together with its partners is committed to implement an inter-sessional work program to pilot and scale adoption of country level roadmaps, develop common principles of STI for SDGs Roadmaps based on lessons learnt, and strengthen international cooperation accordingly. Upon further consultations and analysis, the inter-sessional work program can include the following components:

- Peer learning: nurturing a community of policy practitioners on STI for SDGs Roadmaps, to share common challenges and identify good practices, engaging developed and developing countries and refining conceptual frameworks presented above for further discussions.
- Joint support for pilots: identifying pilot countries for joint assessment, building on existing work programs of IATT agencies and other organizations, with a view to better synergize, harmonize and scale-up existing approaches, methodologies and instruments related to development and implementation of STI Roadmaps through economy-wide and sector/Goal-specific policy reviews, technology needs assessments, foresight exercises, and other technical and financial assistance.
- Donor coordination for contributing to the existing Sustainable Development Trust Fund: promote dialogues among donor countries and agencies to take stock of existing international assistance programs on STI, with a view to strengthen complementarities, increase multi-stakeholder participation (possibly including research funders, philanthropies and private investors) and better address recipients’ needs and gaps.
- Knowledge and advocacy: commissioning a group of experts to mainstream STI for SDGs roadmaps at the broader development policy discourse, gather and synthesize evidence base and country case studies, define future research agendas, and propose concrete actions by TFM to inform possible development of global STI roadmaps to facilitate subnational, national and international efforts toward achievement of the SDGs by all Member States.

The work has already started since early 2018. Further detailed work program will be developed after consultations with all stakeholders.

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38 For more details about IATT, See: https://sustainabledevelopment.un.org/tnm#un
Box 4.1: Global discussions on financing for 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 for STI for SDGs.

On the STI front, G20 under Japanese presidency, through Development Working Group (DWG), acknowledges that multi-stakeholder engagement is essential in unleashing the potential for STI and is formulating the Guiding Principles for the Development of Science, Technology and Innovation for SDGs Roadmaps. The principles touch on structure of roadmaps, role of government, promoting knowledge sharing, international cooperation, and other elements to consider. The work of G20 DWG and UN 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 DWG, G20 Digital Economy Task Force (DETF) is deliberating on a digital action plan for SDGs, focusing on Africa and LDCs, to share the benefits of digitalization and leave no one behind. Following G20 Osaka Summit in June, Japan will host TICAD (Tokyo International Conference on African Development) VII in August 2019, where STI for SDGs Roadmaps can be 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 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, UN announced the creation of a Global Investor for Sustainable Development Alliance, which will be officially launched in September. The Forum also discussed the ‘triangle of technology, SDGs, and financing’ as a crucial new arena requiring attention and deployment of financing.

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 to achieve complementarity among multilateral, regional bilateral institutions and establishing a clear system of metrics to track impact and value for money, by building effective country platforms, owned by governments, to enhance contributions from all development partners including the private sector. In response, Finance Ministers, in its Development Committee Communiqué in April 2019, urged “the WBG to continue to work closely with public and private partners including international financial institutions and the UN, on the most pressing development challenges,” noting 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 underscoring “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 of approaches to such country platforms in enhancing complementarity among national and development partners’ 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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