Science, Technology and Innovation (STI) for Sustainable Development Goals (SDGs) Roadmaps for India

RIS
Research and Information System for Developing Countries
विकासशील देशों की अनुसंधान एवं सूचना प्रणाली

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“I also hope that the Technology Facilitation Mechanism will turn technology and innovation into an effective instrument for global public good, not just private returns.”

Statement by Honb’le Prime Minister Shri Narendra Modi,
at the United Nations Summit for the Adoption of the
Post-2015 Development Agenda on
September 25, 2015

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Acknowledgements

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Preface

Professor Sachin Chaturvedi
Director General, RIS

At RIS we have been extensively engaged in research and policy contributions over the years in the domain of science, technology and innovation (STI) policy and its connect with development. RIS has been deeply engaged in areas like innovation systems, industrial policies, socio-economic assessments of emerging technologies, intellectual property rights among others. In the context of the 2030 Agenda for Sustainable Development, and the SDGs, RIS made seminal contributions to the understanding of the global Technology Facilitation Mechanism (TFM) and eventually made a policy proposal on STI for SDGs at the Think20 forum during the Japanese Presidency of the G20 in 2019.

This idea was finally adopted by G20 Leaders through their support for the draft UN "Guiding Principles for the Development of STI for SDGs Roadmaps" as part of the G20 Summit declaration in 2019.

The Global Pilot Programme on Science, Technology and Innovation for Sustainable Development Goals (STI for SDGs) Roadmaps of the UN was launched in 2019 to enhance global cooperation towards a Technology Facilitation Mechanism (TFM), as envisioned in the Agenda 2030. India has been a leader in the negotiations that led to the launch of the TFM under the 2030 Agenda for Sustainable Development. Under the guidance of the Prime Minister, India joined this major initiative as a pilot country to formulate national STI for SDGs Roadmaps.

It was indeed a great opportunity that Mr Hemang Jani, Secretary, Capacity Building Commission, Government of India (formerly at the World Bank); and Mr Naoto Kanehira, Senior Strategy and Operations Officer, World Bank were instrumental in initiating the dialogue with the Office of the Principal Scientific Advisor to the Government of India and RIS for developing India's STI for SDGs Roadmaps and also connecting us with the Cabinet Office, Government of Japan.

We are immensely grateful to Professor K. VijayRaghavan, former Principal Scientific Adviser for articulating India's leadership in taking this initiative forward and capturing the priorities in terms of India's efforts focused on four specific SDGs, namely Goal-2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture); Goal-3 (Ensure healthy lives and promote well-being for all at all ages); Goal-6 (Ensure availability and sustainable management of water and sanitation for all); Goal-7 (Ensure access to affordable, reliable, sustainable, and modern energy for all) and the co-benefits thereof. In this endeavour, we received invaluable insights from Dr Rajiv Kumar, former Vice Chairman, NITI Aayog. With his guidance we could introduce India's Flagship schemes as a key pillar of STI for SDGs in India. Dr Wei Liu, Coordinator, UN Inter-agency Task Team on Science, Technology and Innovation for the SDGs (IATT), UNDESA has been a great support in building bridges with the TFM and the STI Forum of the UN. It is a matter of great satisfaction that the institutional partnerships leading to India's national STI for SDGs Roadmaps have flourished and deepened.

We are deeply indebted to Hon'ble Principal Scientific Adviser Professor Ajay Kumar Sood for his invaluable guidance and to Scientific Secretary Dr Parvinder Maini for her kind support. We also acknowledge the support received from Dr Preeti Banzal, Adviser, O/o PSA in administration of the project.

We are pleased to present this report on STI for SDGs roadmaps for India. We believe the recommendations would be useful in placing India's STI efforts in sync with its development priorities. This would also support India's South-South and Triangular cooperation initiatives and operationalizing a global Technology Facilitation Mechanism.

Sachin Chaturvedi


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1 Integrated Ecosystem to Address Paradigm Shifts – A Framework towards STI for SDGs Roadmaps for India

1.1 Introduction

In September 2015, member states of the United Nations adopted the 2030 Agenda for Sustainable Development covering 17 Sustainable Development Goals (SDGs). The agenda was meant to be realized through significant scaling up of global cooperation, simultaneously with localisation and convergence in the domestic policy making for last mile delivery. The positioning of Science, Technology, and Innovation (STI) as a means to achieve progress on SDGs has triggered significant efforts to roadmap STI pathways and to foster rapid adoption of technological solutions. Platforms such as the Technology Facilitation Mechanism (TFM), which was established in 2015 alongside the Agenda 2030 to strengthen synergies and cooperation within the science and technology initiatives among UN agencies to achieve the SDGs, will play an important role in fostering cooperative efforts in STI for SDGs.

India has demonstrated a strong commitment to utilise Science, Technology, and Innovation (STI) for sustainable and equitable development, and has played a vital role in securing international support for STI for SDGs at the G20. The country has witnessed significant improvements in various indicators over the past few years. As part of India's commitment to achieve the Sustainable Development Goals, India is very keen to develop a framework to capture SDGs as outcomes of Science, Technology and Innovation (STI) interventions. In this direction, the Government of India launched a major initiative to formulate STI roadmaps for SDGs being led by the Office of Principal

India is one of the six pilot countries of the Global Pilot Programme for STI for SDGs Roadmaps of the UN, an initiative under the Technology Facilitation Mechanism (TFM) launched as part of the Agenda 2030 for implementation of the SDGs. India's strong innovation capabilities, wider expertise in people-centric affordable technology solutions and more recent ICT enabled development transformations offer robust foundations towards undertaking this exercise.

Scientific Adviser to the Government of India (OPSA). In this regard, India is also one of the six pilot countries of the Global Pilot Programme for STI for SDGs Roadmaps of the UN, an initiative under the Technology Facilitation Mechanism (TFM) launched as part of the Agenda 2030 for implementation of the SDGs. India's strong innovation capabilities, wider expertise in people-centric affordable technology solutions and more recent ICT enabled development of safe and secure transformations in many sectors and offer robust foundations towards undertaking this exercise.

The UN Interagency Task Team on STI for SDGs (UN-IATT) supports the process on Global Pilot Program on STI for SDGs Roadmaps. Five Pilot countries were part of the initial rollout namely; Ethiopia, Ghana, Kenya, Serbia, and India followed by Ukraine which joined the initiative in 2021. Japan and the European Union have also joined this initiative to support the pilot countries' SDG Roadmapping endeavors. The UN-IATT members, such as UN-DESA, UNIDO, UNESCO, the World Bank, etc., are among the other participants in this exercise. Given that the majority of six pilot countries are low- or lower-middle-income countries, they have chosen a few interrelated set of SDGs for targeted intervention and better monitoring. SDGs 1, 2, 3 and 4 are the commonly chosen SDGs to leverage the STI interventions in a coordinated and targeted manner. The Global Pilot Program for STI for SDGs Roadmaps is poised to evolve into a very useful tool to strengthen national efforts on STI for SDGs roadmapping. Additionally, it encourages global collaboration in knowledge, technology transfer, networks, and financing for TFM operationalization.

Being one of the six participating countries in the

Global Pilot programme, India's efforts are focused on formulating STI for SDGs roadmaps on four specific SDGs, namely Goal-2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture); Goal-3 (Ensure healthy lives and promote well-being for all at all ages); Goal-6 (Ensure availability and sustainable management of water and sanitation for all); and Goal-7 (Ensure access to affordable, reliable, sustainable, and modern energy for all). These four goals offer significant opportunities for achieving the SDGs in the country, given the deep inter-linkages along with all the other goals of the SDGs. STI applications are at the core of strategies towards the four goals with intrinsic criteria of access, equity, inclusion (AEI) and sustainability. India has a long history of sharing technology, expertise, and capacities with developing countries, as well as making major contributions to other countries' capacity-building efforts. Roadmaps for STI for SDGs are likely to develop as effective policy instruments for mainstreaming STI in SDG initiatives, promoting localisation, and incorporating Access, Equity, and Inclusion (AEI) into STI applications. Similarly, in the domestic context the innovations and technological deployment at scale for achieving developmental targets – particularly related to agriculture, health, water and sanitation and energy- has been majorly administered by the line ministries and associated agencies. The scale effect, externalities and self-sustaining nature of such efforts need to be illustrated.

India's STI pathways are being shaped by its development needs more than ever.

India's STI pathways are being shaped by its development needs more than ever. India's trajectory towards achieving the SDGs has been facilitated through several development initiatives built on the multi-tier institutional structures that provide not only the basic necessities like food, health, education and sanitation but also to bring a substantial change in the living standard of the people particularly those at the bottom of the pyramid. India's own National Development agenda mirrors the SDGs comprehensively. The government has launched many flagship initiatives which are aligned with the SDGs. Initiatives like Ayushman Bharat, One Nation One Ration Card (ONORC), POSHAN Abhiyaan , Ujjawala among others have been launched to address the issue of hunger, health and wellbeing. Within the energy domain, the government has started the National Solar Mission, PM-KUSUM, Grid Connected Solar Rooftop Programme and Technology Mission Programme on Clean Energy.

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Initiatives such as JAM Trinity/MUDRA have contributed immensely in increasing the financial inclusion among the marginalized and underprivileged sections of the society. In the area of clean water and sanitation Government has launched Swachh Bhart Mission, Jal Jeevan Mission and Namami Gange Programme. These schemes and mission mode projects have provided a giant leap forward in addressing the issues of clean drinking water, waste management, water conservation and recycling.

In India's developmental landscape the inter-linkages of initiatives have resulted not only in realising the programme and corresponding SDG targets but has also brought in the supportive benefits with linkages to other SDGs as well. For example, there has been a concerted effort to fast track the implementation of complementary programmes and interventions in promoting sustainable agriculture through various policy initiatives like Soil Health Card, PM Krishi Sinchayee Yojana, e-NAM and high yielding seed varieties among others. Such interventions apart from promoting sustainable agriculture provide livelihood protection and food security as well. It facilitates framing well defined strategies on nutritional security across the country (SDG 2). Nutrition has also been identified as the foundation to health and well-being even as the country's effort towards primary healthcare and universal health coverage has seen a strong push to achieve durable improvement in health indicators among the population at large (SDG 3). Wellbeing and wellness depends to a large extent on sectors like water and sanitation (WASH). The issue of accessibility and affordability of clean water and proper sanitation (SDG 6) has been backed up by immense political will and action by the Government of India in the recent years as part of Jal Jeevan Mission, Swachh Bharat Mission etc with necessary financial allocation. These efforts also

galvanized into people's movement with very impressive outcomes in terms of meeting comprehensive targets of open defecation free villages and providing functional household tap water connection etc. within a short time span. Similarly the challenges of clean cooking fuel and affordable energy (SDG 7) have been addressed through initiatives like free LPG distribution/ connection scheme – Pradhan Mantri Ujjwala Yojana (PMUY) – and subsidized LED bulb distribution under Ujala Yojana. Such initiatives apart from achieving their desired outcomes have also addressed the issues of health and wellbeing (SDG 3) particularly among women who were earlier using wood or coal as cooking fuel. Emphasis is given on providing user-friendly platforms for evidence to policy translation and strengthening programme implementation.

In recent years India's technology deepening and diffusion has been accelerated through new partnerships with private sector including the thriving start-up ecosystem

1.2 STI Ecosystem: Leveraging New Partnerships

In recent years India's technology deepening and diffusion has been accelerated through new partnerships with private sector including the thriving start-up ecosystem. In a few areas this has been self sustained with other sectors catching up. Respective government agencies and department including the ones looking at science and technology more closely have given special attention to this aspect. The nodal agency for STI for SDGs Roadmaps for India, Office of the Principal Scientific Adviser to the Government of India has been instrumental in launching a new mission programme titled AGNIi (Accelerating Growth of New India's Innovations) to boost the innovation ecosystem in the country by connecting innovators across industries, individuals and at the grassroots to market and help commercialize innovative solutions. AGNIi provides a platform for innovators to bring their technology ready

The nodal agency for STI for SDGs Roadmaps for India, Office of the Principal Scientific Adviser to the Government of India has been instrumental in launching a new mission programme titled AGNIi (Accelerating Growth of New India's Innovations) to boost the innovation ecosystem in the country by connecting innovators across industries, individuals and the grassroots to market and help commercialize innovative solutions.

products and solutions to industry and the market, thereby helping propel techno-entrepreneurship which can usher a new era of inclusive socioeconomic growth. The mission covers the services needed to support and advance indigenous innovations that are ready for the market, throughout the entire techno-commercialization cycle. As part of the initiative, government R&D facilities and academic institutions will be partnered with to help commercialise their innovations. Additionally, existing innovation programmes will be leveraged to add value, and scientists, innovators, technology transfer offices, and technology licence offices will receive training and capacity building. The AGNIi program's main goal is to connect particular industry demands to research labs to facilitate the development of affordable, commercially viable solutions.

In order to boost synergy of the Science and Technology organizations, the OPSA has also been actively involved in the creation of Science and Technology (S&T) Clusters as official umbrella structures for S&T organisations in cities that already have a critical mass of S&T-focused organisations. A shared ecosystem—a grouping of 15–20 institutions functioning as one large institution under these S&T Clusters—is being created whilst also preserving their internal autonomy. It also ensures Long-term autonomy, financial viability, and collaboration with participating and external agencies. Similarly, The Indian Science Technology and Engineering Facilities Map (I-STEM), a joint multi-institutional programmes enables the sharing of credit courses for students across different institutions, allowing the exchange of researchers between industry and public R&D labs, are some of the important elements of this shared ecosystem.

