A Guidebook for the Preparation of STI for SDGs Roadmaps

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United Nations Inter-Agency Task Team on Science, Technology and Innovation for the SDGs (IATT)
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The work on the guidebook was led by Naoto Kanehira, Carl Dahlman (World Bank) and Wei Liu (DESA), under IATT Co-Lead agencies' management supervision by Shantanu Mukherjee (DESA), Klaus Tilmes and Paulo Correa (World Bank), Dong Wu (UNCTAD) and Ernesto Polcuch (UNESCO), and participated by Justin Hill (World Bank), Richard Roehrl (DESA), Clovis Freire and Michal Anthony Lim (UNCTAD), Kornelia Tzinova and Angela Sarcina (UNESCO). Background research and synthesis including through background papers were provided by Anupam Khanna, Michal Miedzinski, Rui Kotani, Shuyang Huang, Philipp Sebastian Ruppert and Neda Bostani (World Bank), Mario Cervantes, Olivier Cattaneo, Rolf Schwarz, Sam Mealy and Edoardo Bollati (OECD), and Monika Matusiak (EU JRC).

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Chapter 1. Introduction

1.1 Background and Objective

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.

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.

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

- **STI *for* or *as* individual Goals/Targets in SDGs**. While innovation is the most visible focus of Goal 9 (build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), as reflected in the 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 social as well as environmental goals). Systemic gender disparity in key STI actors in 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.

[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 Annex 1.

- **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[2].

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.

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 a provide a framework and common language and step by step advice** for the practical policymaking and communication purposes.

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, monitoring and adjustment 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.

[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.

Box 1.1 Concepts and Definitions

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, professional societies, universities, and other research institutions. 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, energy, education, defence, 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, and 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. (See Table 2.1 for a broader discussion of different types of innovation.)

1.2 Rationale of STI for SDGs Roadmaps

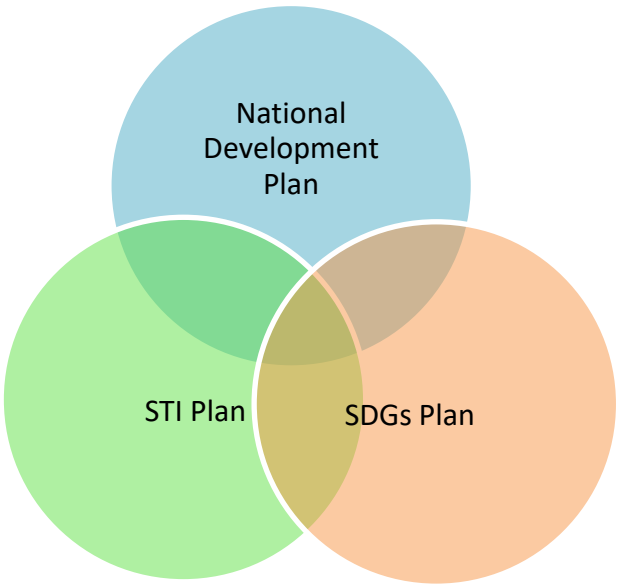
The rationale behind creating realistic and action-oriented STI for SDGs Roadmaps is to speed up the process of developing new, or adapting existing, solutions in time to meet the SDG goals and targets by 2030 and to ensure that the three dimensions of sustainability are properly addressed (Box 1.2).

STI for SDGs Roadmaps are not created in a vacuum. Most countries already have or are developing their 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**. Most 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**. These vary widely in scope, as well as in the degree to which they directly relate to the national development plans. Sometimes they are conceived independently of national development plans, mostly by science and technology ministries. 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.

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



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.

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.

Box 1.2 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 with-in 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 aspects in development strategies as reflected in the SDGs goals. We are also entering a new period of 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.

1.3 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] (Figure 1.2). Many countries are going to fall far short of other goals.[4] Effective use of STI may change the trajectory and accelerate progress toward the future we want, particularly if developing countries are able to benefit more from international partnerships. For example, M-PESA, mobile money in Kenya that increased financial inclusion (SDG Indicator 8.10.2, directly contributing to Targets 1.4, 2.3, 5a, 8.3, 8.10 and 9.3) from less than 30% in 2006 to 90% in 2019, was made possible, in part, by a grant from DFID to a private company[5]. Given the limited maturity of national innovation systems in developing countries and their low institutional capability, there is

[3] World Bank, Poverty and Shared Prosperity Report 2018

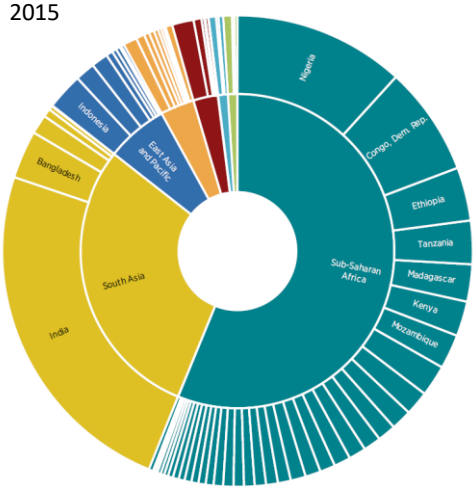
[4] See the UN Secretary General's assessment of four-year progress towards the sustainable development goals. Available at: https://undocs.org/E/2019/68

[5] M-PESA, and other case studies, are described in the background paper on pilot countries (forthcoming).

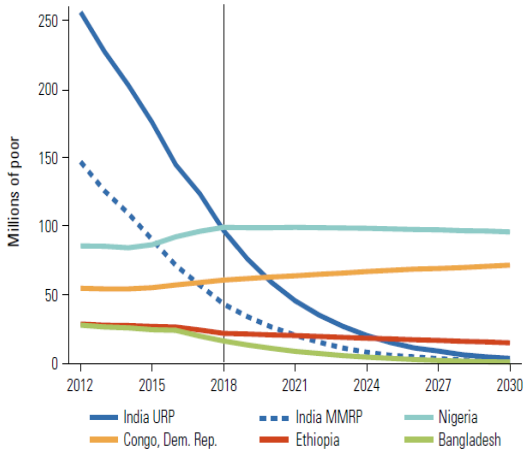
much that can be done by the international community in partnership with developing countries to use STI inputs to make progress toward the SDGs.

Figure 1.2: Business as Usual will leave Africa Further Behind

Global Distribution of the Extreme Poor
2015



Recent and Projected Poverty Reduction
2015 Top 5 Countries



However, the climate for international cooperation is worsening. There are many reasons for this including: the global slowdown in growth; the decline in overall development aid and the diversion of development funds into humanitarian emergencies; the downsizing of operations by cash-strapped UN agencies; growing economic losses from environmental disasters; and the rise of rightwing, nationalistic governments that are against multilateralism and global governance.

In addition, looking forward there are many trends that will increasingly challenge the ability to meet the SDG goals.[6] These include: climate change and extreme weather; rapid environmental depletion, particularly of water and air quality, and deforestation; erosion of trust in government and international institutions; increasing inequality with-in and between richest and poorest nations; increasing trade protectionism; further slowdown in global economic growth; the risk of new global financial crisis; great power competition, the risks of regional frictions escalating into conflicts; and the increasing rate of technical change and innovation, which raise many opportunities, but also many challenges (see Box 1.3).

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

- **Build** capacity of countries' STI ecosystems, including to design STI for SDGs roadmaps.
- **Boost** international flow and supply of STI, including to implement STI for SDGs roadmaps.
- **Broker** STI coalitions to meet global goals, including provision of STI global public goods.

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

[6] IIASA's 2018 report, *The World in 2050*, argues that "Humanity is at a crossroads. Unbounded growth is endangering planetary support systems and increasing inequalities, the rich are getting richer and the poor even poorer."

Box 1.3 Challenges and Opportunities of Emerging Technologies for Developing Countries

There are a large number of both existing and emerging technologies that present many opportunities but also many challenges for developing countries to meet the SDG goals. They are the result or 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 (IASSA 2019). This is speeding up the rate of technological change as well as the way research and innovation are done (OECD 2018). Many new technologies 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. Some of the main challenges for developing countries include:

1. They may not be able to absorb many of these technologies because they lack many of the complementary factors necessary for their successful deployment and use. Thus, there is a considerable risk that they will fall further behind high income countries.
2. Some of these technologies, such as industry 4.0, will erode their export competitiveness based on low cost 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.
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, Baidu, 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 more detailed discussion of the trends and implications for achieving the SDG goals see UN GSDR (2019), IASSA WI2050 (2019 and 2018), Pathways to Prosperity Commission (2019, and 2018 a,b) and OECD (2017); and for the impact on the prospects for developing countries more generally see Weber (2017), Hallward-Driemeier and Nayyar (2018), and Daniels and Tilmes (forthcoming 2020).

1.4 Key Elements of an STI for SDG Roadmap

For the purpose of this Guidebook, an STI for SDGs Roadmap is defined as a forward-looking policy framework, action plan and/or strategy, to continuously guide effective actions 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, focused and prioritized**, by ensuring alignment with the Agenda 2030 and with strategic focus on the impact of interventions to accelerate progress and address gaps
- **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.
- **Financed, localized and action-oriented,** taking into account the specific contexts at different territorial levels, (re-)allocating budgetary or other resources, building policy and implementation capacities, improving predictability and incentivising key stakeholders' contributions, and with explicit mileposts.
- **Coherent and owned by key actors** through multi-stakeholder engagement in design and implementation, with 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.

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. The specific pathways of countries towards harnessing STI to achieve SDGs will differ, depending on the level of development, existing resources and capabilities.

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.

1.5 Structure of the Guidebook

Subsequent to this introduction, Chapter 2 of the guidebook provides **step-by-step guidance to development and implementation of national STI for SDGs Roadmaps**. That 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. That 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[7]

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. These roadmaps are different than STI strategies in three ways. First, they focus not just on STI strategies for economic competitiveness and growth issues, but explicitly include a focus on STI for social and environmental objectives as these are central elements of the SDGS. Secondly, STI is not just science, research and development, technology and R&D based innovation. Instead innovation is used in a broader sense that goes beyond R&D based innovation to include non-technical, indigenous, grassroots, organizational, and social innovation (see broad coverage in Table 2.1). Third, as a result of, this broader concept, while traditional STI has focused on academic excellence measured through scientists and engineering, R&D spending, patents, and productivity, the focus is on how STI, thus broadly defined can accelerate the attainment of SDG goals, such as eliminating hunger, reducing income and gender inequality, protecting the environment, promoting inclusive and sustainable development and other SDG goals.

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

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 actors within them.

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

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

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.

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 (the fourth being housing) 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 2019, 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 to meet SDG goals and targets. It should be kept in mind that the attainment of even a single SDG goal may require many different technologies and innovations, and agents; and that the STI component is just one of the many elements (such political will, finance, institutions and organizations, networks, etc.) that are required to achieve that goal. These guidelines are generic enough that with some adaptation to the specific context they should be useful whether the STI for 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.[8]

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:

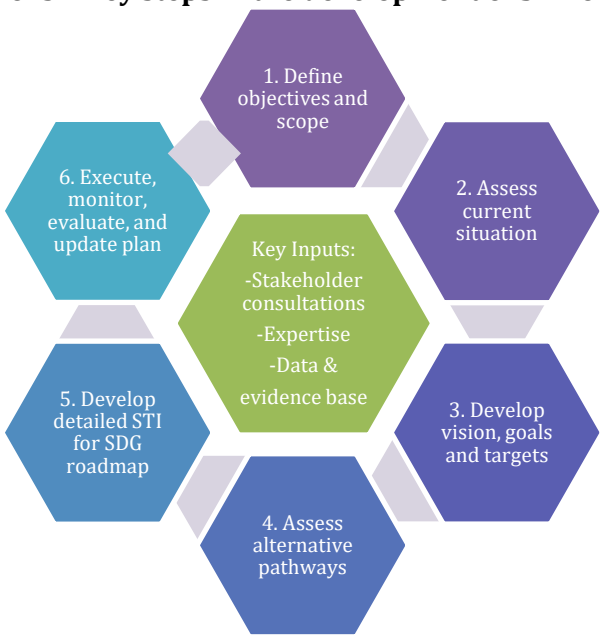
1. Define objectives and scope
2. Assess current situation
3. Develop vision, goals, and targets
4. Asses alternative pathways
5. Develop detailed STI for SDG roadmaps for implementation
6. Monitor evaluate and update plan

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 SDG goals earlier or more efficiently. The steps that are outlined are for 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 SDG goals. The key is that the roadmap is a systematic approach to how STI can be used to accelerate achievement of the goals and coordinate implementation.