Through the Department of Biotechnology (DBT), Department of Science and Technology (DST), Council of Scientific and Industrial Research (CSIR), and Science and Engineering Research Board (SERB), the Ministry of Science and Technology have played a crucial facilitating role towards in creating international S&T alliances in critical fields like energy, water, health, and agriculture. India has significant collaborations in new fields of science and technology, supporting R&D aimed at solving problems in the areas of energy, water, health, and agriculture. In the areas of health/medical science and food security/ agriculture science, Indian Council of Medical Research

(ICMR) and Indian Council of Agricultural Research (ICAR) are the key national agencies respectively. There are specific Programme Divisions within each Department of the Ministry of Science and Technology that support Innovations, Research, Development, and Demonstration (R, D & D) Projects, as well as Capacity Building in the highlighted areas (Ministry of Science & Technology, 2021).

To assist start-ups in offering the most effective clean energy solutions for the benefit of society, India established the Clean Energy International Incubation Center. To become a leader in highlighting the crucial role of science and technology in bringing about positive transformations of SDG targets, the Department of Science and Technology (DST) is building the national STI ecosystem (DST, 2021)). DST has funded research to evaluate state level vulnerability, health and other implications of climate change, access to clean and potable water, and agricultural technology ranging from grassroots to lab-based. Another notable example in the area of emerging technology is classification technique based on Deep Learning (DL) networks created by the department to assess hormone levels for breast cancer prognosis.

DST has rolled out several initiatives in this regard like Synergistic Training program Utilizing the Scientific and Technological Infrastructure (STUTI), Science and Engineering Research Board –Department of Science and Technology (SERB-DST) among others. To address the particular challenges in the domain of SDG 2, 3, 6 and 7 DST has funded and supported projects. DST in collaboration with its autonomous institute Maharashtra Association for the Cultivation of Science (MACS)-Agharkar Research Institute (ARI), Pune developed and supplied 162.5 and 225 quintals breeder seeds of high yielding, disease resistant, early maturing wheat and soybean to the Seed multiplying agencies seed industries, farmers and producers organizations. Cuttings and saplings of grape variety ARI 516 have been supplied to farmers (DST, 2021). Similarly in the area of Goal 3, Sree ChitraTirunal Institute for Medical Sciences & Technology (SCTIMST), established under the DST technical research Centre has developed two biomedical implant devices namely Atrial Septal Defect (ASD) Occluder and Intracranial Flow Diverter Stents in collaboration with National Aerospace Laboratories, Bangalore (CSIR-NAL) using superelastic NiTiNOL alloys. DST has assisted in the development of a novel

technology using UV-Photocatalysis for the treatment of municipal sewage and highly polluting industrial waste water, as well as the Advanced Oxidation Process (AOP) technology for zero discharge water management systems. The Department of Biotechnology is coordinating the national efforts in clean energy research, development and demonstration has established Clean Energy International Incubation Center which is a joint initiative of Tata Trusts and the Government of India supported by Department of Biotechnology, BIRAC, Tata Power and Tata Power – Delhi Distribution Limited.

Last but not the least, the role of line departments beyond the science ministries and scientific agencies has increasingly become key determinant of India's technology adoption. The Ministry of Jal Shakti in collaboration with National Remote Sensing Centre, Hyderabad has been deploying Geographic Information System (GIS), Hydro geomorphological mapping (HGM) and remote sensing technologies for groundwater use efficiency and availability. Likewise, Ministry of Health and Family Welfare along with Immunization Technical Support Unit (ITSU) and United Nation Development Programme (UNDP) has innovatively inculcated the use of ICT and IoT devices for vaccines transportation, storage and warehousing as a cost effective method. Several such initiatives have been rolled out by various ministries and their autonomous and associated bodies. Therefore, line ministries play a pivotal role towards broadening the innovation dimensions on one hand and providing necessary infrastructure for its deployment on the other hand to address the challenges towards SDGs.

1.3 STI for SDGs – Defining a New Conceptual Framework

Role of governments in creating enabling conditions supportive of innovation has been studied in detail in the inter-disciplinary literature in innovation economics and science policy. Scientific research and technology development have been carried out by both public and private institutions and enterprises. However, the role of each of these actors have undergone transformation over time with some countries having stronger institutions and robust modalities to engage in scientific research and thereafter in specific tasks of technology development. Historically, role of public funded research systems have

been critical. Fast moving technology frontiers beyond the earlier industrial revolutions have intensified the role of diverse actors without necessarily diminishing the role of public sector R&D. Developed countries have formalized some part of synergistic interactions that exist between public and private entities and have fostered other forms of exchanges. Developing countries with weaker institutions and lower performance parameters have always found it difficult to institutionalize the interactive relationships that favour knowledge collaborations among scientific agencies and firms. Widespread innovation capabilities in some of the early industrialized countries draw strength from legacy institutions of excellence and greater private sector participation. This has been captured as National Innovation Systems in a later strand of academic research.

The National Innovation System (NIS) is a group of institutions that work together to provide conditions for skill growth and knowledge creation through learning and spillovers, which often lead to new technologies and innovations. Publicly sponsored institutions for higher education and research have been at the heart of NIS in developing countries, and India is no exception. In a process of innovation that is prone to market and systematic failures, the NIS method emphasises the need of

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cross-learning, idea sourcing, and institutional interaction (OECD, 1997)

In some of the developed countries and emerging economies, geographical proximity of institutions in some cases fostered intense knowledge cooperation which led to emphasis on Regional Innovation Systems (Asheim et al., 2003, Doloreux and Parto, 2005) Emergence of highly sophisticated technology capabilities in some sectors, with or without stronger national or regional supportive mechanisms has been credited to the role of the private sector and favourable incentives and regulations. Such innovation ecosystems have been generally understood as sectoral innovation systems (Malerba, 2003, Geroski 1995, Nelson,1993). Several emerging economies have benefitted from close interactions among the latter two systems. However, with greater economic capabilities and increased spending on R&D by national governments and the private sector, the urge for new forms of the national innovation system is coming to the fore in countries like India. However, with new demands of rapid transformations towards inclusive development and sustainable transitions the three purported systems of innovation collapses in time and space towards a more integrated approach (Chaturvedi *et al*, 2023). In this section we discuss the institutional framework and policy alignment that define the three systems of innovation for illustration purposes.

1.4 Innovation System Approach and Relevance

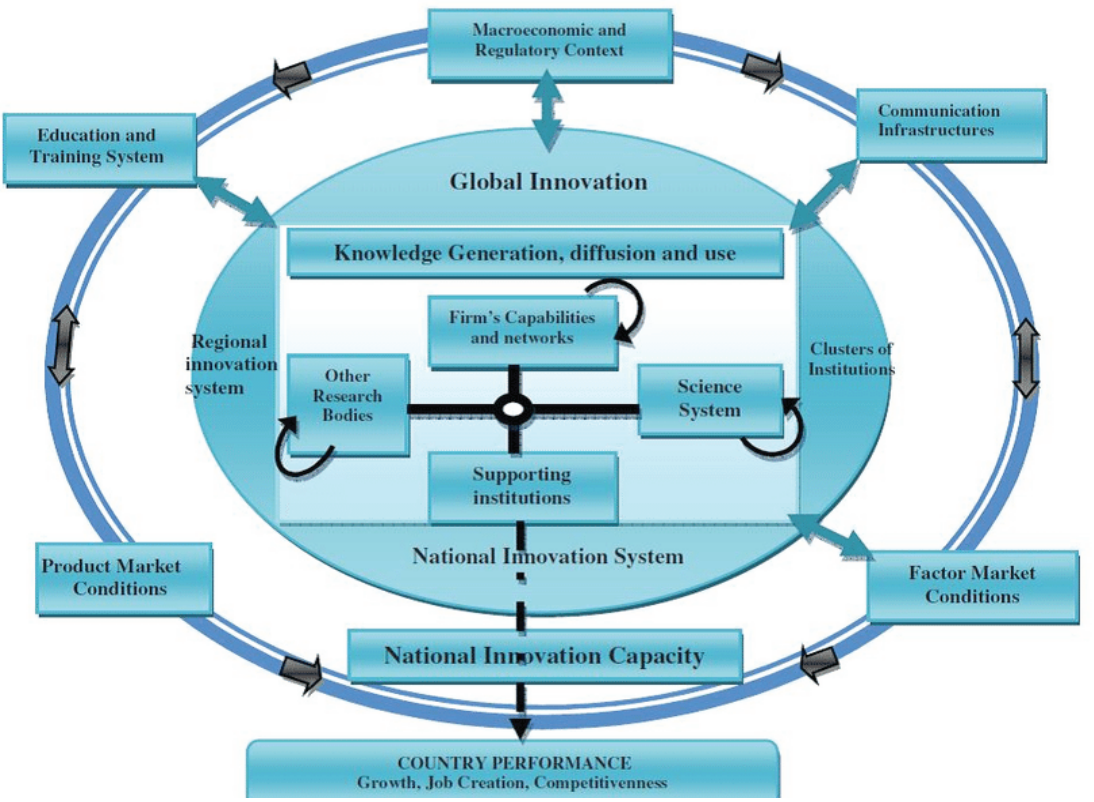
The following discussion will primarily focus on national innovation systems (NIS). It provides a systemic perspective by connecting micro behaviour to the system level in a two-way manner (Lundvall, 2011). Policies influenced by the prevalent innovation systems approaches primarily aim at optimising the institutional environment of firm-based innovation processes and do not aim to transform entire systems of production and consumption. The Innovation Systems approach was developed since the late 1980s and has been very instrumental for legitimising and designing research, technology, and innovation (RTI) policy. (Lundvall, 1992; Nelson, 1993; Edquist, 1997; OECD, 2002; Alkemade et al., 2011). Innovation System are new creations of economic significance and its various processes concerned with the emergence and diffusion of knowledge which is

characterized by complicated reaction mechanism and shared relations (Edquist, 1997).

The links between S&T policy and economics appear as an essential variable when it comes to the concept of Innovation Systems (ISs). The goal of ISs is to give a platform for the examination of market diversity and S&T players, the dynamic of institutions, and their co-evolution with organisations, starting with the most fundamental description of a system as a group of interrelated pieces constituting a complex whole (see Lundvall 1992; Freeman 1995; Nelson, 1993). For a better understanding of the ecosystem, the perspective drawn from the systems of innovation such as national innovation system, regional innovation system, sectoral and technological innovation system as well as the rise of social enterprises, can provide valuable insights.

1.4.1 National Innovation System

Figure 1.1 : Actors and linkages in the innovation system



Source: Ormala, E. (1999)

A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology' (Niosi et al., 1993). The industrial R&D is specifically concerned with product and process innovation for competitiveness. While the universities are more focused on basic research and its broadcasting the Government, however, has a specific role in planning and enforcing policies aiming to make national system of innovation progressive, dynamic and sustainable. Since the beginning of the concept in the early 1980s, the literature on national system of innovation has seen a motion (Lundvall, 2007). But still the system of innovation is labelled as a conceptual framework rather than a formal theory (Edquist, 1997). Being influenced by interactive (Lundvall, 1992) and evolutionary theories (Nelson & Winter, 1982), system of innovation is an extremely complex framework, often characterized by trade, interactivity and feedback mechanism in several loops (Edquist, 1997) also various national governments and international organizations like OECD, European Union has also adopted the system approach while framing their policy framework.

Interactive learning and evolutionary technological change theories, which stem from Schumpeterian and neo-evolutionary Schumpeterian perspectives, are given special emphasis (Nelson and Winter 1982; Freeman 1995, Lundvall 1993). These studies attach importance to institutional settings to support the innovative capacity of firms, while knowledge and interactive learning play a central role in the process of technological change. In terms of the process, National Innovation System, overcomes complexity and dynamism in the most hidden source of economic growth: Knoweldge. The term 'national system of innovation' was first used by Lundvall and the formal explicit use of the concept NIS was done by Freeman (Freeman, 1995). Studying the innovation system at the national level indicates the results of the policy initiatives undertaken at the national level. It also helps in reframing the existing policies or adopting for the new ones for a relatively better innovation system. A large body of literature, exists that studies the innovation

system at the national level (Doelalikar & Roller, 1989; Freeman, 2004; Lundvall, 1992; Nelson, 1987, Edquist & Lundvall, 1993; Nelson, 1993). The main knowledge flow in national innovation systems is the link between the private and public research sectors. (OECD 1997). The main roles in innovation processes (firms, public and private research organisations, government and other public institutions, and their interactions' forms, quality, and intensity) is pictured in the figure,, Several variables that have some degree of national specificity have an impact on these actors, including the financial system, corporate governance, legal and regulatory frameworks, level of education and talent, etc. The levels and forms of public R&D financing partially reflect the changing role of the government (Ormala, E., 1999).

Extending the analysis, Jensen et al. (2007) and Lundvall (2007) define the STI (Science Technology-Innovation) and DUI (Doing, Using, and Interacting) modes of innovation in a developing country setting, respectively. In line with the restrictive definition of innovation systems, the STI mode of innovation focuses on innovations based on research and development efforts. The DUI mode, which refers to learning on the job as employees experience constant changes, is used for a lot of learning, notably implicit and localised information. The DUI method is aligned with the broader idea of the innovation system since it focuses on interactive learning through structures and relationships.

The NSI strategy has gained traction with policymakers because it offers a more comprehensive approach with more chances for involvement than the typical market failure approach, which incorporates policy intervention. The NSI approach's more comprehensive character has two beneficial effects for policy action. Policy instruments can be justified in a larger sense by supporting university-industry collaboration. In a market failure model, this would be justified by the necessity for public investment when the market fails (e.g. universities), but in an NSI model, influencing information dissemination and enhancing company skills would be an obvious rationale. Second, unlike the market failure model, politicians cannot build policies from the top down since they are a component of a complex, interactive system. Top-down strategies have unexpected effects that must be avoided by having more contacts and exchanges that are evenly divided (Soete et al., 2010).

1.4.2 Regional Innovation System

On the other hand, a Regional System of Innovation (RSI) is typically made up of interacting private, semi private, and public organisations that operate within an institutional framework. This framework promotes the creation, utilisation, and dissemination of knowledge, thereby promoting regionally innovative activities (Asheim et.al., 2003). The RSI approach was developed primarily by economists seeking to understand the unique role of institutions and organisations in the regional attention of innovative activities (Asheim et al., 2003). At the same time, new concepts such as regional clusters, industrial districts, Technopole, learning regions, and innovative settings emerged. RSI research, according to Doloreux and Parto (2005), focuses on three main dimensions:

- Firstly, the interactions of the actors of the innovation system in terms of knowledge exchange;
- Secondly, the establishment and role of institutions supporting knowledge exchange and innovation within a region; and
- Thirdly, the role of RSI in regional innovation policy making.

The idea that there is no single optimal policy is one of the primary contributions of the RSI concept to innovation system discussions. Policy instruments must always be context relevant and tailored to the specific circumstances of each location. In the RSI setting, policy interventions are primarily focused on system failures, with the goal of facilitating the successful functioning of complex interactions among regional actors. Policies at the regional level can affect the regional set-up in a variety of ways, such as affecting all actors in a region, just corporations, or even single individuals. The steps taken can assist businesses in overcoming a skills shortage; they can enact hard institutions, such as legislation, or soft institutions, such as a willingness to take chances. They may also engage at the network level, assisting corporations in overcoming lock-in effects (e.g., if two partners have been stagnating their work to the exclusion of others) or initiating more collaborative efforts to assist companies in locating complementary knowledge sources (Asheim et.al., 2013).

1.4.3 Sectoral Innovation System

The Sectoral Innovation System has a knowledge base, technology, inputs, and a demand (potential or

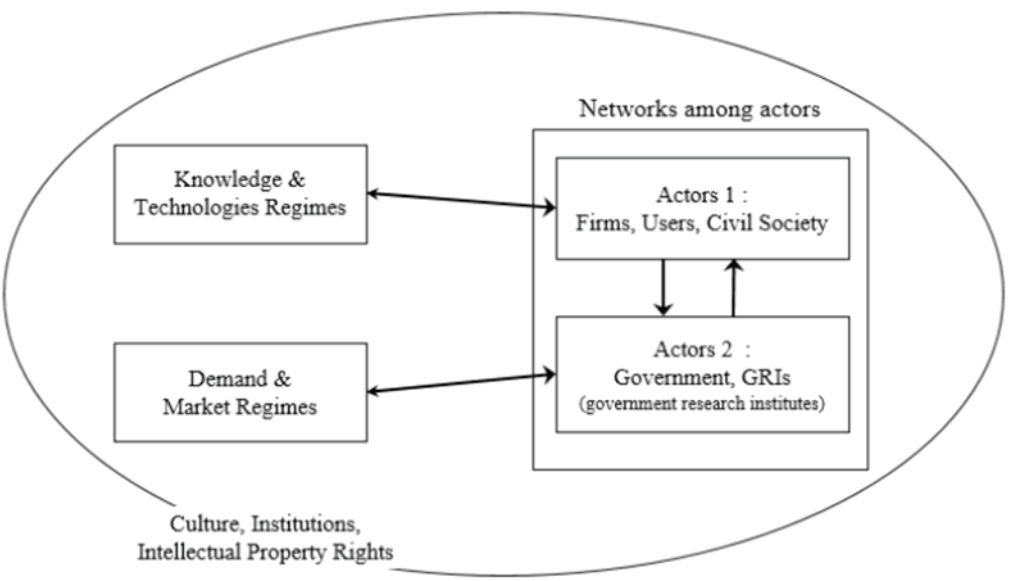
existing). Individuals and organisations at various levels of aggregation are the agents, each with their own set of learning processes, competencies, organisational structure, beliefs, aims, and behaviours. Communication, exchange, cooperation, competition, and command are all methods by which they engage, and their relationships are formed by institutions. Through the co-evolution of its numerous constituents, a sectoral system undergoes processes of change and transition. A better knowledge of the sectoral structure, boundaries, and transition, as well as the agents and their interactions, are the key benefits of a sectoral system approach (Malerba, 2003, Geroski 1995, Nelson,1993).

Sectoral systems have three broad dimensions that influence new technology generation and adoption, as well as the organisation of innovation and production at the sectoral level:

a) Knowledge (and the related boundaries): Knowledge and fundamental technologies impose significant constraints on the full range of diversity in the behaviour and organisation of firms operating in a sectoral system.

b) Actors and networks: A sector is made up of diverse agents such as organisations and individuals (e.g. consumers, entrepreneurs, scientists), firms (e.g., users, producers, and input suppliers) and non-firm organisations

Figure 1.2: Sectoral system of Innovation Framework



Source: Malerba (2003)

(e.g., universities, financial institutions, government agencies, trade unions, or technical associations) are examples of organisations, as are sub-units of larger organisations (e.g., R&D or production departments) and groups of organisations (e.g. industry associations).

c) Institutions: Institutions shape agents perception and action. These institutions include norms, practices, common habits, established practices, rules, laws, standards, and so on.

The concept of sectoral systems may prove a useful tool in various respects:

- Descriptive analysis of the differences and similarities in the structure, organisation, and boundaries of sectors;
- Complete understanding of the differences and similarities in the working, dynamics, and transformation of sectors;
- Identification of the factors influencing innovation, commercial performance, and international competitiveness of firms and countries in the various sectors; and
- Development of new public policy indicators.

The sectoral perspective provides a tool for policy makers to comprehend the differences in innovation systems and for identifying the specific actors that should be influenced by policy (Malerba, 2003, Lundvall 1993, Nelson,1993).

1.4.4 Technological Innovation System

A technological innovation system (TIS) is a particular illustration of a socio-technical system centred around a technological innovation and is described as "a

While the existing systems of innovations can generate internal momentum towards major and minor innovations to various levels of effectiveness, newer paradigms suggest far greater role for external demands, policy push in sectors beyond S&T administration, increased appreciation of the grand challenges as well as survival instincts in times of crisis. The SDGs should create the necessary external push for integrated and inclusive innovations to drive innovation efforts.

dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilisation of technology" (Carlsson and Stankiewicz, 1991). This leads to the conclusion that a TIS is made up of the following structural elements: (1) technology; (2) an actor network; (3) supporting institutions; and (4) a demand side. (Orton and Kamp 2022) (Malerba, 2002). The earlier concept of technological system, introduced and defined by Carlsson and Stankiewicz (1991, p. 111) as a network of agents interacting in a particular economic/industrial area under a specific institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilisation of technology, serves as the foundation for technological innovation system. In the early stages of new TIS, actors join and build networks, and institutional structures are created or modified (Bergek, 2019). The structural elements of a TIS—actors, networks, and institutions—form the framework for the system's expansion and further evolution through the integration of new organisations, network construction, or institutional alignment. The TIS approach connects these structural component interactions and processes to a strategy that encourages new socio-technical configurations to emerge, stabilise, or both (Bergek *et al*., 2008a, p. 408).

With a focus on national, regional, sectoral, or technological innovation systems, the IS approaches place an emphasis on the innovation-activities of firms as key actors in economic and innovation processes as well as the systemic contexts that restrict, direct, or support their innovation activities and capabilities. When used for comparison, they place a special emphasis on variations in institutions and institutional environments, which have an impact on the ability and innovation styles of businesses and other actors (Weber and Rohracher, 2012).

1.5 Conceptual Contours on STI for SDGs – Emergence of New Policy Frameworks

While the existing systems of innovations can generate internal momentum towards major and minor innovations to various levels of effectiveness, newer paradigms suggest far greater role for external demands, policy push in sectors beyond S&T administration, increased appreciation of the grand challenges as well as survival instincts in times of crisis. The SDGs should create the

necessary external push for integrated and inclusive innovations to drive innovation efforts. The pathways and sophistication in problem solving in a dynamic setting in response to external demands have given rise to multiple general frameworks depending on regional contexts. The multiplicity in approaches would accelerate adoption of emerging policy frameworks by specific constituencies. The goal of innovation policies is to give businesses access to an institutional framework that supports their capacity for innovation, fosters synergies and spillover effects, and aids in their ability to respond to changes in the techno-economic environment. Initial research focused on national innovation systems, but more recently, additional systemic contexts have drawn attention, particularly regions, industry sectors, and technical systems (OECD, 1997).

It is useful to take note of the some of the predominant framework building efforts that suggest new policy direction in innovation enterprise going beyond the traditional actors.

Smart specialisation process is one among the new policy direction in innovation enterprise. It is a distinctive method for encouraging entrepreneurial discovery and bottom-up innovation to support territorial place-based development based on particular local resources, capacities, and participation of stakeholders (Foray, 2014). By combining these top-down, aspirational agendas with bottom-up actions become a crucial component of accomplishing the SDGs (Foray, 2014). Smart Specialization Strategies for Sustainability (S4) for nations, regions, cities, and international collaborations were developed by European Commission in consultation with stakeholders and public authorities. To assist socioeconomic recovery and create sustainable, resilient, just, and inclusive growth, S4 may become a critical strategy within the EU's STI initiatives (Foray, 2014, Foray 2017, Nakicenovic et.al., 2021).

"The SDGs are regarded to be dependent on creative ecosystems and complementary assets. The government is responsible for selecting appropriate technologies, products, and services for commercialization for the benefit of citizens, and citizens are more involved in expressing their desires and regulating STI policy".

The other notable policy paradigm in new innovation enterprise is Society 5.0. In the 5th Science and Technology Basic Plan (2016-20), Japan proposed Society 5.0 as the ideal society to strive for, following the models of the hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). Society 5.0 describes the relationship between people and society as being mediated by technology, (Deguchi, 2020). Humans are at the centre of changes in Society 5.0, along with economic expansion, technical advancement, and sustainability. This concept permits the advancement of sustainable technology without impeding economic growth. This innovative societal concept and advancements are discussed, along with their impact on scenarios and educational methods. (Narvaez, 2021)

The SDGs are regarded to be dependent on creative ecosystems and complementary assets (Iizuka and Hane, 2021). The government is responsible for selecting appropriate technologies, products, and services for commercialization for the benefit of citizens, and citizens are more involved in expressing their desires and regulating STI policy. A new frame that is targeted at broader environmental and societal challenges, such as climate change, ageing societies, environment degradation, public health, energy, mobility, etc. is emerging, affecting both STI and mission-oriented policy literature (Haddad, 2022, Schot and Steinmueller, 2018). More specifically, the transformational policy agenda focuses on socio-technical changes rather than the traditional macroeconomics perspective (Steward, 2012, Haddad, 2022).

Grand challenges are increasingly being addressed in terms of innovation policy (Amanatidou et al., 2014). New opportunities for STI policy are created by challenges like those outlined in the 2015 Lund Declaration, the Paris Agreement, and the Sustainable Development Goals (SDGs) (Schot and Steinmueller, 2018). In light of this, the mission-oriented policy literature and STI are both undergoing a transition to a new frame that is focused on larger environmental and social issues, (Haddad et.al, 2022). Grand challenges are defined by multifaceted interdependencies, needing solutions that fundamentally replace unsustainable methods and go beyond technology improvements to encompass behavioural and cultural change in addition to societal change. The Transformative Innovation Policy can be applied in all policy problems,

particularly the grand societal goals or challenges (Amanatidou et al., 2014; Haddad et. al, 2022). More specifically, the transformational policy agenda focuses on socio-technical changes (Steward, 2012). The Sustainable Development Goals (SDGs) and environmental boundaries are the societal objectives or big challenges for this policy framework. For instance, it may be important to provide affordable access to sanitary facilities in a way that is both environmentally and socially responsible in order to achieve societal goals according to SDG 6. Asking how the current system functions should be the first step in addressing impacts at the system level. For instance, if the policy is connected with industrial policy and health policy, greater impacts for treating plastic waste can be achieved. The new emerging frame is claimed to deal with transformative change, which derives from the realisation that a sustainable future cannot be achieved just by extending current trajectories, but requires significant transformation in existing socio-technical systems. Although innovation systems continue to serve as a focusing device for policy formulation, complementary frameworks are becoming necessary as networks expand beyond the traditional boundaries of country and sector due to globalisation of firm activities, digital technology diffusion, and accompanying disruptive business models (Schot and Steinmeuller, 2018).

A transition is a significant shift in how societal demands are met that may take 25–50 years to complete. As transitions necessitate the creation and spread of a wide variety of new technologies as well as the creation of new institutions and social practices, innovation is a crucial activity in transitions (Geels et al., 2008). For the societal subsystems to become viable, socio-technical transformations are required (Alkemade et al., 2011). Given the significance of innovations in sustainability transitions, all innovation policy should be incorporated into transition policy to ensure that inventive activity is focused on more sustainable technologies (Foxon and Pearson, 2008). Several nations have established transition policies in an effort to direct or facilitate sustainability transitions, which is to influence the rate and direction of a socio-technical system's evolution (Alkemade, 2011). While the goal of the transition policy is to promote societal transformations, the objective of innovation policy is usually to facilitate innovation in order to promote economic growth (Alkemade et al., 2011).