[8] 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.

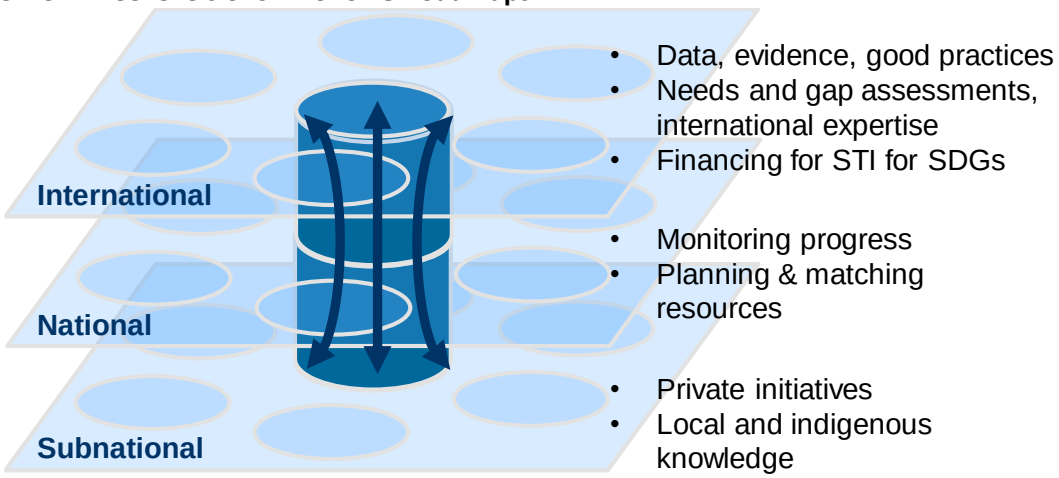
Figure 2.2: Process flow of six key steps in the development of STI for SDG roadmaps



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

In addition, it is important to take into account that there are three levels to the framework (Figure 2.3). One is the subnational level, since roadmaps have to be tailored to the specific local context.[9] 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.[10]

Figure 2.3: Three levels of STI For SDG Roadmaps



[9] STI for SDG roadmaps also can be done at the institutional level such as National Science Council, or National Academy of Science or Engineering, of professional societies to help the institution to identify how it may best contribute to achieving some specific SDG goals to which it can bring its STI expertise. This was emphasized in the Inter-Academy Partnership Study, "Improving Scientific Input into Global Policy Making, with a Focus on the Sustainable Development Goals." https://www.interacademies.org/50429/SDGs Report.

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

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 it 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 mileposts 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 can they 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. The experience of other countries in developing and implementing STI for SDG roadmaps is also very valuable so there should be systematic efforts to develop communities of practice to foster the exchange or relevant experience and expertise among countries and regions.

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 stakeholder 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 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 needs to be supplemented by domestic and foreign expert judgement on relevant domestic data and international data and global trends relevant to the country. 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.[11] 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.[12]

2.4. The Six Steps

Step 1. Define objectives and scope[13]

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. 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 it if 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 1.2 presented 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.

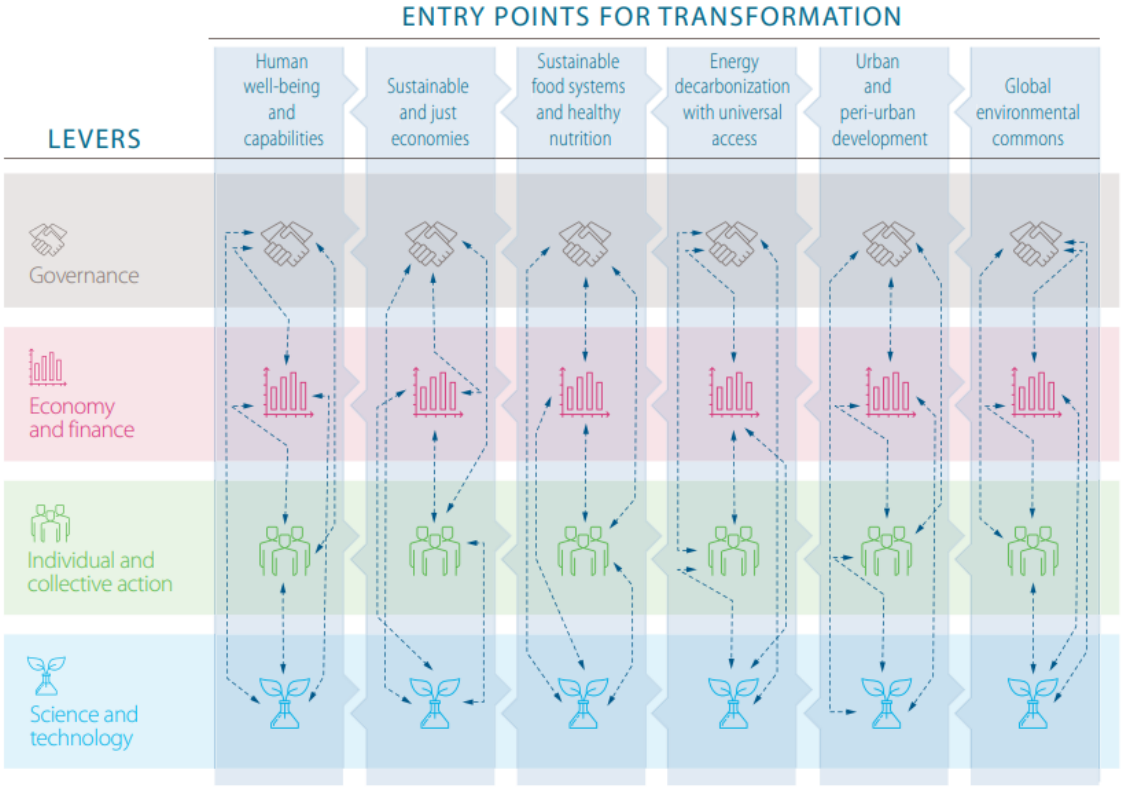
What is the scope?

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.)

[11] See, for example, the presentation by Xu Zhengzhong on 11/27/2018 at the 3rd EGM in Brussels. See also UNCTAD (2017b), on digital tools such as big data and artificial intelligence to support foresight analysis.
[12] 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.
[13] For more guidance on initial planning and preparation see TEC (2013).

Box 2.2: Key Insights and Recommendations from the Global Sustainable Development Report

The first quadrigeminal Global Sustainable Development Report (Independent Group of Scientists, 2019), produced by a group of 15 eminent scientists appointed by the Secretary General of the UN, is an exhaustive science-based "assessment of assessments" of the transformations necessary to meet the SDG goals. A key insight is that "although we are not on track to reach many … SDGs … there is enough scientific evidence to indicate the way forward …. but accelerated results over the next 10 years results are possible … only through an approach that truly builds on a systemic understanding of the indivisible and universal SDG agenda …and intentionally address[es] the trade-offs inherent in the goals, and harness[es] the abundant co-benefits" [p.131]. It proposes six entry points that address the underlying systems behind the goals and four levers that can help achieve the necessary transformations toward sustainable and equitable development, as summarized in below table.



It argues the entry points alone may not be sufficient, especially if actions do not address global interconnections, or take full account of the non-economic, but intrinsic value of nature" (p.23). It further argues that while each of the levers can contribute to the entry points, they generally work best together since these different dimensions have to be addressed in implementation; and the entry points and levers have to be adapted to the specifics of each country's situation. This will require strong political leadership and novel collaboration among government, business and academia. Therefore, countries need to start with what is politically possible, but also strive to expand the range of actions and actors over time. Furthermore, as clear from the title of the report, ***The Future is Now: Science for Achieving Sustainable Development***, action needs to start now, and science and technology have a critical role to play. Actions are necessary at the country and the global level. The global STI community has to do much more to help applying existing STI, but also to develop new technologies that are needed to help attain the goals. This requires partnerships for developing greater STI capability in developing countries as well as global coalitions to develop technologies and innovations that can help to strengthen synergies and bridge some of the trade-offs across goals and targets.

Source: Independent Group of Scientist appointed by the Secretary General, 2019

Here it is worth noting that there can be important synergies as well as trade-offs between different SDG goals. The Independent Group of Scientists commissioned by the Secretary General of the UN had done an exhaustive analysis of the Sustainable Development Goals and had made a strong argument that the goals are all interrelated and need to be tackled simultaneously in order to take advantages of synergies and to offset tradeoffs. They have identified six entry points that take into account these interrelationship as well as four levers that can facilitate the implementation of the entry points (see Box 2.2) [14]. Thus, it is important to take these into account in deciding the scope of the roadmap. Various methodologies are being developed to help countries examine some of those synergies and trade-off to help them determine which goals to focus on and how to work toward attaining them most effectively.

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 targets?

Because the 17 SDG goals are so broad and cover so many targets tackling them all simultaneously may be very difficult. Therefore, it is important for countries to think carefully on which they will prioritize and which they will tackle later as they build up capacity and experience. Presumably, this will have been done in their national development plan, but it can be supplemented in separate STI for 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 chosen. 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.[16] 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 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

[14] IASAA's 2018 World in 2050 report has also convincingly pointed out that there are strong synergies as well as tradeoffs across SDG. They have grouped the SDG goals into six key transformations that have to be accomplished to achieve sustainable development: human capacity and demography; consumption and production; decarbonization and energy; food, biosphere and water; smart cities; and digital revolution (TWI2050, 2018).

[16] See https://council.science/publications/a-guide-to-sdg-interactions-from-science-to-implementation

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 importantly, how STI can help ensure that 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 as well as from the five ongoing country pilots it is clear that there is scope for much more integration across the different plans (see Background paper on the five pilot countries). This closer integration has the potential to leverage resources and actions, as well as to improve the efficiency and effectiveness of the actions considered in the various plans.

Step 2. Assess current situation and emerging trends

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.[17] In addition is it necessary to assess what will affect that situation moving forward. For example, how are trends such as population growth, climate change and extreme weather, water and food availability, conflict and security, etc. likely to impact the targeted SDGs, and how may STI help address or exacerbate them. This involves assessing not only SDG gaps, but how they may evolve under different scenarios. Methodologies for exploring future scenarios will be discussed in the next step. However, in this step it is important to assess not only what the current gaps are, but how they are likely to be impacted by emerging trends in order to understand the magnitude of the challenges to help prioritize the goals.

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

[17] 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.

divided into innovation inputs and innovation outputs[18]. The World Economic Forum's Global Competitiveness Report benchmarks countries on 12 pillars, several of which are very relevant for innovation.[19] 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 analyze 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)[20], OECD STI Policy Reviews. The EU is promoting Smart Specialization Strategies 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.[21] In addition, given limited fiscal resources, governments should review the efficiency and effectiveness of spending on STI. One methodology for doing so which is already available is the World Bank public expenditure reviews (PERs) on science technology and innovation (World Bank 2016.) There are various others, including some that are being developed (see forthcoming Background Paper on Methodologies).

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.[22] Two thirds of the world's 750 illiterate adults are women; women are underrepresented in STEM education, and in R&D personnel, technical publications, patenting, innovation, and management. On the other hand, women spend on average more than three times the number of hours as men in unpaid care and domestic work, limiting the time they have for education, paid work, and leisure; and when they are paid, their wages are lower than those for men.[23] There is much scope for improvements in laws, regulations, and attitudes to improve gender equality, as well as in the use of technology to reduce time spent on chores to give more time for education and work; as well as to improve their access to education and jobs through digitally enabled access, and other technologies and innovations.

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

It is also important to assess whether 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?

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[18] WIPO, Cornell and INSEAD 2018.

[19] 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/)

[20] 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.

[21] For details on the diagnostic tools and their application see their online platform at: http://s3platform.jrc.ec.europa.eu/

[22] On the input side see UNESCSO, Measuring Gender Equality in Science and Engineering: The SAGA Toolkit (available at: http://unesdoc.unesco.org/images/0025/002597/259766e.pdf). On the output side see *Gender Equality and Big Data* which shows how big data can be used to facilitate and assess progress on gender equality (available at: http://undg.org/wp-content/uploads/2018/02/Gender-equality-and-big-data-en.pdf).