As transition policy works to create new, more sustainable socio-technical systems, it also has to help phase out older, less sustainable ones in order to achieve a more sustainable society (Kern and Smith, 2008). While the idea of economic growth is not excluded in sustainable development, innovation for sustainable development places a strong emphasis on enhancing the sustainability of current production systems or on developing new production systems that address needs that were previously met in an unsustainable manner (Jacobsson et al. 2004; Geels 2005; Hekkert et al. 2007). Sustainability issues are viewed by socio-technical transitions as a significant societal challenge that is on par with the several social problems in the modern era (Geels 2006). Similarly dealing with environmental problems requires shifts to new transport systems, energy systems, food systems, etc. Such transformations involve not only new technologies but also modifications to markets, user behaviours, policy and cultural discourses, as well as governing structures (Geels et.al., 2008, Geels and Schot 2007, DiMaggio and Powell, 1983). A better knowledge of socio-technical dynamics provides policymakers with a more solid foundation for policy interventions. Because they emphasise co-evolution, complexity, and multi-actor dynamics, socio-technical approaches avoid simple policy prescriptions. They suggest that policy instrument configurations should change depending on unique challenges and possibilities. Insights from the literature on sustainability transitions are included into third-generation innovation policies. Third-generation mission-oriented policies now concentrate on broad challenges rather than more specific issues. This suggests a change from handling issues that need for the cooperation of numerous parties to a single government entity managing (technical) difficulties (Schot and Steinmueller, 2018, Haddad, 2022). In this way, third-generation innovation policy differs from prior generations, regardless of whether the earlier generation was growth-oriented STI policy or policy focused on completing narrowly specified goals (Haddad, 2022).

Technology advancement helps to achieve SDG targets by increasing the efficiency and effectiveness of new and more sustainable development methods. Given the requirement for accelerated progress to meet the objectives by 2030, the adoption of new technologies may be critical for achieving the SDGs. The rise of new technologies like

artificial intelligence (AI), robotics, and blockchain, as well as their confluence, will be the driving force behind comprehensive transformation. The advent of enabling technology and its impact on many sectors require an assessment of its effect on the achievement of the Sustainable Development Goals. Thus, the development of new technologies that promote research and inspire innovation is essential. The STI Policy of India describes the transformative potential of STI applications in all sectors of the Indian economy. Various sectors, such as agriculture, health, water, and energy, have been identified, and the most relevant and effective tools produced from STI will be used in better programmes, activities, and their implementations. Based on the literature, three stages of technology are compared to highlight the importance of the STI ecosystem in terms of transformative change: emerging, enabling, and general-purpose technology (See Table 1.1).

Emerging technology is frequently cited as the driving force behind the insight of the fourth industrial revolution. It is defined as "radically innovative and reasonably fast-growing technology characterised by a certain degree of coherence that persists over time and has the ability to exert a significant impact on socioeconomic spheres." The definition implies that the impact of "developing technology" will be felt in the future. In contrast, GPT and enabling technology have real-time effects through spread and materialisation of complementarities Iizuka and Hane (2021).

Table 1.1: Types of Technology

	Emerging Technology[1]	**Enabling Technology**[2]	**General Purpose Technology**[3]
Novelty	Radical technology	Drive radical change in use	Affect broad socio-economic areas
Impacts	Uncertain and ambiguous	Enhance user capability	Change extant economic and social structure
Impact of technology	Coherence/ Convergence	Applicability to diverse field	Creates many spillover effects
Observed change	Relatively fast growth in use	Rapid development of subsequent technology	Societal transformation
Complementarity	Explore methods of use	Complement for broader impacts	Complementary for transformative change and acceleration

Source: Iizuka and Hane, 2020

New actors like the start-ups and Social Enterprises are driving transformations by creating new pathways on immediate problem solving and through extensive use of emerging technologies. The feedback loop is user-centric (and not solely associated with price signals) leading to faster proliferations in certain geographies. In the innovation process, start-ups are essential (Colombo and Piva, 2008; Davila et al., 2003; Mustar et al., 2008). For start-ups, numerous studies demonstrate that building relationships with outside partners is essential for businesses to succeed (Teece, 2010; Pangarkar and Wu, 2012; Kask and Linton, 2013). Additionally, open innovation (OI) approaches must be adopted by startups in order to avoid the risks associated with their inexperience and small size (Bogers, 2011).

Social Enterprises (SE) is the process of pursuing innovative solutions to social problems. Social entrepreneurs are catalysts for change in a wide range of disciplines and industries. They use entrepreneurial innovation and business methods to achieve their social objective. SEs focuses on marginalised and socio-economically disadvantaged people. Social enterprises provide new and inventive ways for the underprivileged to obtain goods, services, and livelihood opportunities. These firms, on the other hand, require access to money and other forms of assistance in order to thrive. Social enterprises, for example, are frequently riskier than typical firms since they do not always promise remarkable profits that would justify a purely financial investment. They may be developing new supply channels and other enabling infrastructure, or they may be creating new markets. The social economy sector, which sits between the market and the state and is typically associated with terms like "third sector" and "non-profit sector," has spawned social companies. Social enterprises have demonstrated large-scale systemic change and impact (OECD, 1999).

In the emerging technology scenarios, wherein, technology is at core of realizing the goals and targets set under the Agenda 2030, there is an imperative to go beyond the contemporary conceptual and analytical framework to comprehend the development of an STI ecosystem suitable for the purpose of achieving SDGs. In this scenario, there is a need to develop and pursue an integrated approach, where all the relevant stakeholders such as government, private sector, academia, research, international agencies and civil society, are taken on board.

In particular, Social enterprises can be defined by their ability to innovate, sustainably create mutually beneficial partnerships with business and/or the public sector or engage directly with poor or marginalised people and /or communities. The categories include direct social impact, reach and scope and replicability (adaptation to other regions of the world). The creation of social businesses, as well as the range of goods and services they provide, has occurred against the backdrop of welfare state reforms toward a mixed economy of private, public, and third-sector suppliers (OECD, 1999).

SEs has emerged as a powerful tool for achieving policy goals in two key areas of social and economic policy: service delivery (SEs may provide welfare services to specific groups of people or within a spatially defined community) and social inclusion (SEs facilitate social inclusion by integrating marginalised people into the workforce (e.g. long-term unemployed, disabled, minorities, etc) (Nabanita and Tapas, 2018). Social enterprises may be accredited by globally recognised certification agencies, and have a triple bottom line strategy that focuses on 3Ps (People, Planet, and Profits) - or returns that include social, environmental, and financial factors. (Chaturvedi *et.al*. 2019). Social enterprises have also been instrumental in creating technology solutions that allow local communities to create, evaluate, and control verified data about the issues that matter most to them. SEs have potential to contribute to SDGs by acting on and modifying the economic, social and environmental challenges of communities (Macassa, 2021). Governments are also changing how they collaborate with social entrepreneurs. Many governments have similar goals for achieving the SDGs, and they've realised that collaboration is crucial for creative social sector solutions to have a long-term impact. Governments in developing nations rapidly understand that in order to accomplish the SDGs, they must accelerate these collaborations (Kristine and Colin, 2021).

1.6 India's Emerging STI Ecosystem for accelerated outcome on SDGs

In the emerging technology scenarios, wherein, technology is at core of realizing the goals and targets set under the Agenda 2030, there is an imperative to go beyond the contemporary conceptual and analytical framework to comprehend the development of an STI ecosystem suitable for the purpose of achieving SDGs. In this scenario, there

is a need to develop and pursue an integrated approach, where all the relevant stakeholders such as government, private sector, academia, research, international agencies and civil society, are taken on board. Several agencies have prepared their respective roadmap drawn from methodologies of UN DESA *(See appendix for the detailed methodologies to support STI for SDGs Roadmaps prepared by UN DESA)*

In this integrated approach, connecting the national innovation system with other forms of innovation system such as regional and sectoral, becomes more organic and spontaneous. During the pandemic, the integration of the national innovation system with the bio-medical sector in India, could lead to the development and delivery of healthcare products and services in a short span of time. Such a new approach needs to be pursued in multiple sectors towards achieving the SDGs. The UN Guidebook on STI for SDGs Roadmap has elaborated the rationale for STI for SDGs Roadmap and the need for strengthened international partnerships on STI for SDGs towards creating such a Roadmap, the Guidebook has also argued for an integrated approach which is depicted in Figure 1.

The emerging integrated approach in India is a reflection of the importance of some of the components of the UN Guidebook on STI for SDGs Roadmaps. It is essential to establish a STI ecosystem, composed of all

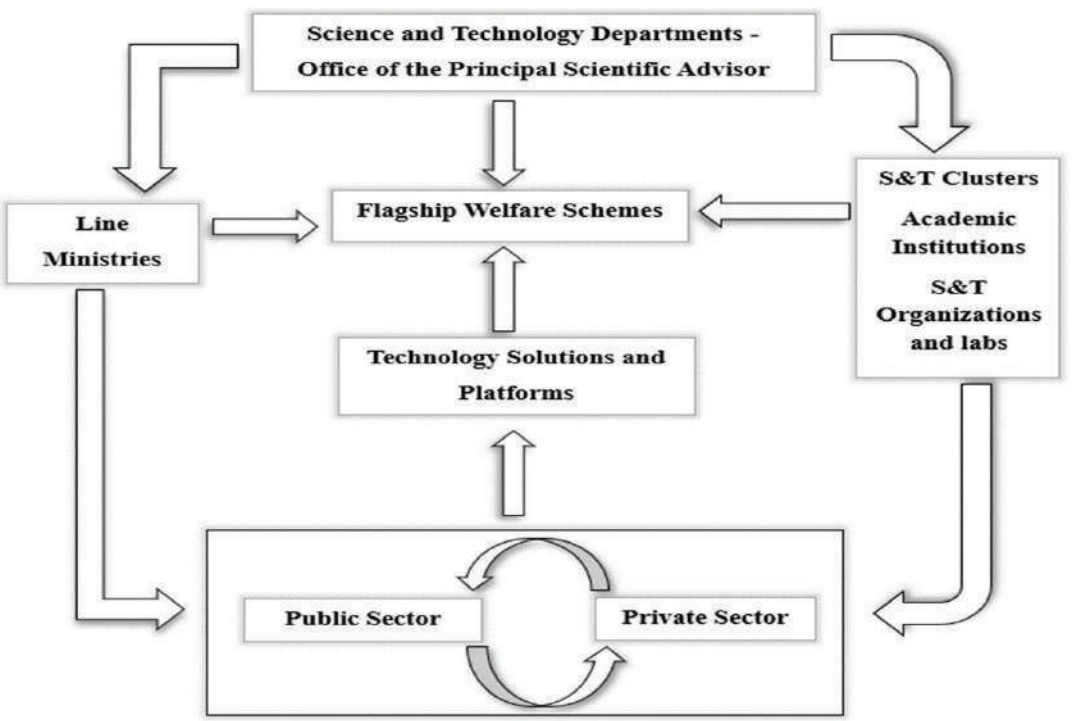
Figure 1.3: An Integrated Approach

Source: UN Guidebook on STI for SDGs Roadmaps (2021)

Imperatives for building an ecosystem is to connect and synchronize the efforts of public and private actors to create a big push for technology adoption.

relevant stakeholders, including government ministries/ departments, state governments, academic and research institutions, the public and private sector, and civil society organizations. Such an ecosystem would facilitate close coordination among the relevant stakeholders and would help the line ministries in formulating their respective plans to integrate the application of STI for achieving the related SDG goals and targets. All important scientific ministries and departments are vital participants in the process and must play a significant role in directing India's STI activities towards achievement of the SDGs. As development partners in this effort, organisations from the public and private sectors, businesses, start-ups, and social enterprises are integral to the process. Based on the emerging experience, India's new integrated ecosystem for large scale technology adoption for SDGs that delivers on major welfare schemes for accelerated outcomes on SDGs can be depicted as follows (Figure 1.4). Imperatives for building an ecosystem is to connect and synchronize the efforts of public and private actors to create a big push for technology adoption.

Figure 1.4: STI for SDGs Roadmaps for India
Integrated Ecosystem for Large Scale Technology Adoption for SDGs



Source: Developed by RIS

1.7 Mainstreaming SDG Indicators for Creating Appropriate STI for SDGs Roadmaps - A Way Forward

The intention on using STI for SDGs is to carry forward successful experiences in a more integrated and convergent manner that can enable sustainable development transformations, promote sustainable consumption and production, bring in greater equity in development, improve all parameters of human development, deepen resilience against emerging challenges and chart a futuristic course of development for the 21st century. The timelines for SDGs should trigger such aspirations in all nations and societies. Proactive policy measures in this direction would strengthen the resolve and streamline deliverables. The Global Pilot Programme on STI for SDGs should enable robust experience sharing in this regard.

It is important that better synergy is established between national, regional and global priorities in interconnected domains of development and sustainability in the spirit of the SDGs. Two key outcomes would be in the nature of understanding the nature of contributions made by India towards STI for SDGs efforts globally and adding to information base on localisation strategies on STI for SDGs comprising of institutional framework, innovation, deployment, gap analysis, and outcome indicators among others.

However, outcome and process based indicators on STI and their linkages with development and sustainability would be crucial for resource allocation and institutional interventions. The roadmap should address gaps in indicators and should facilitate development of relevant indicators, besides identifying appropriate guidelines (with methodologies) for collection, compilation and management of data.

In this context, the Roadmaps should broadly be shaped through partnerships and the information metrics. It is essential that the framework that is adopted under this programme is informed of local contexts, sector specificities and the efficiency with which it makes generalisations at the global level. The following are the basic parameters for the STI for SDGs programme to support national level efforts on STI:

- Means to build an ecosystem of institutions and processes for STI-SDGs aided by data and indicator driven technology foresight, gap analysis, priority interventions and qualitative information.

The future direction of STI for SDGs Roadmaps is to create a comprehensive ecosystem, which is emerging from India's own experiences in mainstreaming development through robust implementation of technology driven welfare schemes and infrastructure.

- Developing appropriate classification of technologies, in terms of use, stage of development, cost of development, ethical and socio-economic assessments, ownership and technology transfer models. Wider application and potential of technologies in solving long standing challenges should trigger faster adoption.
- Partnering with the private sector, start-ups and social enterprises for improving development, deployment and access to STI products and services. Ensuring greater participation of the private sector in the National Innovation System. Encouraging the private sector to invest more on R&D and contribute to technology development in the public sector aimed at fulfilling the objectives of the SDGs.
- National agencies working on STI for SDGs must also develop suitable information sharing mechanisms to strengthen the TFM and also promote knowledge sharing apart from tangible technology transfers with other countries.

1.8 Conclusion

The Covid-19 pandemic and rising conflicts have unleashed a devastating blow to the prospects of universal achievement of SDGs. While finance and technology were selected as the two most significant means of implementing the SDGs, the role of technology has become even more crucial in accelerating the achievement of the SDGs as a result of the pandemic-induced delay. The progress in achieving the SDGs was derailed by the pandemic. The pandemic has changed the world view and created a space for enhanced STI-led development agenda. The fast development of vaccines and diagnostic test provides ample justification for mainstreaming STI for SDGs at all levels. In this context, moving India onto a sustainable path will depend not only on deployment of already existing appropriate technologies, but also by bringing in innovations and changes in behaviours. Science and Technology is necessary but not sufficient for a sustainable pathway. Capacity for innovation is key, and (social) innovation is needed to induce changes in behaviours. Overall, STI is vital to minimize the costs of transition pathway, including in areas like livelihood. STI can be a common objective of the public and the private sectors to mobilize, actuate and animate all investments towards sustainable development.

The future direction of STI for SDGs Roadmaps is to create a comprehensive ecosystem, which is emerging from India's own experiences in mainstreaming development through robust implementation of technology driven welfare schemes and infrastructure. This STI for SDGs Roadmaps aims to build synergies with recent technological developments in India, especially in order to address the interlinkages between SDGs 2, 3, 6 and 7. The major Flagship Schemes have shown to be incredibly successful in mainstreaming technologies. The role of public, private, and other institutions in the area of technology platform and solutions to achieve these goals are key pillars of India's prospective STI for SDGs Roadmaps.

Apart from the introductory chapter *Building Ecosystem of Institutions and Processes for STI for SDGs Roadmaps for India*, the report consists of four chapters. The STI for SDGs Technology Mapping and India's Leading Capabilities in SDG targets are shown in Chapter 2. An Input to India's STI for SDGs Roadmaps, a thorough Indicative Technology Mapping (ITM), and selection and categorization of technologies for strengthening the Technology Facilitation Mechanism are included in this chapter. Chapter 3 presents the transformative role of technology enabled flagship welfare schemes rolled out by Government of India in achievement of SDGs. Chapter 4 describes the positioning and role of international agencies. This chapter includes roadmap for India's Contribution to the TFM. The Way forward elaborates on the milestones India has achieved till now and the efforts that need to be put in for leveraging STI for SDGs and strengthening the TFM.

Endnotes

1 Emerging technologies include a variety of technologies such as educational technology, information technology, nanotechnology, biotechnology, robotics, and artificial intelligence.

2 Enabling Technology is the use of various forms of devices and tech to support a person with disabilities to live as independently as possible. These types of technologies include sensors, mobile applications, remote support systems, and other smart devices.

3 General-purpose technologies are technologies that can affect an entire economy. GPTs have the potential to drastically alter societies through their impact on pre-existing economic and social structures. These include the steam engine, railroad, interchangeable parts, electricity, electronics, material handling, mechanization, control theory (automation), the automobile, the computer, the Internet, medicine, and artificial intelligence


ECG
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2 STI for SDGs Technology Mapping and India's Leading Capabilities:

An Input to India's STI for SDGs Roadmaps

2.1 Introduction

As a part of road-mapping efforts, this chapter is an attempt towards building a comprehensive "Indicative Technology Mapping (ITM)" for the selected four SDGs (2, 3, 6 and 7), their underlying targets and interlinked indicators from a cross-domain perspective. The ITM has mainly focused on a set of existing as well as emerging technologies, whose adoption and diffusion are critical to achieving progress on all the selected SDGs. It also aims to indicate areas of technological capability dominance which are vital for achieving progress on select SDGs. Utilizing domestically accessible technologies, India can strengthen TFM and seek and provide technological exchanges under South-South Cooperation Partnerships (SDG17). For technologies that are not readily available domestically or are inappropriate for the Indian conditions, there is a need to pursue aggressive indigenisation through appropriate policy measures and incentives. The chapter aims to document the availability, diffusion and innovation, and deployment potential of relevant technologies which are crucial for achieving the key focused SDGs.

The tabulation presented in the chapter depicts the scale and diversity of technologies which are deployed or have the potential for deployment at scale for achieving the relevant targets under the SDGs. The indicator wise

The ITM also aims to indicate areas of technological capability dominance which are vital for achieving progress on select SDGs. Utilizing domestically accessible technologies, India can strengthen TFM and seek and provide technological exchanges under South-South Cooperation Partnerships (SDG17). For technologies that are not readily available domestically or are inappropriate for Indian conditions, there is a need to pursue aggressive indigenisation through appropriate policy measures and incentives.

categorization and the cross sectoral linkages of the technologies with SDGs and its inter linkages with other SDG targets and indicators will provide a comprehensive view of how the deployment of such technologies can complement the achievement of not only key focused SDGs but also of other SDGs as well.

2.2 Indicative Technology Mapping (ITM) and Identifying and Categorizing Technologies for Strengthening TFM

This section elaborates on the technical aspects of STI for SDGs road mapping in the Indian context. It illustrates the case for SDG 2, 3, 6 and 7 and describes a 3-level template for Indicative Technology Mapping (ITM).

The mapping of technologies with their respective indicators and SDG targets open different areas of innovation, as laid out in the UN Guidebook for preparation of STI for SDGs Roadmap. Given that there exists an array of technological options that could cater to these challenges, it is imperative to first assess these alternatives. One way of doing this is by first classifying all these technologies into existing, emerging or new. Since newer technologies will take some time to fully penetrate their desired markets, the prioritization of alternative technologies will have to be such that utmost importance is given to existing technologies, then emerging and least to new technologies.[1] This way also allows us to identify gaps in the existing technology landscape. This information could be very useful in channeling research investments into new technologies that address these gaps.

I. Mapping SDG Targets and Indicators

Targets defined under each SDG are development objectives that need to be achieved universally, in totality and in spirit to fulfill the aspirations of a sustainable and equitable world. Targets are also instruments to connect more than one SDG so that achievement of a particular target would support fulfilling objectives under other SDGs as well.

While countries are free to define their indicator framework, a reference indicator framework has been identified by the UN after rigorous negotiation process among statistical agencies of various countries. While the range of indicators that have been identified captures the spirit of the related target, the aspiration of the target as well as that of the concerned SDG goal can only be achieved by addressing the slated issues going beyond the scope of specific indicators in some cases. This is partly due to the fact that indicators are developed keeping in mind data availability as well as the status of the methodology that goes into computation of indicators. However, abilities of statistical agencies to report relevant data are widely divergent. While many countries depending on the development context as well as maturity of the statistical systems have expanded the list of indicators beyond the scope of the UN indicators, several countries especially those with weaker statistical systems are likely to depend on the UN indicators as well as on reporting done by third parties primarily specialised UN agencies like FAO, WHO, ILO, UNESCO etc. *(See appendix for detailed methodologies to support STI for SDGs Roadmaps prepared by UN DESA)*

The national level monitoring of the SDGs in India is developed by Ministry of Statistics and Programme Implementation (MoSPI). MoSPI has created 306 national indicators (now revised to 295 indicators) in line with the 169 SDG targets and the Global Indicators Framework to monitor progress and the amount of achievement of the targets and Goals. In addition to the 295 indicators, 62 priority indicators have been identified for measuring India's most essential developmental goals.

In the context of the project, it may be noted that STI interventions are desired in areas that are helpful in achieving the defined objective of the SDG/Target and is not restricted to the scope of indicators that are based on quantifiable dimensions only. STI interventions should ideally be independent processes that would

inform the implementation roadmaps on specific SDGs, notwithstanding the fact that eventually new scientific discoveries are possible that could lead to accelerated and perhaps new course of action and help in fulfilling the composite objective. Statistical feasibility might lead to narrower perspectives on subjective wellbeing.

However, we consider it important that only those indicators that are closely aligned with the UN list are referred to for identifying gaps under specific SDGs for the purpose of global comparisons. This is particularly important in the context of Global Pilot Programme on STI for SDGs Roadmaps to allow easier interpretation of the distinct conceptual framework defining STI for SDGs roadmaps in pilot countries in order to encourage cooperation and exchange. The identification of the developmental challenge and decomposition into specific product and process components is crucial for initiating the roadmapping exercise. The same can be undertaken for each target and the underlying indicators.

2.3 Target Specific Illustration: Mapping of National vis-à-vis Global Indicators

2.3.1 SDG 2: End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture

Target 2.1 suggests that by 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

The UN Indicators identified in this regard include:

- 2.1.1 Prevalence of undernourishment
- 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
- The corresponding National Indicator Framework identifies the following indicators:
- 2.1.1 Percentage of children aged less than 5 years who are underweight

2.1.2 Proportion of beneficiaries covered under National Food Security Act 2013, (in percentage)

Clearly, the challenge of food security and ending hunger that we derive from this target-indicator combination to inform STI intervention is directly linked with availability,

The identification of the developmental challenge and decomposition into specific product and process components is crucial for initiating the roadmapping exercise. The same can be undertaken for each target and the underlying indicators.

access and affordability to food as well as nutritional security. While access may be a distributional issue, availability coupled with considerations for nutritional security are dependent on a variety of factors including agricultural productivity and nutritional content. Whereas affordability encompasses various components of incomes and transfer payments including safety nets, especially for the most vulnerable. This rationale also forms the basis of considering Target 2.1 together with Target 2.2 which states that by 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children less than 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons. While the indicators identified both at the global and the national level seeks to measure outcome/progress for specific groups, the core components of developmental intervention include availability and access to nutritional food.

Target Specific Illustration: Identifying the nature of Technology Needs

Drawing upon our previous example of Targets 2.1 and Target 2.2 the key areas of intervention with regard to STI inputs are 1) Productivity (linked with quantitative outcomes); 2) Quality (linked with nutritional content). However, the question of productivity is not only linked with farm mechanization which in itself falls in the category of technological intervention, a substantial consideration would be about improving input use efficiency as well as quality of inputs in the first place such as high yielding and disease resistance seed varieties. Taking into account sustainability issues higher productivity in agriculture has to be achieved by promoting sustainable practices in terms of energy and water use during tilling as well as at all stages of industrial level production of inputs. Directly linked with the question of nutrition security (using bio-fortification) are considerations towards improving nutritional quality of farm produce as well as preserving nutritional values through later stages of processing and storage.

Upcoming food processing technologies would better reduce wastage and spoilage, cut down on nutritional losses and maintain food texture and taste. In turn these would check against distress sales, stabilize prices, and

thus enhance GVA in agriculture. Some of the emerging technologies include pulsed electric field (PEF) treatment. Further, the next level Ultra High Temperature (UHT) processing technologies would require shorter processing bursts and provide hygienic and high shelf-life products in the value chains.

Another strand of food processing technologies involve harnessing air in place of argon etc. and use solar energy to run extruders, extractors, driers, desalination units etc. Modern cold chain technologies, including solar powered micro units; for horticulture, agro-marine and other products can preserve nutritive products and ensure their year-round supply. Nanotechnology can help protect sensitive bio-actives like vitamins, minerals, omega-3 fatty acids.

Target 2.3 states doubling agriculture productivity and enhancing farmers' income. Information and Communication technology is important to connect rural farmers to market information, products, and related services to improve incomes as well as agriculture productivity. Some other enabling technologies that will support achievement of the target are bioinformatics, GIS, and data analytics.

Target 2.4 brings forth the sustainability dimension. By 2030 it seeks to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

The associated UN identified indicators is:

- 2.4.1 Proportion of agricultural area under productive and sustainable agriculture.

However, this indicator has been listed under Tier II.

The national indicators are as follows:

- 2.4.1 Proportion of Net Sown Area to Cultivable land, (in percentage)
- 2.4.2 Percentage of farmers issued Soil Health Card
- 2.4.3 Percentage of net area under organic farming.

It is apparent that the indicators are focused on the outcomes and considering the processes leading to those outcomes would be equally important. Sustainable and resilient agriculture significantly depends on know-how, improved methods and greater use of scientific knowledge

Taking into account sustainability issues, higher productivity in agriculture has to be achieved by promoting sustainable practices in terms of energy and water during tilling as well as at all stages of industrial level production of inputs. Directly linked with the question of nutrition security are considerations towards improving nutritional quality of farm produce as well as preserving nutritional values through later stages of processing and storage.

including niche areas like carbon capture utilization and storage (CCUS), CRISPR-cas9, etc. This may also entail availability of a range of technologies that include use of space technology for weather forecasting, Remote Sensing, Artificial Intelligence for predictive modeling to determine appropriate crops to be grown as per climatic conditions.

In the context of Target 2.5 which aspires by 2020, to maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed. The immediate STI input that may be relevant in this case is promotion of 'gene bank'.