[23] See UN Secretary General's Report (2019) for more details on gender inequality.

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 task. 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 timeline to reach the objective(s).[24]

How ambitious is the vision?

Countries also need to decide how ambitious to make the vision and the goals. This is a political as well as an economic decision, and it depends on 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 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.

[24] 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.

Approaches for developing visions include foresight workshops, alternative futures, horizon scanning, scenarios, and others.[25] 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 vison. If not here, they need to be spelled out in further detail in step five of the roadmap. In addition, consideration has to be given to how that vision will be communicated. Beyond the preparation of a document, when and how will it be launched? Should the vision be part of other major government announcements or should it be launched independently? Should the vision be announced early to create momentum and support, or should it be launched only when the full STI roadmap has been developed? This will depend on country specific circumstances and traditions. However, it should be articulated by the highest level possible and launched through mass media including the press, television, and social media in order to help create momentum and alignment.

Step 4. Assess alternative pathways

This is the most critical step 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.[26] 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 innovation covers a broader space than pure research for scientific or technological purposes as it includes new ways of producing, delivering, and using goods and services which may already exist elsewhere, and which can accelerate the achievement of SDGs if they can be effectively harnessed in the local context.

[25] Foresight methods and techniques can be used to support many steps in the process. see: CSTD-UNCTAD. Strategic Foresight for the Post-2015 Development Agenda: 23 Feb. 2015, http://unctad.org/meetings/en/SessionalDocuments/ecn162015d3_en.pdf, SDG17 SDG8 SDG9 SDG10 SDG7 SDG11 SDG13; UNCTAD; Digital Tools for Foresight. Oct. 2017; http://unctad.org/en/PublicationsLibrary/ser-rp-2017d10_en.pdf, SDG1 SDG2 SDG3 SDG4 SDG6 SDG7 SDG8 SDG9; UNESCO, Transforming the Future: Anticipation in the 21st Century, 2018, http://unesdoc.unesco.org/images/0026/002646/264644E.pdf,SDG4 SDG9 SDG10 SDG17; and UNDP Foresight Manual. https://www.undp.org/content/undp/en/home/librarypage/capacity-building/global-centre-for-public-service-excellence/ForesightManual2018.html

[26] 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).

Table 2.1 Innovation is Diverse: The Main Faces of Innovation for the SDGs

Product and service innovation

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

Organizational (institutional) innovation

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

Marketing innovation

- 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
- Science-based campaigns and awareness raising, for example on water and sanitation, sustainable consumption

Business model innovation

- New ways of organizing businesses and their products and services, for example using internet-based platforms to match supply and demand 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
- Changes in value proposition and product-service systems of companies (e.g. circular economy business models, including product sharing and functional sales)

Pro-poor, inclusive innovation and frugal innovation

- Various types of innovation designed to address the needs of poorer, marginalized groups
- Affordable products from the informal sector that have 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)

  Products or services designed or redesigned to reduce their cost and complexity (can be modular but can still be high-tech) while retaining their core functions.

Grassroots innovation

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

Social innovation

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

System innovation

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

Source: Authors based on UNCTAD (2017, 2019), Miedzinski et al (2017a, 2017b), Radjou and Prabhu (2015), Dutrénit and Sutz (2014)

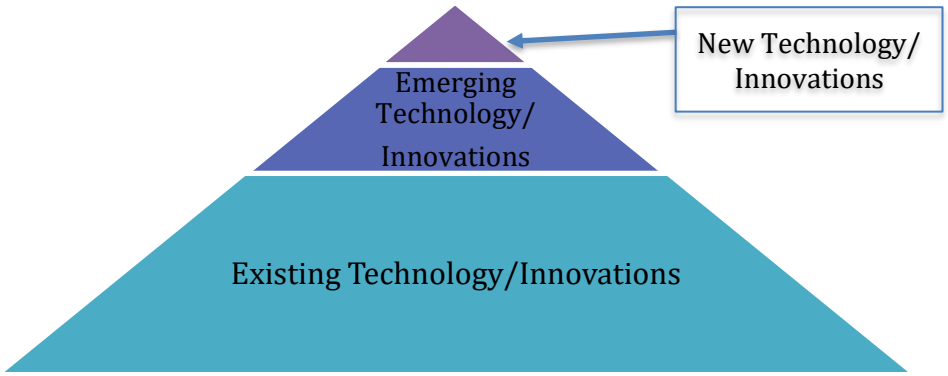
Table 2.1 presents a comprehensive overview of innovations, ranging from incremental process improvements to system innovation (OECD 2015)[30] as well as grassroot,[31] pro-poor, inclusive and frugal innovation.[32] The use of the term innovation in this report will vary depending on the context. Sometimes it will be in terms of globally new technology, sometimes it is a product or service that exists elsewhere in the world but is new to the local context and may need to be adapted to the conditions in that context, sometimes it is in reference to an indigenous innovation that needs to be scaled up and diffused to other users. An effort is made in the text to clarify how the term is being used, but the reader will often have to infer that from the context. In addition, different types of innovation are needed in different local contexts. For example, if the focus is placed on diffusing an 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 the 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). 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.

Figure 2.4 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. In this discussion innovation is in terms of the traditional use of innovation as technology to produce and deliver a product or a service that is new to the developing country context.

For the planning horizon to 2030 the reality is that most developing countries will be best served by taking maximum advantage of broad dissemination and use of existing technologies/innovations as well as emerging technologies/innovations. This is why they are in the broader bottom parts of the pyramid in Figure 2.4. 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.[33] 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 Chapter 3.

[30] One perspective on transformative innovation is the notion of system innovation (Geels 2005, OECD 2015).
[31] 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.
[32] Pro-poor, inclusive, and frugal innovation refers to innovations that have been designed to address the needs of poorer, marginalized population. They may include both high-tech and low-tech innovations. These include use of satellite technology to identify sources of clean water for poor rural communities, advanced but low-cost eye surgery to remove cataracts for as low as $30 per person, low cost water purification pumps, 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).
[33] For a very revealing analysis of the time it has taken different technologies to diffuse globally see Comin and Mestieri, 2014.

Figure 2.4: Pyramid of Relative Relevance of Different Technologies/Innovations to Achieve SDGs



Source: Authors

What existing technologies can 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.[34]This means that developing countries could go a long way toward attaining some of the SDGs by using technology that already exists.

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 on 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

[34] See for example OECD (2014) and Ciera and Maloney (2017)

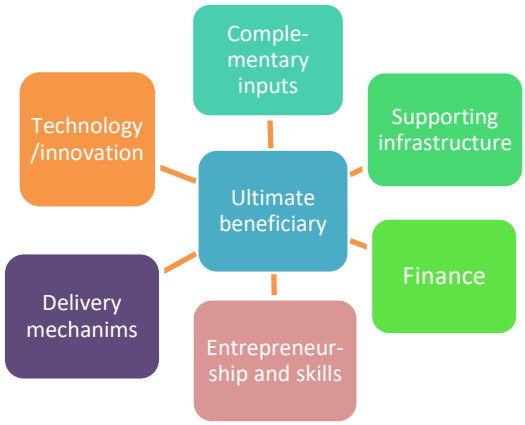
disseminate medical technologies/innovations, such as vaccines, require a system of health providers. Also, something as simple as oral rehydration therapy, essential to reduce mortality because of dehydration from diarrhea, requires not just a few cheap chemicals, but trust by the target population in the providers, as well as clean water, which is usually not easily available in the communities where the problem is most endemic. Figure 2.5 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 2.5: Technology and Innovation are Just One Element of the Deployment System Required to Reach Beneficiaries



Source: Authors

Developing and deploying a technology/innovation also requires finance. Given the risks involved in developing and testing new technologies, this often requires some source of finance which may be the developers' own capital, seed funding, or some sort of grants by governments or NGOs. Only once a new technology is beyond the conceptual stage is it likely to attract venture capital or social investment funds. And even when a technology has been widely demonstrated to be effective, it is often not easy to attract capital to finance expansion. Banks are risk-averse, so they 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.[35]

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/innovations that are new to the target environment there is often some risk that they 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.

Deploying technology/innovation also requires a delivery system (See Box 2.3). For commercial technologies/innovations 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/innovations in sectors such as basic education, preventive health, security, and social protection, it is typically some sort of government organization or NGO. These are not generally already in place for the delivery of new technologies. Therefore, they have to be developed as part of the delivery ecosystem. In addition, for some technologies/innovations (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. Artificial intelligence also has the potential to bring in a wave of complementary innovations with wide impact and may help to substitute for some of the skill and knowledge gaps in developing countries.

However, it must also be kept in mind that some disruptive technologies, such as artificial intelligence, automation and robotics, 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 biotechnologies may have negative side effects, including bio and environmental hazards.

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

Box 2.3: Some Relevant Insights from the Global Solutions Summit

Five key points came out of the Global Solutions Summit held in NYC just before the UN 4th and 5th STI Forums, 2018 and 2019. The summit brought together social entrepreneurs, foundation executives, high net worth individuals, NGOs, scientists and government officials 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 broader than the conventional geographic concept related to proximity to the grid, and includes 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 have 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 must be reached if we are to achieve the SDGs. What is required is a way to radically scale-up and massively deploy these successful innovative solutions.
3. ***Building an efficient and effective deployment ecosystem***. Scaling up and replicating successful business models to deliver SDG solutions requires an ecosystem involving technical, financial, human capital, supply chains, infrastructure, political support, entrepreneurship, innovative business models and delivery systems, and financing. This entails a two-pronged strategy. First, developing a platform "so that 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 the Addis Ababa Action Agenda of catalyzing development finance from billions to trillions and developing innovative financial conduits so that these funds can be invested in increments of thousands and millions of dollars. Private business, NGOs and social enterprises are developing some of these innovative conduits via traditional and non-traditional banking systems as well as new fintech solutions to reach the last mile customers.
5. ***Generating income to deliver the SDGs***. The problem of reaching last mile customers is that they cannot afford the services. Therefore, effective STI for 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

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

Source: Watkins (2018) and Watkins (2019)

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?

There is also the possibility that global innovation initiatives in agriculture (more drought and pest resistant crops, more nutritious food), energy and environment (advances in alternative energy technologies, carbon capture and sequestration), health (new vaccines or better diagnostic and preventive medicine, 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 new technologies and how the country should position itself to take advantage of them. For example, what kinds of scientific/engineering/technical skills, physical and virtual infrastructure, institutions (such as technology and training center, business incubators/technology parks, etc. may be necessary for the country to be able to acquire/develop/use these new technologies.

What alternative innovation pathways are there to reach those goals?

Because there can be different ways of using science, technology and innovation to meet some of the SDGs, it is critical 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/innovations will have falling costs and become more competitive as they are further developed and scaled up. Also, old technologies typically reach a saturation point and 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 needed 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 and benefits 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 road-mapping 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
- Feed-back loop to use monitoring and evaluation to adjust the roadmap

Some of the key issues are discussed below.

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

Generally, roadmaps for attaining 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 many 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 still others, such as no poverty, zero hunger, good health and wellbeing, it will be a wide variety of actors, including also 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; and issues such as data ownership, privacy, and security—and these are relevant to developing as well as developed countries.

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

- Adoption and use of existing and emerging technologies/innovations. 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/innovation 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 encourage more collaborative approaches to big challenges, as well as to help mitigate the risks

Regardless of the level of development and technological capability, countries may opt to use instruments supporting a combination of all three types. Challenge-driven approaches to STI policy, such as mission oriented or transformative innovation policy, are likely to use instruments from all three types. 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

Regulatory framework levers • 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 • Intellectual property protection which provides an incentive to develop new technology and also facilitates the transfer of technology by allaying the fear of foreign investors and technology supplier that their technology will be pirated. In addition, the information contained in patent documents can provide insights into how to develop other technologies. • Prices that reflect economic costs (i.e. carbon pricing; removing subsidies on carbon-based fuels, etc.) • Regulations for the challenges of the digital economy including, unfair competition, privacy, security, data access and ownership • Reskilling and social protection legislation and institutions to help persons negatively affected disruptive technology • Regulations and institutional arrangements underpinning gender equality in STEM, research, and entrepreneurship • Product and process standards and certification for safety, health, social and environmental goals • Intellectual property regulation and incentives (such as purchases of licenses) to encourage use and diffusion of technologies helpful for the attainment of SDG goals • Rules and regulation for development of venture capital and other finance relevant for new technologies that can help reach SDG goals
Instruments to absorb, disseminate, and use relevant technology and innovations • Public awareness campaigns and outreach activities to support use of technologies/innovations for SDG goals • Creation and support of online innovation platforms that facilitate access to and transfer of technologies such as the UN online technology platform and WIPOs Green Technology Platform • Business advisory services to build up management capability and help increase productivity, and attainment of safety, health and environmental standards and gender equality • Establishment of WIPO TISC National Network to provide value-added intellectual property services for the support of innovation and use of relevant technologies,

- Technology extension services to demonstrate and diffuse new technologies/innovations relevant for SDG goals, including scale-up and dissemination of indigenous and grassroot innovations
- Technology/innovation centers to help solve firm problems related to the SDGs by using relevant new technologies/innovations
- 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
- Supplier development programs to help firms integrate into domestic and international value chains
- Vouchers for firms to contract specialized technical assistance to use relevant new technologies/innovations
- Tax incentives or grants to first (pioneer) firms to use relevant new technologies/innovations
- Development of firm clusters to generate economies of scale and agglomeration for learning about and effectively using (and developing) relevant new technologies/innovation
- Skills upgrading and training programs to use new technologies including digital technologies
- 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)

Instruments to adapt and disseminate new emerging technology and innovations

- Development grants and subsidized loans for emerging technologies/innovations 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

Instruments to develop new technologies and system-wide innovations

- Grants to universities and research centers to develop new technologies/innovations relevant for the SDGs
- R&D tax incentives or grants to firms to develop new technology/innovations relevant for the SDGs
- Support to clusters and science and technology parks to stimulate development of relevant technologies/innovations to help reach the SDG goals and its commercialization
- Procurement specifications for new technological or innovation solutions accompanied by research grants and promises of large purchases if products or services demanded meet performance specs
- Challenge grants to develop new technologies and innovations to address specific needs in environment, health, education, agriculture to help reach the SDGs
- Grants and tax incentives for researchers and innovation consortia to develop new technologies/innovations in specific targeted areas deemed relevant to help meet SDG goals
- Major government coordinated initiatives with significant government funding to create consortia of business, the academic community and public research institutes to develop new radical technologies

Source: Authors

The choice and design of STI policy instruments to support the selected pathways have 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 problems in 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. 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 stakeholders from government, the private sector, and civil society on board to commit to their respective responsibilities (see Box 2.4 on engaging the private sector). This is why stakeholder involvement is such a critical input for developing a successful roadmap.

What capacities in government and other agents 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.

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 provide them. 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 or to develop new technologies) 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 road-mapping 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 road-mapping 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 an 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.

Step 6. Execute, monitor, evaluate, and update plan

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

How will the roadmap be executed?

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

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? The indicators to monitor are not just the traditional STI inputs such as scientists, engineers, technical publications, and patents, but also technology licensing, technical assistance, twinging arrangements, etc.; and more importantly, outcome indicators such as: reduction of hunger, reduction of income and gender inequality, reduction of green-house gas emissions, increases in use of non-fossil fuel energy, reductions in infant and maternal mortality, reduction in incidence of communicable diseases, increases in life expectancy, preservation of biodiversity, etc., as relevant to the targeted SDG goals.

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. This may require building into the roadmap proper provisions to create this capacity in the country.

What mechanisms will there be for continuous horizon scanning for changing sub-national, national, and global conditions?

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. In addition, changing subnational, national and global conditions which may affect the plan need to be continuously scanned, such as trade tensions, fragility and conflicts, the impact of more frequent extreme weather, or other disruptions. Who will be responsible for this and how will it be done? Continuous horizon scanning is often done by specialized departments within government or think tanks.

Some developing countries are already carefully monitoring the impact of some of these trends, particularly the impact of new technologies. Mexico, for example, has undertaken a major effort to assess the impact of disruptive technologies on the country (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 for continuous learning and monitoring 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 analyzed 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.

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

2.5 Ensuring that a Country takes Full Advantage of the Global STI System

STI for SDG roadmaps 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. The way that most countries tap global STI inputs for theirs 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.

To a large extent getting access to and using global STI resources and expertise is intermediated by a country's national innovation system (see Chapter 3). Assessing the capacity of the country's national innovation system to acquire, adapt, deploy and use global STI to help attain the SDG goals has various dimensions. There are several useful methodologies for doing reviews of a country's national innovation system. The Background Paper being prepared by the JRC of the EU will have a table summarizing some of the methodologies for analyzing countries' national innovation systems as well as developing a methodology for developing STI for SDG roadmap. What is proposed here is more narrowly focused on the extent to which a country's national innovation system is supportive and "fit for purpose" for effectively tapping into and domestically deploying elements from the global STI system that can help the country attain specific SDG goals it chooses. Some of the key aspects to consider include:

- 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]

- 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[37] 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

[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.

[37] The Background Paper on International STI Collaboration 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.

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 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. In addition to addressing cross-border spillover effects inherent to some of the SDGs (e.g. water resource management in major river basins), there can be important economies of scale in addressing some STI for SDG issues such as through 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.

Chapter 3. International Partnerships for STI for SDG Roadmaps

This chapter is about the international dimension of the framework for STI for SDG roadmaps presented in Chapter 2[38]. The objective of this chapter is to outline how international partnerships can do more to support the development and implementation of STI for SDG roadmaps. It draws heavily on the background paper "International STI Collaboration and Investment for Sustainable Development."

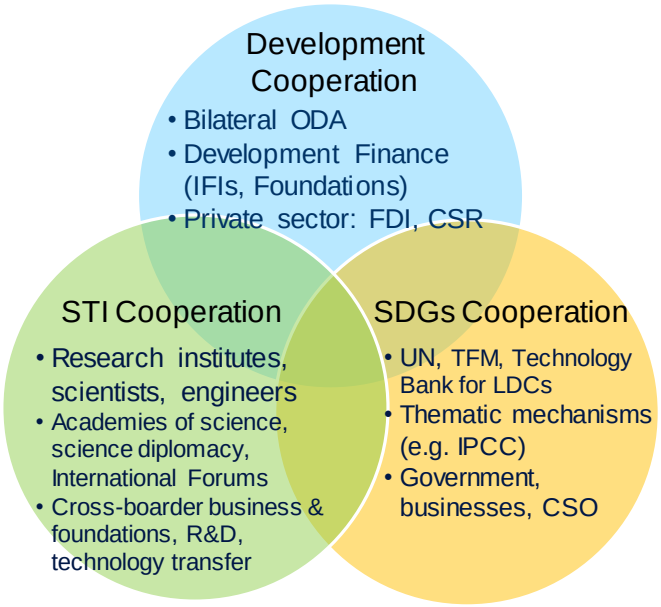
The structure of the chapter is the following. Section 1 provides the global landscape for international partnerships. It identifies three main communities involved, provides an overview of the relationship between the global innovation system and that of individual countries, and places the relative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

3.1 Landscape of International Cooperation on STI for SDGs

Domains and Actors

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

Figure 3.1 International STI Cooperation of SDGs: Domains and Actors



[38] This is consistent with the technology-related targets under SDG 17 (17.6, 17.7, 17.8 and 17.16) which focuses on international partnerships on STI to help achieve the SDGs. See Annex 1.

SDG Cooperation

The SDG cooperation community is the newest as it dates from 2015, although it builds on the Millennium Development Goal community. Progress on meeting most SDG goals is occurring naturally as part of the development process. International partnerships for SDGs are explicit in goal 17, and Innovation is explicit in Goal 9, while more effective use of STI can help accelerate the achievement of all the goals.[39] Many actors are involved in SDG cooperation, from governments to foundations, the private sector, the academic and professional community, NGOs, and civil society. International cooperation to help achieve the SDG is ongoing, and some of the SDG goals could be reached with enough time and resources. The key point is to accelerate their achievement. For this there needs to be a stronger emphasis on leveraging STI more effectively into plans to achieve the SDG goals.

Development Cooperation

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

STI Cooperation

There is growing awareness that there is a global innovation system that now includes developing countries actively participating; and that it also has multiple actors, not just governments, academia and the private sector, but indigenous knowledge and frugal innovation; and that foundations are playing a role in funding R&D and innovation, which before was more limited to governments and the private sector. The STI community is increasingly aware of the need to incorporate SDG goals into their work (UNCTAD 2018, 2019; OECD 2018). There is a need for a new innovation system that pays more attention to inclusiveness and environmental sustainability, which is partially addressed by some of ongoing international STI collaborations. To meet the SDG goals there is a need to direct more STI effort towards those goals. There is also needed to increase capability in LDCs of help them leverage STI for the achievement of the SDGs.

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

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

The Relationship between the Global and National Innovation Systems

Figure 3.2 presents a stylized schematic of the **global STI system**, linking the global supply of science, technology and innovation to a country's national innovation system and STI needed to accelerate the achievement of the SDGs. For expository purposes, international STI supply can be conceived as consisting of global science supply and global technology and innovation supply.

The main forms of science collaboration are training in science and mathematics, joint research with participants from developing countries, formal scientific collaborations and networks (e.g. the Belmont Forum), mobility of researchers and highly skilled labor, as well as research on the specific needs of developing countries. Science is also transferred by making available the output of scientific work through scientific and technical papers, international science conferences and symposia, and scientific data bases. Many of these collaborations occur through non-market mechanisms.[40]

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

The middle of Figure 3.2 depicts the ***national innovation system***[41], distinguishing between four main kinds of actors (universities and research centers, firms and organizations, national and subnational governments, and consumers and civil society), the broader context and framework conditions, and the underlying natural resource endowment.

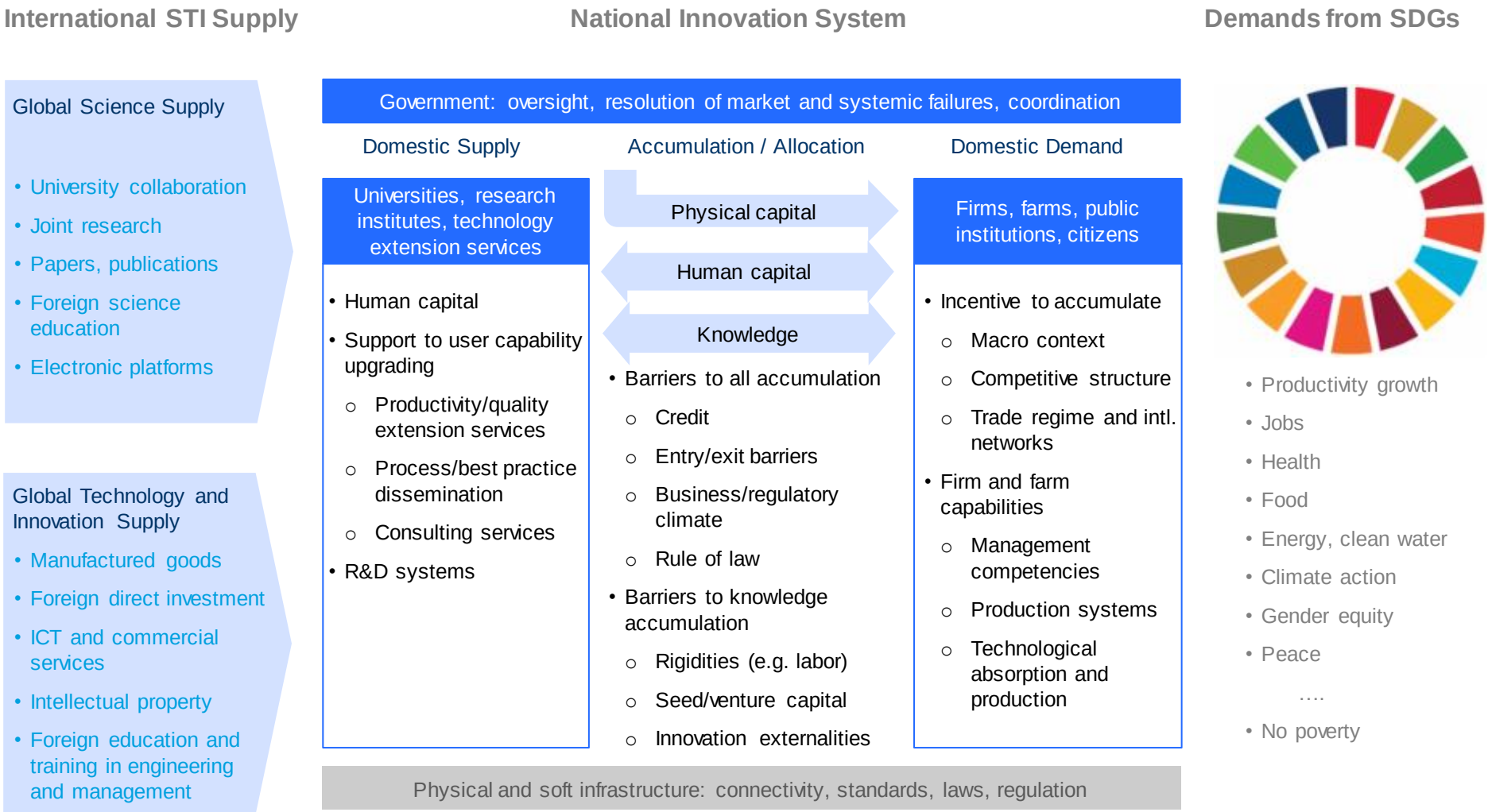
Critical elements are the linkages, flows and accumulation of knowledge, people, finance among the actors. The broader context includes key infrastructures that are most relevant to the national innovation system such as STI infrastructure (universities and research parks; research centers; business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