The indicative technologies that have been highlighted here are yet to be used fully. In case of new technologies there will be a gap in terms of time between their potential demonstrated in lab and gain realised in the field or in use. In case of many technologies, regulations are in the offing or not there currently. Their Technology Readiness Level (TRL) status is not fully known nor do we know everything about their viability. Hence, Technology Assessment must be appropriately incorporated to maintain due caution on promotion of any class of technologies.

Table 2.1 STI for SDGs Roadmaps: Indicative Technology Mapping: SDG-2

SDG-2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture		
Global Targets and Indicators	**NIF 3.0 Indicators**	**Mapping of Technologies as per NIF3.0 Indicators**
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round UN Global Indicators: *2.1.1:Prevalence of undernourishment* *2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)*	**National Indicators:** **2.1.1 :** *Percentage of children aged under 5 years who are* *Underweight.* **2.1.2:** *Proportion of population (marginalized and vulnerable) with access to food grains at subsidized prices* **Interlinked national indicators:** *1.1.1: Proportion of population living below the national poverty line* *1.1.2: Poverty Gap Ratio* *1.3.2 : Number of Beneficiaries under Integrated Child Development Scheme(ICDS)* *3.2.1 Under - five mortality rate, (per 1,000 live births)* *12.3.1 : Per capita food availability* *12.3.2 Post harvest storage and distribution losses of central/states pool stocks of wheat and rice*	***Sufficient food**: Technologies for increased crop productivity* • Conventional Breeding, Tissue Culture and Micro propagation, Marker-Assisted Breeding, etc. ***(Can be shared with other countries)*** • Bio-nanotechnology • Gene Editing using CRISPR/Cas-9 Technology ***Emerging Technologies*** *Synthetic Biology* as an emerging technology area with applications in medicine, healthcare, etc. ***Safe Food:*** • Bio-remediation, Organic Foods, Pulsed Electric Field Treatment Processing Technology, Ultra High Temperature Processing Technology, Better Packaging using nanotechnology, Bio-Fertilizers-based Production, Less Insecticides-based Production, Better Processed Food ***Nutritious Food:*** • Bio-fortification ***(Can be shared with other countries)*** • Nanotechnology to save vitamins, minerals, Omega-3 fatty acids, etc. ***Food Accessibility:*** • PDS system using ICT technologies (including One Nation One Ration Card Scheme) ***(Can be shared with other countries)***

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons UN Global Indicators: *2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age* *2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)* *2.2.3 Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage)*	**National Indicators:** *2.2.1 : Percentage of children under age 5 years who are stunted* *2.2.2 : Percentage of children under age 5 years who are wasted* *2.2.3 : Percentage of women whose Body Mass Index (BMI) is below normal (BMI<18.5 kg/m2)* *2.2.4 : Percentage of pregnant women age 15-49 years who are anaemic (<11.0g/dl)* *2.2.5 : Percentage of Children age 6-59 months who are anaemic (<11.0g/dl)* **Interlinked national indicators:** *1.3.2 : Number of Beneficiaries under Integrated Child Development Scheme(ICDS)* *1.3.6 : Number of senior citizens provided institutional assistance through Old Age Homes/Day Care Centres funded by the Government* *3.1.1 Maternal Mortality Ratio, (per 1,00,000 live births)* *4.2.2 : Gross early childhood education enrolment ratio*	***Nutrient-Enhancement Technology:*** • Vitamins, micro-nutrients and Iron Supplements using Bio-Fortification & Conventional Selective Breeding, Agronomic Breeding ***(Can be shared with other countries)*** • Genetic Modification, Nutrigenetics ***National Nutrition Mission (POSHAN Abhiyaan)*** • ***ICDS-CAS (ICDS-Common Application Software)*** *enables growth monitoring of children with the help of auto plotting of growth charts on the mobile application. SMS alerts to the concerned authorities for taking remedial action* ***(Can be shared with other countries)*** • ***POSHAN Tracker App:*** *complete beneficiary management for pregnant women, lactating mothers and children. The proposed system should enable real-time monitoring and tracking of all AWCs, AWWs and beneficiaries* ***(Can be shared with other countries).***

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment UN Global Indicators: *2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size* *2.3.2 Average income of small-scale food producers, by sex and indigenous status*	**National Indicators:** *2.3.1 : Agriculture productivity of wheat and rice (yield per hectare)* *2.3.2 : Gross Value Added in Agriculture per worker* *2.3.3: Ratio of institutional credit to agriculture to the agriculture output.* **Interlinked national indicators:** *5.a.1 : Operational land holdings - gender wise* *5.a.2 : Proportion of female agricultural labourers* *5.a.4 : Agricultural wages (gender wise)* *5.a.5 : Exclusive women SHGs in Bank linked SHGs* *5.a.6 : Percentage of adult having an account at a formal financial institution* *5.a.7 : Percentage of women having an account at a formal financial institution* *6.b.1 : Percentage of developed Irrigated Command Area brought under Water Users Association(WUAs)* *8.2.4 : Annual growth in agriculture sector* *9.1.1 : Proportion of the rural population who live within 2 km of an all-season road* *9.c.1 : Proportion of population covered by a mobile network, by technology* *12.3.2 : Post harvest storage and distribution losses of Central/States Pool stocks of wheat and rice* *14.1.3 : Percentage change in use of nitrogen fertilizers in the coastal States* *14.b.1 : Assistance to the traditional / artisanal fishers for procurement of FRP boats and other associated fishing implements.* *15.3.3 : Percentage increase in net sown area*	• High-yield hybrid seed varieties ***(Can be shared with other countries)*** • Better Biotic and Abiotic Stress-Resistant (such as Insect or Disease-Resistant, Drought) Seeds varieties using GM • Better Animal Hybrids (including Fish) ***(Can be shared with other countries)*** • Better Animal Vaccines and Nutritious Feed and Fodder; RFID and Micro-chips based Ear Tags for Livestock Tracking ***(Can be shared with other countries)*** • Farm Machineries: Mechanised Tillers, Sowers, Tractors, Threshers, Solar-powered pumps ***(Can be shared with other countries)*** • Advanced Irrigation Technologies: Drip Irrigation. Micro Irrigation ***(Can be shared with other countries)*** • Better Extension Services: Mobile Applications, ICT, Tele-Centres, Local Language AV Content • Post-Harvest Technologies: Solar Dryers, Cold Storage Facilities (including solar energy-powered) • Digital technologies underpinning programmes like 'JAM Trinity' for financial inclusion, Access to Banks/Credits, Direct Benefit Transfer (DBT), Insurance, etc. ***(Can be shared with other countries)*** • Better Market Access through ICT Web-based Platforms, Mobile Apps, e-NAM • Precision Agriculture (through Remote Sensing) • Value-Addition (through Food Processing techniques for crops, fruits, vegetables, meat, fish and dairy products), Pasteurization, caning, dehydration, Preservation Technologies ***(Can be shared with other countries)*** ***Emerging Technologies:*** • AI, NLP, Robotics, Drones, 3D Printing, Packaging Technology using nanotechnology, radiofrequency, high intensity pulsed light, ultrasound, irradiation and new hurdle technology

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality UN Global Indicator: *2.4.1 Proportion of agricultural area under productive and sustainable agriculture*	**National Indicators:** *2.4.1 : Proportion of degraded land to net sown area* *2.4.2 : Percentage of farmers issued Soil Health Card* *2.4.3 : Percentage of net area under organic farming* **Interlinked national indicators:** *6.4.1 : Percentage ground water withdrawal against availability* *12.4.2 : Development of national policy for environmentally sound management of hazardous chemical and waste* *13.1.1: Number of States with strategies for enhancing adaptive capacity and dealing with climate extreme weather events.* *14.4.1: Maximum Sustainable Yield (MSY) in fishing.*	• Efficient Irrigation Technologies (such as Drip Irrigation) • Farm Machineries: Mechanised Tillers, Sowers, Tractors, Threshers, Solar-powered pumps ***(Can be shared with other countries)*** • Organic Farming Techniques: Use of Biopesticides, Biofertilisers, Manure • Soil Health Cards using Soil Testing Technologies ***(Can be shared with other countries)*** • Less Water Intensive and Less Pesticides Intensive, Drought Resistant Crops Varieties (through Breeding and GM technologies) • ICT-based Application providing Farmers with Information on Better Agricultural Practices, Usage of Fertilisers and Water, mKisan, Kisan Suvidha App ***(Can be shared with other countries)*** ***<u>Emerging Technologies:</u>*** • AI, IoT, Robotics
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed UN Global Indicators: *2.5.1 Number of (a) plant and (b) animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities* *2.5.2 Proportion of local breeds classified as being at risk of extinction*	**National Indicators:** *2.5.1 : No. of accessions conserved in the base collection (-18 degree Celsius) at National Gene bank* *2.5.3 : Conservation of fish genetic resource (in number)* **Interlinked national indicators:** *15.6.1 : Number of Access and Benefit Sharing (ABS) agreements signed* *15.8.1 : Percentage change in prevention and control of invasive alien species*	• Efficient Seeds Banks, Indian Seed Vault ***(Can be shared with other countries)*** • Germplasm Conservation Technologies like Cold Storage and cryopreservation • ICT-based ABS Measurement System

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 UN Global Indicators: *2.a.1 The agriculture orientation index for government expenditures* *2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector*	**National Indicators:** *2.a.1 : Percentage share of expenditure in R&D in agriculture to GVA in agriculture.* *2.a.2 : Proportion of publicinvestment in agriculture to GVA in agriculture.* **Interlinked national indicators:** *6.a.2: Number of MoU/Co-operation agreements for capacity building and technology transfer* *9.5.1 : Percentage share of expenditure in R&D to total GDP* *9.5.2 : Researchers (in full time equivalent) per million inhabitants* *9.5.3 : Total number of Patents issued* *9.b.1 : Share of Intellectual Property Products in total Gross Fixed Capital Formation* *9.b.2 : Share of GVA of companies with research & development as main activity in total GVA from Private Corporate Sector* *9.b.3 : Share of GVA of Information and Computer related activities in total GVA* *9.c.1 : Proportion of population covered by a mobile network, by technology* *9.c.2 : No. of broadband subscribers per 10000 persons*	• R&D on Modern Biotechnologies for Crop Productivity Enhancement ***(Can be shared with other countries)*** • ICT-based Efficient Extension Services • Food Quality Testing and Phyto-sanitary Laboratories • Real-time Monitoring of Agricultural markets using ICT ***(Can be shared with other countries)*** ***Emerging technologies:*** • AI, Block chain
2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round UN Global Indicator: *2.b.1 Agricultural export subsidies*	**National Indicator:** *National Indicator not yet evolved*	
2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility UN Global Indicator: *2.c.1 Indicator of food price anomalies*	**National Indicator:** *2.c.1 : Percentage of Agriculture Mandis enrolled in e-market*	• Online National Agriculture Market or eNAM- online trading platform for agricultural commodities ***(Can be shared with other countries)*** • ICT-based, mobile-based Real time Food Price and Market Information to Farmers • mKisan, Kisan Suvidha, Agrimarket Apps

Source: Complied by RIS.

2.3.2 SDG-3: Ensure Healthy Lives and Promote Well-Being for All at All Ages

I. Mapping SDG Targets and Indicators

Target 3.1 aims to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030.

The UN Indicator identified in this regard is:

3.1.1 Maternal mortality ratio

3.1.2 Proportion of births attended by skilled health personnel

The corresponding National Indicator Framework identifies the following indicators:

3.1.1 Maternal Mortality Ratio, (per 1,00,000 live births)

3.1.2 Percentage of births attended by skilled health personnel (Period 1 year)

3.1.3 Percentage of births attended by skilled health personnel (Period 5 year)

3.1.4 Percentage of women aged 15–49 years with a live birth, for last birth, who received antenatal care, four times or more (Period 5 years/1 year) (in percentage)

The challenges of quality and affordable health care that we get from this target-indicator combination to guide STI intervention is directly related to ensuring healthy lives and promoting well-being for all. The impediment to provision healthy lives and well-being for all may be access to quality health care, quality and accountability of health services, affordable treatment etc. This is to say that different solutions would have to be devised depending upon the issue at the particular location. There are other targets also within this goal that try to reinforce these efforts like Target 3.8 to achieve universal health coverage, including financial risk protection, access to quality essential health-care service, access to safe, effective, quality and affordable essential medicines and vaccines for all, and Target 3.b to provide access to affordable essential medicines and vaccines. Target 3.2 seeks to end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births. For Target 3.2, the NIF has suggested the following indicators:

- 3.2.1 Under - five mortality rate (per 1,000 live births)
- 3.2.2 Neonatal mortality rate (per 1,000 live births)

The accessibility, affordability, monitoring, and

evaluation of the standard of healthcare services within the country are directly impacted by how we measure the target and related indicator of SDG-3 and the STI intervention. While access may be tied to the population's access to quality health care, quality monitoring and assessment encompasses health services, particularly maternal and child health, whereas, the affordability includes the expenses of disease treatment (like Cancer, TB, HIV, Hepatitis-B etc.). This rationale also serves as the foundation for considering target 3.3, which aims to eliminate the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases, as well as combat hepatitis, water-borne diseases, and other communicable diseases and boost water usage efficiency, and target 3.4 which intends to reduce premature mortality from non-communicable diseases by one-third through prevention and treatment, as well as to promote mental health and well-being. While the indicators defined at both global and national levels strive to monitor outcome/progress for certain groups, the essential components of developmental intervention include the availability and access to better health care services for all. A feasible, effective methodology for promoting better health and wellbeing in one location can essentially be applied to another location as well.