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

[40] These are activities that are not provided as a transaction of money paid for a good or service based on market relationship. However, it includes grants and prizes and collaborations where different parties contribute time and effort towards a common goal.

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

Figure 3.2: Positioning the National Innnovation System to Benefit from International STI Supply and Address the SDG Demands

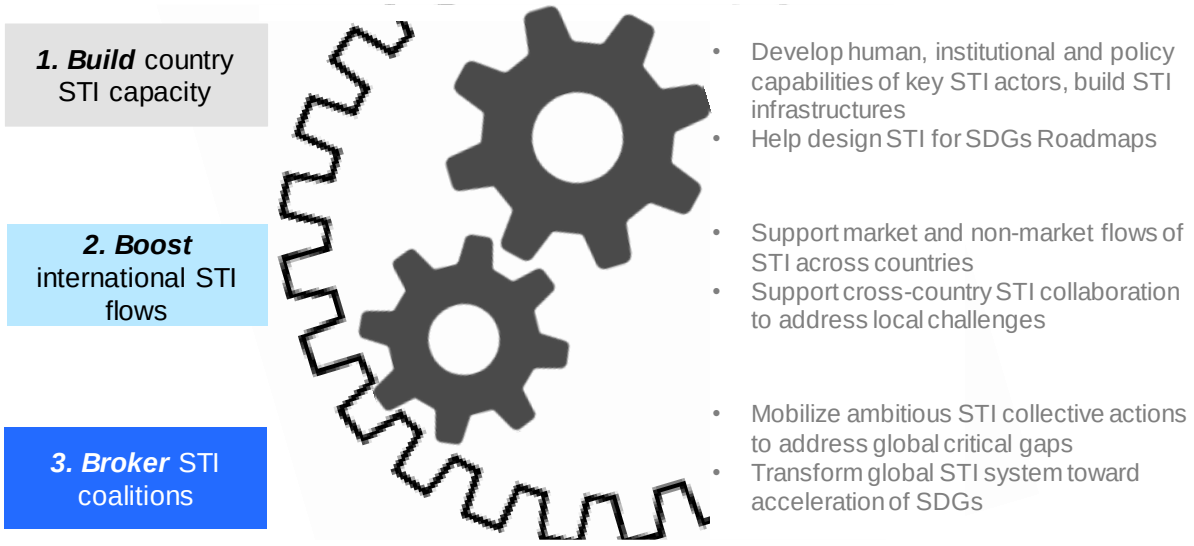


3.2. Three-Pillar Framework for International Partnerships – "Build, Boost, Broker"

The low STI capability in developing countries is a critical constraint for international collaboration[44]. This applies to different actors including firms and entrepreneurs, research and education systems, government, consumers/users, and civil society and citizens. This is therefore built into the three-pillar framework for international STI collaboration proposed below in Figure 3.3.[45]

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

Figure 3.3. Three pillars for international STI collaborations for the SDGs



Source: Authors

The second pillar of collaboration focuses on boosting international flows of relevant knowledge, technology and innovation across countries and on supporting cross-country STI collaborations addressing the SDGs. One objective of this international collaboration is to shape international STI markets and remove bottlenecks impeding the flows of knowledge, people, and finance directed towards the SDGs, including adapting international framework conditions to foster existing STI for the SDGs as well as promoting stronger non-market flows such as scientific, academic, and professional cooperation. Another is to foster STI collaborations to create new STI that can help countries address local challenges in attaining the SDGs. As a result of this intervention, knowledge, people and

[44] Also see Colglazier (2018) for a strong rationale for why it is important to create more STI capability in developing countries.

[45] Underlying analysis, case studies and a typology of various interventions are elaborated in the Background Paper on International STI Collaborations.

investments relevant for the SDGs will reach countries and communities where they are most needed more effectively. This pillar also includes supplying global public goods (GPGs) needed to facilitate better matching of STI supply and demand such as data, expertise and scientific knowledge.

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

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

Successful instruments and collaboration mechanisms tend to address more than one pillar of collaboration. For example, CGIAR includes dedicated activities aimed at building local capacity (Pillar 1), knowledge sharing e.g. via participation in multi-stakeholder platforms (Pillar 2) as well as facilitating integrated international collective actions addressing global challenges and global transformations (Pillar 3). Similarly, Mission Innovation includes information and knowledge sharing activities (Pillar 2) as well as joint technology demonstration (Pillar 3).

The pillars, and their respective actions and collaboration mechanisms, are interdependent, therefore need to be "*geared*" toward fitting each other to maximize collective impact with multiplier effects. These interdependences are not necessarily linear or one directional. For example, focusing on strengthening STI capabilities of developing countries cannot overcome bottlenecks in the international STI flows and effective address challenges of GPGs. Boosting international STI flows alone will not overcome capability gaps on a country level. Taking international collective action will not replace building country level capabilities. On the other hand, however, improving international STI flows can directly help countries to build their domestic capabilities whilst investing in collective STI action can help to develop specific domestic capabilities in developing countries.

Table 3.1 Summarizes current practices of international STI cooperation for each of the three pillars. For Pillar 2 on boosting STI flows, the table distinguishes typical non-market from market mechanisms since they have different targets of support and instruments. The last column of the table gives some illustrative examples, although more than one pillar can be addressed. While developing coalitions for Pillar 3 is quite challenging, there are numerous historical examples as well as some ongoing efforts. These are worth studying for the lessons they have for how to develop more coalitions necessary to successfully tackle critical SDG gaps (see the Background Paper.

Given the complexity and urgency of challenges we face, countries and international community need to engage in all three pillars of international collaboration to mobilise STI for Global Goals. The three pillars should not be translated into a simple step-by-step strategy in which the collaborative effort needs to first focus on improving country STI capacities, then addressing international knowledge flows and then considering international collective STI action. The importance of each pillar of international

Table 3.1: Current practices of international STI cooperation for SDGs

		Unit of intervention	Areas of international support (instruments and recipients)	Select examples
Build STI capability		Individuals	- Researchers: scholarships, research grants - Farms/firms absorptive and innovation capacity: training, BDS, agricultural/management extension services - STI policymakers: training, peer-learning, learning-by-doing	ASEAN-India S&T Development Fund
		Human capital base and institutions	- STEM education, digital skills, basic and applied research institutes - Entrepreneurship/deployment system, intermediaries, networks - Public service delivery (e.g. health, education, water, conservation…)	WB ACE UN agencies STI training programs
		Broader STI system	- STI-related infrastructure (quality systems, connectivity…) - STI system diagnostics, policy advice / assistance to reforms - Sectoral R&D and innovation systems (e.g. energy)	UNEP TNA STIPR/Go-Spin/PER
Boost STI flows	Non-market	Link / strengthen existing STI for SDGs	- University partnerships, exchange programs - Multi-stakeholder platforms, networks, communities of practitioners	PASET AOSP
		Increase new STI for local challenges	- Supply-push: joint research projects - Demand-pull: government procurement, prizes	CGIAR, UK GCRF X Prize
	Market	Barriers to markets	- Matchmaking STI supply and SDGs demands by online repository /platforms, challenge competitions, demonstration projects	TFM online platform
		Trade and investment flows	- Donor/IFI projects to crowd in and catalyze R&D, technology transfer and innovation linkages through private capital and blended finance - Treaties and other agreements conducive to STI flows (e.g. IP)	Lighting Africa US FtF WEF NVA, WRG
Broker STI coalitions		Norms, values, standards, statistics	- Global visions, strategies, monitoring reports - Cross-country monitoring and evaluation systems	UN Digital Cooperation Panel
		Coalitions addressing critical global gaps	- Partnership/funding/governance frameworks - Mission-innovation programs, grand challenges	US PEPFAR, DE4A, WEF Frontier 2030
		Transformative STI system (global/regional)	- Joint or aligned fiscal/procurement/research policies - …	Horizon 2020

Source: Authors, informed by WB-OECD, the Background Paper on International Collaborations for STI for SDGs Roadmaps (forthcoming)

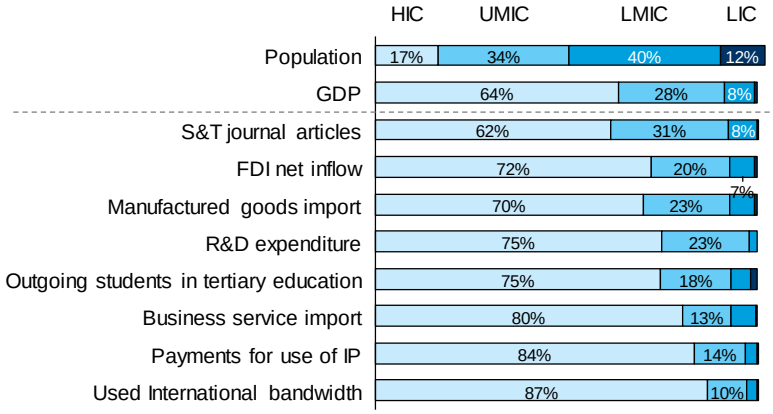
STI collaboration needs to be catered for the specific challenges and context. In some cases, the collective STI action for GPGs can be used as a strategic lens to concentrate international efforts to build specific STI capacities and infrastructures in (mostly but not only) developing countries who are either most exposed to specific challenges or could create most value benefiting other countries or disadvantaged communities.

3.3. Key Priorities and Actors for STI Collaborations for SDGs

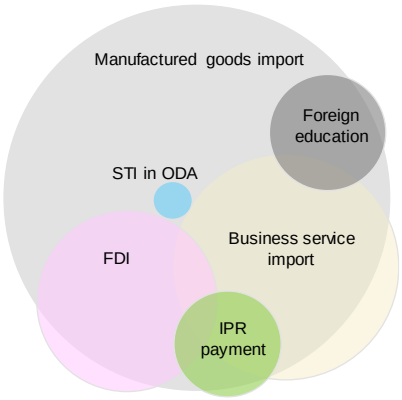
It is helpful to put the key actors and elements of the three pillars in perspective before outlining what government can do, Figure 3.4 provides some details on the relative size of countries at different income levels in terms of population, GDP and STI activities. The main points to note are:

Figure 3.4: Distribution and Significance of STI Flows to Developing Countries

Distribution of STI flows, by country income groups



Relative significance of STI flows



Source: Background Paper on International STI Collaborations

- While the developing world (middle- and low-income countries) accounts for 83% of global population, it only accounts for 36% of its income because their average per capita level is only 11% of that of high-income countries. These differences are less pronounced for upper middle-income countries and most pronounced for low income countries whose average per capita incomes are only 1.8% of that of high- income countries.
- R&D capability, as proxied by R&D expenditure is even more skewed, with developing countries accounting for just 23% of world R&D. Moreover, the bulk of the R&D in developing countries is done by China (not in table but it is $258 billion or 60% of all the R&D done by developing countries). Lower middle-income countries account for only 1.9% of global R&D, and low - income countries do virtually no R&D.
- The output of scientific and technical journal articles is less skewed than R&D expenditures, with developing countries accounting for 38.9% of the total. And lower middle-income countries' share at 7.5% is almost four times as high as their share of R&D expenditures.
- The largest 1000 companies account for 42% of global R&D ($782 billion out of total of around $1,860 billion in nominal dollars).[46] Moreover, transnational companies are the main mode of global dissemination of technology and innovation through their trade and direct foreign investment activities and technical information transferred through supply chain links.
- Cross-border data flows, proxied by used international network bandwidth, is the most concentrated in high income countries (even with China and India grouped as middle-income

[46] See Jaruzelski et al. (2018) for R&D by largest companies.

have small shares), indicating the serious risks developing countries face to be left behind digital transformation.

The key points to note are that most science, technology, and innovation is done in high income countries for their needs and for strengthening their international competitive position. Developing countries have much bigger challenges than high income countries in meeting the SDGs because their SDG gaps are much larger. In addition, most R&D is done by the private sector, large multinational companies in particular.

To advance international STI collaborations more fit for global goals, it is useful to examine the current situation from developing countries' perspectives. Most of the activities of the ODA, STI and SDG communities oriented on STI for SDGs are non-market .[47] This contrasts greatly with market driven flows which transfer technology and innovation that may be relevant for SDGs, and are driven mostly by private sector activity. The main market flows are: net inflows of foreign direct investment, imports of manufactured products, imports of ICT and business services, payments for the use of intellectual property rights, and tertiary education abroad, which is an important way to acquire foreign knowledge.[48] As can be seen in Figure 3.4 (right panel) these market flows are much larger than the STI oriented activities of ODA.

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

- The size of ODA on STI is very small compared to market STI flows. In addition, ODA emphasizes capacity building for STI (with debatable outcomes and facing measurement issues), and funding for R&D, but appears to have less effort on boosting the flow of existing STI across countries, and very little on brokering global public goods because it is largely delivered through bilateral programs. However, despite their small size, ODA and multilateral STI related activities can be used by governments to leverage those of other actors, including the scientific community, NGOs, and the private sector, as will be developed in the next section.

- STI cooperation is more focused on pushing the boundaries of knowledge and doing R&D than on building country capacity to use STI for SDGs, which is relatively small compared to international collaboration among advanced countries[49]. However, the role of the STI community can potentially be very large in all pillars. This is very forcefully argued in the Global Sustainable Development Report 2019 (Independent Group of Scientists 2019, see also Box 2.2), which emphasizes in particular the need for science to do much more in developing new science and technology to take advantage of the synergies among the goals and to ameliorate the trade-off and address negative impacts. The role of the STI, community in Pillar 3 is limited by the difficulty of brokering coalitions to take on large scale challenges because of problems of scale, limited finance, and the challenge of workable governance arrangements.

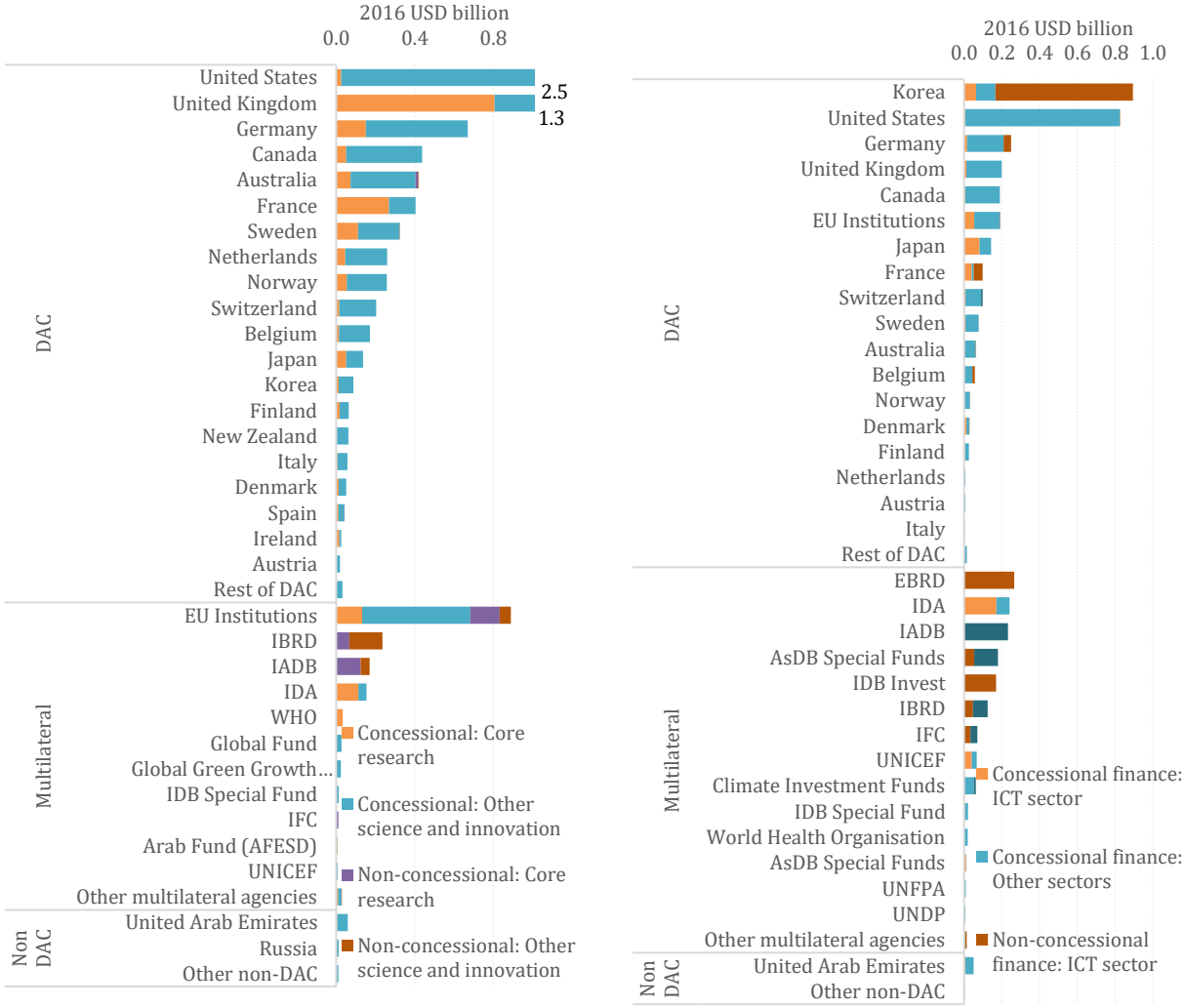
[47] The activities of NGOs a tend to be mostly non-market. The activities of international institutions fall partly under ODA but mostly under market activities of the private sector since while they finance some STI capacity, they mostly finance many STI related activities (even R&D activities and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

[48] More details in the Background Paper on International STI Collaboration.

[49] Since most of these activities are non-market, it is harder to quantify the actual volume of R&D focused on developing countries and less on STI for SDGs. Details in the background paper.

- SDG cooperation on STI such as UN's TFM, despite the clearly articulated need to harness STI to help meet the SDGs, has not been able to do much on any of the pillars. This is largely because of its limited funding even to boost the flow of existing knowledge, or broker concrete collaborations to create new STI, or build country capacity beyond some training, methodologies and policy advice. However, its role is potentially very large in brokering global STI coalitions to address grand SDG challenges through its advocacy role and convening power. This is an area that will be addressed in the next chapter.

Figure 3.5: Sources and contents of STI in ODA Supporting Science and Innovation (left panel) and Technology (right panel): Disbursements in 2016 prices



Source: Background Paper on International STI Collaboration, cited from OECD 2019.

- The private sector plays a very large role in delivering on the second pillar through its role in creating and transferring knowledge and technologies through market activities, including direct foreign investment, R&D, sale of intellectual property and sale of manufactured products and business services. Typically, though, market incentives do not necessarily assure inclusion outcomes to the most marginalized. The private sector has a weaker role in building country capability to use STI for the SDGs, although multinationals often build SMEs absorptive capacities and improve management practices through supply chains, and contract and strengthen key elements of national innovation system such as research centers and develop STI related training programs at universities. On the other hand, the private sector is very weak on the third pillar because almost by definition there are problems of incentives because of the lack

of appropriability, high risk, and complexity. However, more recently, the private sector is realizing that it has a critical and major role to play in achieving the SDG goals as illustrated by major initiative launched in January 2020 (see Box 3.1), showing that there is great potential for governments to work together with it and the scientific and NGO community to boost and broker STI for SDGs.

Box 3.1. New Private Sector Initiative on Unlocking Technology for the SDGs

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

At its Annual Meetings 2020 WEF launched a new initiative called Frontier 2030--a New Fourth Industrial Revolution for Global Goods Platform, with an accompanying report. The report analyzed over 300 Fourth Industrial Revolution technologies that could make contributions to meet the SDGs. But they found that there were significant barriers and risks to scaling these applications. The barriers include: "poor data access and quality, lack of basic infrastructure, an inadequate governance and policy environment, upskilling and reskilling needs, [and for]…public goods-focused solutions—a lack of viable business models and commercial incentives for scaling" (p.7). The basic argument is that business as usual is not an option for meeting the SDGS by 2030 and that "a gearshift is needed from the current race to deploy new technologies for short term growth and private gain to a more long-sighted and principled approach that actively manages and harnesses the role of technology can play for humanity and the environment" (p.20). The report argues that the private sector has a critical role to play in partnership with government, the scientific community, and civil society in developing and scaling the technologies to facilitate the achievement of the SDGs; and to manage the downside of that technology revolution, including from security and control risks to socioeconomic risks such as job displacement, and even unintended environmental risks. They identified eight "enablers needed to continually accelerate innovation and investment into the new solutions that help tackle our grandest challenges, and to create viable markets for those solutions in the long term":

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

They issue a call to action by tech sector executive and government leaders for "coordinating, mobilizing and tracking commitments and action, around a collective mission to accelerate and realize technology's potential to tackle the Global Goals" and to organize vital pathways that also help different stakeholders recognize the respective and complementary roles that each needs to play to change business as usual (WEF 2020, p. 36).

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

3.4. What Donor Country and Pilot Country Governments Can Do

Donor Country Governments

As governments are the key audience for this report, this section focuses on what they can do. Donor country governments, including not just those from developed countries, but also developing country governments that have strong STI capabilities and development assistance programs, can undertake various initiatives to improve the use of STI in developing countries to help them reach the SDG goals.[50]

These include three areas:

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

Improve the coherence and effectiveness of the STI components of ODA 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 on international STI collaboration) suggests that it may amount to 10%. These ODA-for-STI programs 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.[51]

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[52]. More systematic efforts are needed for donors to understand what different ministries and agencies are already doing in this area. There are different country models of STI related ODA assistance. 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 should 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 in developing countries. In addition, donor countries may find it useful to undertake public expenditure reviews of the efficiency and effectiveness of the STI components in their ODA.[53]

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

[51] More analysis of the coherence of action is needed across countries to overcome barriers.

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

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

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

Leverage the Country' Broader STI Supply to Build and Boost STI in Developing Countries

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

To develop more effective assistance and leverage STI inputs to accelerate 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.

As previously noted, the private sector is the main agent in the generation and global dissemination of technology and innovation. While it is primarily motivated by its own profit-making interests, it does undertake STI activities that can be relevant to help achieve SDG goals such as more energy efficient and alternative energy technologies, lower cost health services, cures for diseases, lower cost sustainable shelters, etc. when it find profitable opportunities. Moreover, it responds to regulations and incentives and other instruments that government has to influence its activities. Therefore, there is scope to try to influence private sector contributions to STI for SDG goals such as carbon pricing on fossil fuels, regulations on emissions and other environmental "bads".

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

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.