II. Mapping of Technology Needs for Achieving SDG Targets

It can be observed from the previous section that the challenges broadly encapsulated under Goal 3 are the following:

- Access to quality health care (PHC, CHC, DHC, Anganwadi centers)
- Quality monitoring and evaluation of health services (especially maternal and child health)
- Affordable treatment (for Cancer, TB, HIV, Hepatitis-B etc.)

Target Specification Illustration: Identifying the nature of Technology Needs

Drawing upon our previous example of Targets regarding SDG 3 the key areas of intervention with regard to STI inputs are 1) Access to quality health care 2) Affordable treatment 3) Quality monitoring and evaluation of health services. However, the question is not only linked with the category of technological intervention but also improving input use efficiency as well as quality of health care and affordability

Upcoming health care technologies have made it much easier for patients and health care professionals to monitor their health using various medical devices, which are easy to use and require very little manual operation. As a result, diagnostics and health monitoring have become more accessible. Utilizing these new technologies lead to enhanced care and efficiency, better disease control, and more accessible therapy while taking sustainability concerns into mind. Emerging technologies like artificial intelligence (AI), the internet of things (IoT), virtual reality, etc. are rapidly changing how surgeries are performed and medical equipment is used, resulting in higher precision and lower costs.

Target 3.4 seeks to reduce premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being. Information and Communication Technology, (Indian Council of Medical Research, 2022), 3T MRI diagnostics etc. is important to reduce premature mortality from non-communicable diseases. Some other enabling technologies that will support achievement of the target are cervix cancer treatment - screening strategies i.e., visual inspection with acetic acid (VIA) (Poli 2015), and emerging technologies like surgical robots with 3D cameras, embedded (National Cancer Institute, 2022), implanted and digestible sensors to detect cancer biomarkers.

Target 3.8 aims to achieve Universal Health Coverage (UHC), including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all. Information and Communication Technology is mainly used in this area to access safe, quality and affordable medicines and vaccines. Emerging technologies that will support to achieve the target are intelligent automation and AI-based claims resolutions, usage-based insurance, block-chain, and the Internet of Things. Under this target the AI and block-chain are mainly used for data information and data aggregation. Providing access to affordable essential medicines and vaccines is the focus of Target 3.b. Information and Communication based technology and conventional vaccine technologies are mainly used in this area to provide access to medicines and vaccines for all. Some other enabling technologies that will support achievement of the target are m-RNA vaccine technologies, Internet of Things and Sensors.

Table 2.2 STI for SDGS Roadmaps: Indicative Technology Mapping: SDG-3

Goal 3: Ensure healthy lives and promote well-being for all at all ages		
Global Targets and Indicators	**NIF 3.0 Indicators**	**Mapping of Technologies as per NIF3.0 Indicators**
3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births UN Global Indicator: *3.1.1 Maternal mortality ratio* *3.1.2 Proportion of births attended by skilled health personnel*	**National Indicator:** *3.1.1 Maternal Mortality Ratio, (per 1,00,000 live births)* *3.1.2 Percentage of births attended by skilled health personnel (Period 1 year)* *3.1.3 Percentage of births attended by skilled health personnel (Period 5 year)* *3.1.4 Percentage of women aged 15–49 years with a live birth, for last birth, who received antenatal care, four times or more (Period 5 years/1 year) (in percentage)* **Interlinked national indicators:** *2.2.3: Percentage of women whose Body Mass Index (BMI) is below normal* *2.2.4: Percentage of pregnant women age 15-49 years who are anaemic (<11.0g/ dl)*	• Digital Hemoglobinometer –True Hb and HemoCue (Can be shared with other countries) Handheld Ultrasound Device (HUD) but need of GPRS tracking device inside the HUD • ICT - Mobile electronic medical record system/ mobile app/ dashboard like Pradhan Mantri SurakshitMatritva Abhiyan Mobile App • Test for molecular diagnosis of beta thalassemia • Health Technology Assessment (HTA) ***Emerging Technologies*** • Non-pneumatic anti-shock garment (NASG) to control post-partum hemorrhage (pilot technology) • AI based application for effectiveness and efficiency of service delivery of maternal, new-born and child health • Predictive analytics and machine learning • Use of drones to deliver medical supplies in remote or disaster-prone regions
3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births UN Global Indicator: *3.2.1 Under-5 mortality rate* *3.2.2 Neonatal mortality rate*	**National Indicator:** *3.2.1 Under - five mortality rate (per 1,000 live births)* *3.2.2 Neonatal mortality rate (per 1,000 live births)* **Interlinked national indicators:** *2.1.1: Percentage of children aged under 5 years who are underweight* *2.2.5: Percentage of Children age 6-59 months who are anaemic (<11.0g/dl)* *1.3.2: Number of Beneficiaries under Integrated Child Development Scheme - ICDS*	• ICT - Mobile electronic medical record system/ mobile app/ dashboard like Inter-Operable Electronic Health Records System (Can be shared with other countries) • Mobile App: Indra-dhanush Immunization (Can be shared with other countries) • Phototherapy for treating jaundice in newborns. • Neonatal intensive care technologies (NICU) *- Thermoregulation in the NICU* *- Newborn jaundice treatment* *- Neonatal ventilation and lung protection- NICU Lighting- Noise in the NICU- Automated regulation of FiO2 for NICU* ***Emerging Technologies*** Heart Rate Observation System (HeRO)

3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases UN Global Indicator: *3.3.1 Number of new HIV infections per 1,000 uninfected population, by sex, age and key populations* *3.3.2 Tuberculosis incidence per 100,000 population* *3.3.3 Malaria incidence per 1,000 population* *3.3.4 Hepatitis B incidence per 100,000 population* *3.3.5 Number of people requiring interventions against neglected tropical diseases*	**National Indicator:** *3.3.1 Number of new HIV infections per 1,000 uninfected population* *3.3.2 Tuberculosis incidence per 1,00,000 population* *3.3.3 Malaria incidence per 1,000 population* *3.3.4: Prevalence of Hepatitis 'B' per 1,00,000 population* *3.3.5 Dengue: Case Fatality Ratio, (in ratio)* *3.3.6: Proportion of grade-2 cases amongst new cases of Leprosy, (Per million population)* *3.3.7: Percentage of blocks reporting < 1 Kala Azar case per 10,000 population out of the total endemic blocks* *3.3.8: Percentage of districts reporting < 1% Microfilaria rate (MF) out of Targeted Endemic districts* **Interlinked national indicators:** *5.6.3: Percentage of population aged 15-24 years with comprehensive knowledge of HIV/ AIDS, 2015-16*	• Antiretroviral therapy (ART) • Sharps Injury Prevention (SIP) devices, Auto - disable Syringes, Re-Use Prevention (RUP) syringes ***(Can be shared with other countries)*** • Attracticide technology ICT- Mobile electronic medical record system/ mobile app/ dashboards • Mobile health as a feasible digital health technology for lymphatic filariasis patients • **Tuberculosis -** MDR-TB drugs (bedaquiline, delamanid and pretomanid), • DOTS for TB • Bi-directional screening for early detection and prompt management of TB and diabetes • Leprosy Vaccination Programme – MDT for Leprosy • **Dengue** - Mobile app - India Fight Dengue ***Emerging Technologies*** • AI & Machine Learning to identify potential candidates for pre-exposure prophylaxis • ICT-enabled HIV testing (mobile) • Digital Health Technology Ecosystem • MERA – Malaria Elimination Research Alliance • Use of space technology tools for early warning system for JE, mapping of malaria and model for printing filariasis through GIS • TruNAT Rif, a cost effective rapid molecular diagnostic kit for TB • Geo spatial solution for disease surveillance particularly for vector borne diseases • Personal Cooling Garment (PCG) to protect workers exposed to hot environment

3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being UN Global Indicator: *3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes, or chronic respiratory disease* *3.4.2 Suicide mortality rate*	**National Indicator:** *3.4.1 Number of deaths due to cancer* *3.4.2 Suicide mortality rate, (per 1,00,000 population)* **Interlinked national indicators:** *16.1.3: Per 1,00,000 Population subjected to physical, psychological or sexual violence in the previous 12 months* *16.2.1: Proportion of Crime Committed against Children during the year, (Per 1,00,000 children)*	• Latest version for MRI diagnostic tools like 1.5T or 3T MRI diagnostics • Cancer Registry Programme • Diffusion MRI useful for the diagnoses of conditions (e.g., stroke) or neurological disorders • Oxygen Concentrators • ICT- Mobile electronic medical record system/ mobile app/ dashboard to help health care providers like No More Tension Mobile App • Cervix cancer treatment - Screening strategies i.e., visual inspection with acetic acid (VIA) • - Papanicolaou test (Pap smear) and HPV DNA test ***Can be shared with other countries)*** • ***Emerging Technologies*** • Magnifying Device (Magnivisualizer) for cervical, cancer screening • Personalized vaccines, Cell therapy, Gene editing & microbiome treatments • Technologies to assist identification of tumour and healthy tissue • Mobile stroke units • Web based tools on assessment and analysis of cancer
		• Silico trials with advanced biological networks, organs-on-a-chip or even network medicine will then help choose the right drug candidates within seconds • DNA cages to treat healthy cells • Surgical robots with 3D cameras • Embedded, implanted and digestible sensors to detect cancer biomarkers Point-of-care testing (POCT) for home testing and diagnostic options during chemotherapy Future technology like Quell, a wearable technology with intensive nerve stimulation clinically proven to help managechronic pain

3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol UN Global Indicator *3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders* *3.5.2 Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol*	**National Indicator:** *3.5.1 Percentage of population (men (15 - 49 years) & women (15 - 49 years)) who drink alcohol about once a week out of total population (men (15 - 49 years) & women (15 - 49 years)) who drink alcohol* *3.5.2 Number of persons treated in de-addiction centres* *3.5.3 Percentage of population (men (15-54 years)) and women (15-49 years)) who consume alcohol*	• ICT- Mobile electronic medical record system/ mobile app/ dashboardWeb-based psycho-social skills training intervention for individuals with substance use disorders ***(Can be shared with other countries)*** ***Emerging Technologies*** Use of A.I., Internet of Things (IoT), big data for tracking online/offline sale of alcohols
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents UN Global Indicator: *3.6.1 Death rate due to road traffic injuries*	**National Indicator:** *3.6.1 People killed/injured in road accidents (per 1,00,000 population) (exactly similar to 11.2.2)* **Interlinked national indicators:** *9.1.1: Proportion of the rural population who live within 2 km of an all-season road* *11.2.1: Proportion of Households in urban areas having convenient access to public transport*	• Handheld Ultrasound Device for immediate ultrasonography during emergencies (Can be shared with other countries) • NHP Directory Services for hospital and blood banks • Emerging Technologies • 5G technology and Integration of Blockchain for security enhancement. • "V2X" communication for real-time communication through WIFI among commuters • A.I, predictive modeling, and big data to analyzse traffic congestion and weather change prediction
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes. UN Global Indicator: *3.7.1 Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods* *3.7.2 Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age group*	**National Indicator:** *3.7.1: Percentage of currently married women aged 15-49 years who have their need for family planning satisfied with modern methods, 2015-16* *3.7.2: Adolescent birth rate (aged 15–19 years) per 1,000 women in that age group* *3.7.3: Percentage of Institutional Births (5 years/1 years), 2015-16* *3.7.4: Percentage of currently married women (15-49 years) who use any modern family planning methods (similar to Indicator 3.8.1 and 5.6.1)* *3.7.5: Percentage of women aged 15-19 years who were already mothers or pregnant* **Interlinked national indicators:** *4.5.1: Gender Parity indices for Primary/ Secondary/Higher Secondary/ Tertiary education* *4.6.1: Literacy rate of youth in the age group of 15-24 years, 2011* *5.3.1: Percentage of women aged 20-24 years who were married by exact age 18 years, 2015- 16* *5.3.2: Proportion of cases reported under the Prohibition of Child Marriage Act (early marriage of children below 18 years of age) to total crime against children* *5.6.1: Percentage of currently married women (15-49 years) who use modern methods of family planning (similar to Indicators 3.7.4 and 3.8.1)* *5.6.2: Unmet need for family planning for currently married women aged 15-49 years, 2015-16 (in percentage)*	• Addition of Nexplanon to current Family planning portfolio ***(Can be shared with other countries*** • ICT- Mobile electronic medical record system/ mobile app/ dashboard with training and education modules for super speciality para medical care ***Emerging Technologies*** • AI, Machine learning, predictive modeling and Big-data for assessing and planning and addressing emerging needs and challenges

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all UN Global Indicator *3.8.1 Coverage of essential health services* *3.8.2 Proportion of population with large household expenditures on health as a share of total householdexpenditure or income*	**National Indicator:** *3.8.1: Percentage of currently married women (15-49 years) who use any modern family planning methods (similar to Indicator 3.7.4 and 5.6.1)* *3.8.2: Proportion of population with large household expenditures on health as a share of total household expenditure or income* *3.8.3: Percentage of people living with HIV currently receiving ART among the detected number of adults and children living with HIV* *3.8.4: Prevalence of hypertension among men and women age 15-49 years 2015-16 (in percentage)* *3.8.5: Percentage of population in age group 15-49 who reported sought treatment out of total population in that age group having diabetes* *3.8.6: Percentage of women aged 15-49 who have ever undergone Cervix examinations* *3.8.7: Percentage of TB cases successfully treated (cured plus treatment completed) among TB cases notified to the national health authorities during a specified period* *3.8.8: Total physicians, nurses and midwives per 10,000 population, (similar to Indicator 3.c.1)* **Interlinked national indicators:** *1.3.1: Percentage of households with any usual member covered by a health scheme or health insurance* *1.3.5: Proportion of the population (out of total eligible population) receiving social protection benefits under Pradhan Mantri Matritva Vandana Yojana (PMMVY)* *1.3.6: Number of senior citizens provided institutional assistance through Senior Citizen Homes/Day Care Centers funded by the Government* *5.a.7: Percentage of women having an account at a formal financial institution* *8.8.2: Percentage of migrant workers* *8.8.3: Number of accidents in factories*	• Information System— eHospital, e-sushrut, My health record system ***Emerging Technologies*** • Intelligent automation and AI-based claims resolutions in insurance sector • Usage-based insurance, block-chain, and the Internet of Things