Leveraging activities being done by other agents or institutions in the country 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. It also includes non-financial levers, such as by providing leadership and coordination of activities in the country supporting greater STI inputs to help developing countries reach the SDG goals.

Stakeholder consultations should be held 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 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 (such as through 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 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.

Broker international coalitions of STI actors to take on Grand Challenges

Beyond what donor governments can do to coordinate their own country's STI supply to developing countries, they should also consider creating international coalitions of STI actors to address grand challenges. As has been clearly articulated in the GSDG 2019, there is an urgent need for more concerted scientific effort to address the synergies and particularly the trade-offs among SDGs, as well as some of the global trends that may negatively impact the achievement of the goals such as climate change, and increasing inequality, and environmental degradation. Many of these global challenges are beyond the capability of any one country to address. They require large scale efforts by many countries and multiple stakeholders working individually and collaboratively toward shared goals. Examples of some area requiring this type of global effort include the transition to sustainable development, eradication of some endemic diseases, solving the challenges of the energy/water/food nexus, particularly in poor countries, etc.

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

Main lessons for brokering 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 technology to the design of the ecosystem that is necessary to deliver benefits to the ultimate user

Brokering coalitions of interested stakeholders requires:

- 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, 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

Main lessons for brokering successful international coalitions to undertake collaborative programs for technology global public goods are the following:

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- 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 technology to the design of ecosystem that is necessary to deliver benefits to the ultimate user

A promising example of this kind of effort is a global coalition to bring some of the benefits of the digital revolution to Africa which is called the Digital Economy for Africa (summarized in Box 3.1). While it only addresses some of what is needed to help Africa take advantage of the digital revolution, it is noteworthy for its ambition (and "$25b + $25b" financial commitments) to provide some of the key elements including: digital infrastructure, digital skills, digital platform, digital financial services, and digital entrepreneurship. It involves the collaboration of a supra regional organizations, multiple governments, various UN agencies and multilateral development banks, private companies, and multiple philanthropic agencies.

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

What Receiving Country Governments Need to Do

The discussion in this chapter has shown the great need as well as the tremendous potential for the international community to do more to leverage STI to accelerate the achievement of the SDGs, and especially to help developing countries. As emphasized, a great challenge is the weak STI capacity in developing countries. But the challenge is not just the weak human and physical infrastructure and limited resources. As noted in the last section of Chapter 2, it also involves the mindset and the policy and regulatory frameworks in developing countries. Some of the key elements of this are:

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

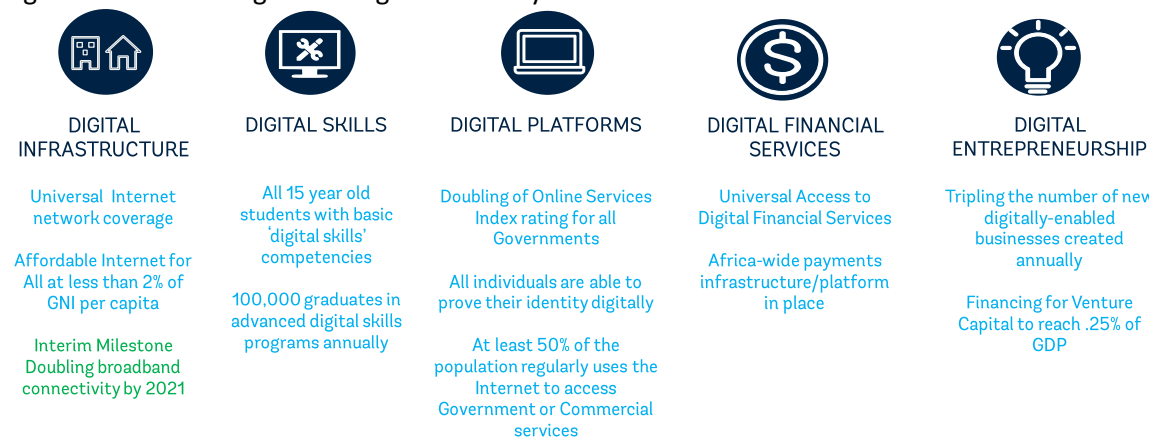
Box 3.1: African Digital Transformation Strategy

Digital innovation is creating unprecedented opportunities for Africa to grow its economy, create jobs, and transform people's lives. With the aim of ensuring that every African individual, business and government is digitally enabled by 2030, the African Union, with the support of the World Bank Group and many partners, has embarked on an ambitious journey— Digital Economy for Africa (DE4A) 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 an 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



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 and Next Steps

4.1. Key Messages

This guidebook introduced a step by step approach for policymakers to develop and implement national STI for SDGs roadmaps, and to participate in and benefit from international partnerships to harness STI 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 STI, the underlying analysis has necessarily been very preliminary. However, it has attempted to outline what is possible and the kinds of thinking, strategizing and planning that 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 and to exploit this potential are 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 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 old and emerging challenges.

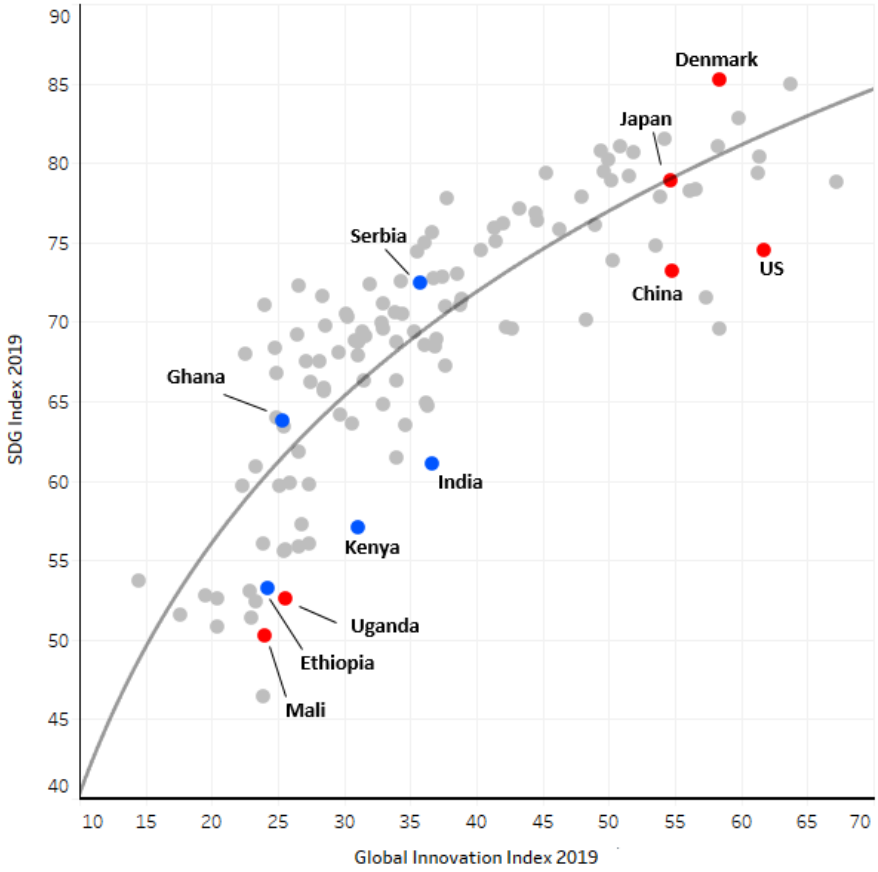
UN System through TFM will stand ready to work with Member States to cultivate communities of practitioners and partners to foster a learning environment to test and improve the approaches as proposed in this guidebook, apply the methodologies to country specific STI for SDG roadmaps, learn from the experiences to further refine the guidebook and potentially initiate or stimulate fit-for-purpose international partnerships.

4.2. Global Pilot Program on STI for SDGs Roadmaps

As an initial step to pursue the above objectives, IATT launched, during the UN High Level Political Forum in July 2019, the Global Pilot Program on Science, Technology and Innovation for SDGs Roadmaps with a group of five pilot countries. Under the program's first phase, IATT will support design and implementation of roadmaps in Ethiopia, Ghana, India, Kenya and Serbia. In addition, the European Union and Japan have joined the Global Pilot Program to strengthen international partnerships on STI for SDGs roadmaps. The results will be presented at the Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs to be held in New York in 2021.

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

Figure 4.1. Five Pilot Countries in terms of the SDG Index vs. Global Innovation Index



Source: Compiled based on indices in Sustainable Development Report 2019, Global Innovation Index 2019.

Table 4.1 characterizes the state of the STI for SDG roadmaps in the five pilot countries[55] at their initial stages. While the countries vary significantly in terms of preparation status as well as the analytical, consultative and planning activities already undertaken, early lessons and opportunities for peer-learning are as follows.

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

Policy planning cycles. Countries have different planning cycles (either on national development, STI or SDGs), indicating varying extents with which underlying policy frameworks are fully established, up to date to serve as an anchor in piloting roadmaps (and for roadmaps to be grounded in a robust administrative momentum that survives political cycles which may face shorter time periods). Alternatively, in some countries, STI for SDGs roadmaps, depending on their scope and ownership, can be useful inputs to the next cycle of broader policy planning.

[55] Country-specific contexts, progress and considerations for successful outcomes are being documented in a Background Paper on Pilot Country Case Studies (forthcoming).

Scope and approaches. Given the diversity of underlying SDGs gaps, STI capabilities and national development priorities, the scope and contents of STI for SDGs roadmaps also vary. There is a tension between depth of "deep-dives" and breadth of a systemic approach (i.e. addressing trade-offs, harnessing co-benefits, turning vicious- into virtuous cycles), as evident in the case of Kenya. While IATT does not intend a "cookie cutter solution," UN and other supporting partners should be in a position to supplement pilot counterparts, oftentimes facing capacity and bandwidth constraints, eventually to report back on harmonized methodologies with lessons and good practices.

STI-Digital integration or complementarity. Conceptually, there is no doubt that "science, technology and innovation" and "digital economy / digital transformation" have large overlaps (in policy issues and relevant stakeholder groups), and both require coherent and effective policy responses in maximizing opportunities and mitigating risks in achieving the SDGs. Practically, though these two agendas tend to fall under separate agencies (e.g. S&T ministry and ICT ministry) as well as departments in international organizations (e.g. AU, EU, WB, UN). This relates to the institutional arrangement and scope/approach (either as a result or cause). It would be a missed opportunity if the roadmap falls in a silo either on the pilot country or supporting partner sides.

International dimension. Pilot plans also vary in terms of addressing subnational, national and international levels of roadmaps, from solely domestic/national focus to willingness to internationally contribute, most represented by India. Plans by international partners (Japan, EU) to support roadmap pilots are at nascent stages, with emerging promising initiatives broader multi-stakeholder cooperation (e.g. Japan-India-Africa trilateral cooperation among policy think tanks; private participation spearheaded by Toyota-Kenya agreement; active discussions on contributions by academies of sciences in pilot countries and partners). To produce greater collective impact, IATT and other partners may be in a position to proactively engage pilot counterparts to raise the level of ambition and identify opportunities to produce positive international spillovers.

Methodological harmonization or synergies. Combinations of IATT or other partners vary significantly across pilots. Pilot countries are in the driver's seat in identifying national demands for assistance from various development partners and coordinating accordingly – while the pilot program intends to demonstrate UN System-wide approach and will eventually need to claim additionality compared to individual agencies' business as usual in the areas of STI.

Early pilot experiences are also informative on adaptation of the step-by-step guidance:

- Step 1: Defining objectives and scope takes time – 6 months to reach consensus in Kenya even with the clarity of its "Big Four" agenda.
- Step 2: Assessing current situation, both on SDGs demands/gaps and STI supply/capabilities, require competent agencies (few countries would have an agency that can conduct both). Assessing emerging trends is likely a challenge and international partners could consider how best to support this analysis in real time given the fast-changing global environment
- Step 3: Developing a vision, goals and targets varies widely across the pilot countries because of their different institutional set ups through which countries have engaged in the pilot exercise. All have chosen a narrow set of SDG goals because of the difficulty of tackling all the SDGs simultaneously. Most have started with a focus on agriculture and STI related goals without much analysis of potential synergies and trade-offs among different goals. As they further develop their roadmaps and gain experience in implementation, they may take on addition goals. Here more country specific advice from the international community on trade-offs and complementarities beyond the six transformations provided by TWI2050 and the GSDR2019 would be useful.
- Step 4: Assessing alternative pathways is arguably most complex and expensive step, requiring stakeholders representing different stages in innovation chain (e.g. new R&D vs diffusion and

adaptation). Scarcity of foresight analyses adequate to developing country contexts adds to this challenge. This is another area where assistance from international partners could be beneficial.

- Step 5: The pilots have not yet fully developed the details of their roadmaps and are at different stages of their development. Important elements that most pilot countries still have to address are how the actions of the different parts of government as well as those of other key actors will be coordinated. Another critical element is the financing arrangements for the plans. Here there is an important opportunity to for the international community to provide financial as well as implementation assistance.
- Step 6: None of the ongoing pilots seem to have put monitoring and evaluation systems in place or considered learning and feedback mechanisms as an explicit component of the STI for SDG roadmaps (arguably, with an exception of India). As noted in the guidebook, this is a critical step because the implementation of the roadmaps is essentially a learning exercise where it will be important to monitor and evaluate what is being done in order to make adjustments and corrections as they are implemented.

IATT expects interim updates from a few pilot countries at the STI Forum 2020, and full results of the first phase of the program in the STI Forum 2021. To support individual country pilots, analyse and cross-fertilize emerging experiences and lessons, as well as stimulating and galvanizing international support, IATT will continue to work with current and prospective partners to make achieve the intended results through the pilot program.

Table 4.1: Five Countries Participating in the Global Pilot Program for STI for SDGs Roadmaps

		Kenya	Ghana	Ethiopia	India	Serbia
Team structure		- Treasury, Dept of Planning - NACOSTI, ACTS - Line ministries (Edu S&T, Foreign, ICT, Agri, Industry)	- Min of Env & STI - CSIR-STEPRI	- Min of Inno & Technology	- PSA Office - Niti Aayog, Min of ext. affairs, RIS - National Coordination Committee	- - Min of Edu, S&T; Ministry of Economy, Public Policy Secretariat; National Statistics office, National Patent Office; National Analytics team
Underlying policy frameworks		- Kenya Vision 2030 - MTP III 2018-22, Big Four - STI Policy, Research Priorities - Digital Economy Blueprint	- Agenda for Jobs 2017-2021 - CPESDP 2017-24 - National STI Policy 2017	- GTP III 2015-20 - STI Policy 2012	- Strategy for New India@75 - STI Policy 2013	- EU Accession Process and Smart Specialization - New STI and industrial policy under Prime Minister
Scope and objectives of roadmap		- Big Four (agri, health, manufacturing, housing) - Agro-processing and ICT as an initial focus	(tbd)	SDG 8 (Job creation)	- Agri, energy, water, health; align with key initiatives (e.g. Doubling Farmers Income, JAM Trinity) - Strong international focus – Africa and Far East	- defined smart specialization priority domains and horizontal actions - creative industries; food for the future; machines and production processes of the future; ICT
Approach to pilot		- Sectoral deep-dive, target-driven (100% food and nutrition security by 2022) - R&D & adoption/diffusion - Aiming for an East Africa regional model	- Build on technology incubation centers - Aim for investment proposals and institutional strengthening	- Sectoral: build on 24 technology roadmaps	- International national and subnational levels (Lighthouse India, cooperative federalism) - Data/Dashboard to be substantiated through STI-PER inputs	- work at national level, with the subnational and international dimension - mix of deep dives and horizontal activities
Key milestones			(tbd)		- First 6 months (in India) - End 1st year (AfDB AMs?) - End 2nd year (in NY)	- adoption of S3 draft (December 2019)
Partners	IATT focal	- WB (STI PER) - UNESCO (Saga, Go-SPIN)	- UNESCO - WB	- UNCTAD (STIP Review) - WB, UNESCO	- WB (STI PER) - ESCAP	- UNIDO - UNESCO
	UN, Others	- Priv. partnership (Toyota)	- OECD	- UNDP, UNIDO	- OECD - UNDP	- EU/JRC (RIS3)
		Possible EU/ACP, AUC, RECs, Japan-India-Africa cooperation				

* Key abbreviations: [Kenya] National Commission on Science, Technology and Innovation; African Center for Technology Studies; Mid Term Plan III. [Ghana] Council for Scientific and Industrial Research – Science and Technology Policy Research Institute; Coordinated Programme of Economic and Social Development Policies. [Ethiopia] Growth and Transformation Plan III. [India] National Institution for Transforming India; Research and Information System for Developing Countries; electronic National Agricultural Marketing; Mission Indradhanush; Swachh Bharat Mission Gramin; National Innovation Foundation. [Serbia] Research and Innovation Strategies for Smart Specialization.

4.3. Moving Forward

In response to strong interest expressed by countries participating in the deliberations so far, UN IATT[56] together with its partners is committed to pilot and scale adoption of country level roadmaps, codify and disseminate lessons learnt, and strengthen international cooperation accordingly. Upon further consultations and analysis, the next phase of the inter-sessional work program on STI for SDGs Roadmaps can include the following components:

- **Intensify joint support to pilots**: IATT agencies to strive to secure additional resources, onboard UN country teams, engage new UN and other interested partners and stakeholders, and align to countries' aspirations and constraints according to the respective pilot plans.
- **Foster learning environment**: orchestrate multi-tier engagements for experience sharing, such as through regional tracks led by UN regional commissions and/or other regional bodies (e.g. ASEAN, AUC, EU) and participated by current and prospective pilot countries. Cultivate communities of practitioners and networks of knowledge career (e.g. policy think tanks in pilot countries) to codify and disseminate emerging lessons. Address evidence and data gaps to support development of monitoring and evaluation systems.
- **Initiate or stimulate international STI partnerships**: use pilots as tangible entry points to galvanize multi-stakeholder forums to match collective actions to address identified common challenges, and develop pipeline/portfolio of partnerships with private sector, donor countries, STI stakeholders.
- **Mainstream STI in broader SDGs work**: apply the six entry points in Global Sustainable Development Report (GSDR) – 1) human well-being and capabilities, 2) sustainable and just economies, 3) food systems and nutrition patterns, 4) energy decarbonization and universal access, 5) urban and peri-urban development, and 6) global environmental commons – for STI for SDGs roadmaps in existing or new pilot countries, if countries desire.
- **Solidify multi-year program of work**: define intermediate and final outcomes to be demonstrated by 2020 and 2021 STI Forums, and align with pilot counterparts to work backwards and use milestone events to pace and accelerate the roadmap exercise. Plan for the second phase pilot cohort, toward an appropriate timing when useful lessons will be generated from the first phase, while the current momentum can be sustained (and 20+ interested countries remain interested). Define longer term objectives such as addressing current fragmentation of international support activities by using critical mass demands through roadmaps and convening donors and research funders.
- **Mobilize resources**: build the case for multilateral pooled resource to support both individual pilot support and collective program delivery/expansion, and align with interested and willing donors[57].

TFM started as IATT member agencies' voluntary efforts without additional resources, and its work on STI for SDGs roadmaps has evolved as one of most tangible deliverables over the last 2 years, through the hard work by piloting and other interested countries, technical and intellectual contributions by institutional partners and participants of the series of Expert Group Meetings, and seed funding contribution and championship by Japan, among others. Co-leads of the IATT sub-working group on STI roadmaps, namely the World Bank, DESA, UNCTAD and UNESCO, welcomes interested partners and countries to join forces to further promote this promising work.

[56] For more details about IATT, See: https://sustainabledevelopment.un.org/tfm#un

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

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), acknowledged that multi-stakeholder engagement is essential in unleashing the potential for STI and reached consensus on 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) deliberated on a plan for action towards SDGs through digitalization, 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) 7 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 Communique 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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Annex 1 STI as Explicit in Agenda 2030 Languages

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

9	9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of **clean and environmentally sound technologies and industrial processes**, with all countries taking action in accordance with their respective capabilities	Outcome: Tech
	9.5	Enhance **scientific research, upgrade the technological capabilities of industrial sectors** in all countries, in particular developing countries, including, by 2030, **encouraging innovation** and substantially **increasing the number of research and development workers per 1 million people** and **public and private research and development spending**	Outcome: Inno
	9.a	Facilitate **sustainable and resilient infrastructure development** in developing countries through enhanced **financial, technological and technical support** to African countries, least developed countries, landlocked developing countries and small island developing States	MoI: Tech
	9.b	Support **domestic technology development, research and innovation in developing countries**, including by **ensuring a conducive policy environment** for, inter alia, industrial diversification and value addition to commodities	MoI: Inno
	9.c	Significantly increase **access to information and communications technology** and strive to provide universal and affordable access to the Internet in least developed countries by 2020	MoI: Tech
12	12.a	Support developing countries to strengthen their **scientific and technological capacity** to move towards more sustainable patterns of consumption and production	MoI: Sci/Tech
14	14.3	Minimize and address the impacts of **ocean acidification**, including through **enhanced scientific cooperation** at all levels	Outcome: sci
	14.4	By 2020, effectively **regulate harvesting and end overfishing**, illegal, unreported and unregulated fishing and destructive fishing practices and implement **science-based management plans**, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	Outcome: sci
	14.5	By 2020, **conserve at least 10 per cent of coastal and marine areas**, consistent with national and international law and based on the **best available scientific information**	Outcome: sci
	14.a	**Increase scientific knowledge, develop research capacity and transfer marine technology**, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	MoI: sci/tech
17	17.6	Enhance **North-South, South-South and triangular regional and international cooperation** on and access to **science, technology and innovation** and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a **global technology facilitation mechanism**	MoI
	17.7	Promote the **development, transfer, dissemination and diffusion of environmentally sound technologies** to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	MoI
	17.8	Fully **operationalize the technology bank and science, technology and innovation capacity-building mechanism** for least developed countries by 2017 and **enhance the use of enabling technology, in particular information and communications technology**	MoI
	17.16	Enhance **the Global Partnership for Sustainable Development**, complemented by multi-stakeholder partnerships that **mobilize and share knowledge, expertise, technology and financial resources**, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	MoI

STI commitments in Addis Ababa Action Agenda (AAAA)

National STI Policy Framework

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

Scientific Research and Education

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

Industry and Innovation Systems

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

Technologies Supporting Specific Development Outcomes

- *promote the development and use of **information and communications technology infrastructure**, as well as capacity-building, particularly in LDCS, LLDCs and SIDs, including rapid **universal and affordable access** to the Internet (**§114)***
- *encourage the development, dissemination and diffusion as well as transfer of **environmentally sound technologies (§120)***
- *support developing countries to strengthen their scientific, technological and innovative capacity to move towards more **sustainable patterns of consumption and production** through science and technology (**§120)***
- *increase scientific knowledge, develop research capacity and transfer **marine technology** (…) in order to improve **ocean health** and to enhance the contribution of **marine biodiversity (§121)***
- *step up international cooperation and collaboration in science, research, technology and innovation, including through public-private and multi stakeholder partnerships, and on the basis of common interest and mutual benefit, focusing on the needs of developing countries and the achievement of the sustainable development goals (**§** 120) [such as, amongst others, research and development of **vaccines and medicines**, including relevant initiatives like GAVI (**§121)**; preventive measures and treatments for the **communicable and non-communicable diseases (§121)**; **earth observation (§121)**; **rural infrastructure (§121)**; **agricultural research and extension services and technology development (§121)**; increase scientific knowledge, develop research capacities and transfer **marine technology (§121)**]*
- *further facilitate accessible technology for **persons with disabilities** and to promote access to technology and science for **women**, **youth** and **children (§114)***

Supportive international arrangements

- *enhance international cooperation in these areas, including **ODA**, in particular to **LDCs, LLDCs, SIDS and countries in Africa** and **e**ncourages other forms of international cooperation in these areas, including **South-South cooperation (§120)***
- *recognizes the importance of adequate, balanced and effective protection of **intellectual property rights** in both developed and developing countries in line with **nationally defined priorities** and in full respect of **WTO rules (§116)***
- *strengthen **coherence and synergies** among science and technology initiatives within the UN system (**§122)***
- *established a **technology facilitation mechanism** to support the SDGs (**§123)***
- *operationalize the **Technology Bank for Least Developed Countries** by 2017 (**§124)***

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