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination UN Global Indicator *3.9.1 Mortality rate attributed to household and ambient air pollution* *3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)* *3.9.3 Mortality rate attributed to unintentional poisoning*	**National Indicator:** *3.9.2: Proportion of men and women reporting Asthma in the age group 15-49 years* *3.9.3: Mortality rate attributed to unintentional poisoning, (per 1,00,000 population)* **Interlinked national indicators:** *6.3.1: Percentage of sewage treated before discharge into surface water bodies, 2020* *7.1.2: Percentage of household using clean cooking fuel* *12.4.1: Whether the country has ratified international Multilateral Environmental Agreements on hazardous waste and other chemicals* *12.4.2: (a) Hazardous waste generated per capita (in MT/person); and (b) proportion of hazardous waste treated, by type of treatment*	• **FBTec** sewage treatment system ***Emerging Technologies*** • Photo-irradiation and Adsorption based systems for Water-treatment • (**PANIWATER**) an international effort to develop, deploy and validate six different prototypes for the removal of chemical and biological contaminants from water, using Advanced Oxidation Processes.
3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate UN Global Indicator: *3.a.1 Age-standardized prevalence of current tobacco use among persons aged 15 years and older*	**National Indicator:** 3.a.1: Percentage of adults 15 years and above with use of any kind of tobacco (smoking and smokeless)	• Mobile-app based Tobacco Cessation Programme • FCTC Global Knowledge Hub on smokeless tobacco
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	**National Indicator:** *3.b.1: Proportion of the target population covered by all vaccines included in their national programme* *3.b.2: Budgetary allocation for Department of Health Research, (in Rs. 3201 crore for 2022-23)* **Interlinked national indicators:** *8.3.2: Total number of patents issued (granted) (similar to indicators 8.2.2 and 9.5.3)* *9.5.1: Percentage share of government spending on IPP (Research and Development) to total GDP* *9.5.2: Researchers (in full time equivalent) per million population*	• Conventional vaccine technologies ***(Can be shared with other countries)*** • Mission Indradhanush to increase full immunization cover ***Emerging Technologies*** • m-RNA vaccine technologies

UN Global Indicator: *3.b.1 Proportion of the target population covered by all vaccines included in their national programme* *3.b.2 Total net official development assistance to medical research and basic health sectors* *3.b.3 Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis*		
3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States UN Global Indicator: *3.c.1 Health worker density and distribution*	**National Indicator:** *3.c.1: Total physicians, nurses and midwives per 10,000 population, in percentage (similar to Indicator 3.8.8)* *3.c.2: Percentage of government spending (including current and capital expenditure) in health sector to GDP*	
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks UN Global Indicator: *3 d.1 International Health Regulations (IHR) capacity and health emergency preparedness* *3.d.2 Percentage of bloodstream infections due to selected antimicrobial-resistant organisms.*	**National Indicator:** 3.d.1: International Health Regulations (IHR) capacity and health emergency preparedness	• AAYUSH system of medicines ***(Can be shared with other countries)***

Source: Complied by RIS.

To illustrate this process the example of National Digital Health Mission (NDHM) can be taken. This mission is set out to address the one of the challenge that we discussed earlier i.e. access to quality health care. Digital health can expedite the transformation of services on preventive and promotive healthcare. In terms of technological intervention, the mission is mainly based on ICT to digitally identify people, doctors, and health facilities, make paperless payments, securely store digital records, and connect people to provide opportunities to streamline healthcare information through digital management. The Mission looks for new and emerging technologies like block chain, Internet of Things in this field for this aim. The Ministry of Health and Family Welfare, Ministry of Electronics and Information Technology and National Health Authority established a Technical Committee to give technology suggestions to develop and enhance healthcare India through digital management. Furthermore, the Ministry has been sponsoring R&D initiatives in these areas.

The other challenge that the Mission tries to address is that of quality monitoring and evaluation of health services. To address this issue, ICT like Poshan Tracker mobile application is using (under POSHAN Abhiyaan 2.0) new and emerging technology like Big data and AI in this area. The Ministry of Health and Family Welfare gives technology suggestions for developing and enhancing healthcare in India and also sponsor R&D initiatives in these areas.

Finally, the third challenge is affordable treatment (for Cancer, TB, HIV, Hepatitis-B etc.) where most progress has been made in recent times owing to technological intervention. The Pradhan Mantri Jan Arogya Yojana (PM-JAY) aims to ensure universal health coverage, including financial risk protection and access to vital medications and vaccinations that are secure, efficient, of high quality, and affordable for everyone. Information and communication based technology helps to verify beneficiaries from the entitled database. This Mission also seeks out new and emerging technology like Block chain and big data in this area.

2.3.3 SDG-6: Ensure Availability and Sustainable Management of Water and Sanitation for All

I. Mapping SDG Targets and Indicators

Target 6.1 aims to achieve universal and equitable access to safe and affordable drinking water for all by 2030.
The UN Indicator identified in this regard is:

- 6.1.1 Proportion of population using safely managed drinking water services

The corresponding National Indicator Framework identifies the following indicators:

- 6.1.1 Percentage of Population getting safe and adequate drinking water within premises through Pipe Water Supply (PWS) (similar to 1.4.1)
- 6.1.2 Percentage of population using an improved drinking water source (Rural)

The challenges that we derive from this target-indicator combination to inform STI intervention is directly linked with access and quality of drinking water. The impediment to provision of safe drinking water in a particular place may be water quality issues, overexploitation of local water resources, vulnerability to drought, etc. Different solutions would have to be devised depending upon regional challenges. There are other targets also within this goal that try to reinforce these efforts. Target 6.3 aims to improve water quality by reducing pollution while targets 6.4 and 6.5 are all aimed at increasing water use efficiency, For target 6.3, the NIF has suggested the following indicators:

- 6.3.1 Percentage of sewage treated before discharge into surface water bodies
- 6.3.2 Proportion of water bodies with good ambient water quality
- 6.3.3 Proportion of waste water treatment capacity created vis-à-vis total generation

For Target 6.4 which aims to increase water use efficiency, the suggested indicators in NIF are:

- 6.4.1 Percentage ground water withdrawal against availability
- 6.4.2 Per capita storage of water(m3 /person)
- 6.4.3 Per capita availability of water (m3 /person)

Target 6.5 tries to follow up on the previous target of water use efficiency by tracking the implementation of integrated water resources management at all levels. The suggested NIF indicator for this is- *percentage area of river basins brought under integrated water resources management.*

Further, target 6.6 has been included specifically to protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. The NIF has suggested the following indicators for this target:

- 6.6.1 Percentage of blocks/mandals/ taluka over-exploited
- 6.6.2 Percentage sewage load treated in major rivers
- 6.6.3 Biological assessment information of surface water bodies
- Finally, targets 6.a and 6.b talk about linkages at the international and local levels respectively. NIF indicator for target 6.b is:
- 6.b.1 Proportion of villages with Village Water & Sanitation Committee [VWSC]

Apart from access to safe drinking water, another important target which has been encompassed in this goal is target 6.2 which aims to achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. Indicators suggested by NIF for this target are:

- 6.2.1 Proportion of households having access to toilet facility (Urban & Rural)
- 6.2.2 Percentage of Districts achieving Open Defecation Free (ODF) target
- 6.2.3 Proportion of schools with separate toilet facility for girls

Unlike the issues related to water, solutions for sanitation and ending open defecation are not as contextual. This is to say that an affordable, successful model of providing sanitation in one place can be pretty much replicated as it is to another place as well.

II. Mapping of Technology Needs for Achieving SDG Targets

It can be observed from the previous section that the challenges broadly encapsulated under Goal 6 are the following:

- Quality of water (filtration/treatment of water sources)
- Access to water (development of distribution systems)
- Water-use efficiency (reduction of overexploitation)
- Access to sanitation facilities

Technological advancements in the field of clean water and sanitation have made it much easier for the population to gain access to water and sanitation services. Use of these new technologies has resulted in increased water efficiency (reduction of over exploitation). Emerging technologies like Clean Water AI (AI to detect dangerous bacteria and harmful particles in the water), Narrowband-IoT (Smart water meters, and placing acoustic sensors on underground mains pipelines network to precisely detect and prevent leaks in their distribution). Remote sensing, Internet of Things based systems, GIS and mathematics optimization are being used to increase the water-use efficiency, quality and access to water and sanitation facilities.

Target Specification Illustration: Identifying the nature of Technology Needs

Based on the above mentioned Targets regarding SDG 6, key areas of intervention with regard to STI inputs are Quality of water (filtration/treatment of water sources), access to water and sanitation facilities and water-use efficiency. However, the question is not only linked with category of technological intervention but also improving input use efficiency as well as quality of water and access to sanitation facilities.

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Target 6.1 aims to achieve universal and equitable access to safe and affordable drinking water for all.

Ozonation, Ultraviolet technology, Reverse Osmosis (RO), TERAFIL water filter High flow arsenic filters, solar water purification systems are important to attain this target. To monitor water quality modern technology like Smart iQ, IoT-based real-time water quality monitoring systems and Supervisory control and data acquisition (SCADA) are being used in this field. Smart water meters, and sensors are used to precisely identify and stop leaks in the water distribution system.

Target 6.3 seeks to improve water quality and reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally. Rotating Disc System, Activated Sludge Plant (ASP), ETP/STP, Sequencing Batch Reactor (SBR) are using in this area to attain this target. Some other enabling technologies that will support achievement of the target are wastewater sludge gasification, Grey water treatment technology, Bio-filtration and Vermi-filtration technology and soil bio-technology.

In order to illustrate this process, the example of Jal Jeevan Mission can be taken. The Mission aims to address the first two challenges that we discussed earlier i.e. quality and access of water. The Mission's primary aim, however, is to ensure universal access to water and enable every household in villages to have Funconal Household Tap Connecon (FHTC) in the next five years. In terms of technology intervention, IoT and sensor-based technology is used. Under this mission this is a relatively low-hanging fruit as the existing technologies in pipeline engineering can be used to advance this pursuit to a larger extent. The other challenge that the Mission tries to address is that of water quality. For this purpose, the Mission seeks out new and emerging technology in this area. The Ministry of Drinking Water and Sanitation constituted a Technical Committee to make technology recommendations for the states to consider implementing their own drinking water and sanitation projects. Further, the Ministry has also been funding R&D activities in related areas.

The third challenge is increasing water-use efficiency. In India, around 80 per cent of the water is used for agricultural purposes. Agricultural practices, particularly widespread cultivation of paddy is given to be a major contributor to overexploitation of ground water in northern India (Sargar,

Table 2.3: STI for SDGS Roadmaps: Indicative Technology Mapping: SDG-6

SDG 6: Ensure availability and sustainable management of water and sanitation for all		
Global Targets and indicators	**NIF3.0 Indicators**	**Mapping of Technologies as per NIF 3.0 Indicators**
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all UN Global Indicator: *6.1.1 Proportion of population using safely managed drinking water services* *6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water*	**National Indicator:** *6.1.1 Percentage of Population getting safe and adequate drinking water within premises through Pipe Water Supply (PWS)* *6.1.2 Percentage of population using an improved drinking water source (Rural)* **Interlinked national indicators:** *1.4.2: Proportion of population (Urban) living in households with access to safe drinking water & sanitation (Toilets)*	***Water Purification and Treatment Technologies:*** • Ozonation, Ultraviolet technology, Reverse Osmosis (RO), TERAFIL water filter ***(Can be shared with other countries)*** • High flow arsenic filters, Domestic Iron Filter, High Flow Rate De-fluoridation Plant, ***(Can be shared with other countries)s*** • Solar water purification systems ***Systematic monitoring systems*** • Supervisory control and data acquisition (SCADA) monitoring system • IoT-based real-time water quality monitoring systems in pipelines ***Low-cost, scalable water treatment solutions for Rural Settings*** • **Mark II & Mark III handpumps** along with **biofilters** installed simply to the handpump to remove bacterial contamination. ***(Can be shared with other countries)*** • Cost-effective **cellulose membranes** for arsenic and fluoride removal in water filtration have been developed in India using nanotechnology.

6. 2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	**National Indicator:** *6.2.1 Proportion of households having access to toilet facility (Urban & Rural), (in percentage), (similar to 1.4.7)* *6.2.2 Percentage of Districts achieving Open Defecation Free (ODF) target* *6.2.3 Proportion of schools with separate toilet facility for girls (in percentage)* **Interlinked national indicators:** *1.4.2: Proportion of population (Urban) living in households with access to safe drinking water & sanitation (Toilets)* *1.b.1: Proportion of budget earmarked under gender budget*	***Low-cost, decentralized sanitation facilities*** • **Twin-pit toilets** (low cost, scalable, easy to build technology) ***(Can be shared with other countries)*** • **Tiger toilets with** biological agents to treat human waste - requires little water for flushing ***(Can be shared with other countries)*** • **Anaerobic Bio-digesters** ***(Can be shared with other countries)***
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally UN Global Indicator: *6.3.1 Proportion of domestic and industrial wastewater flows safely treated* *6.3.2 Proportion of bodies of water with good ambient water quality*	**National Indicator:** *6.3.1 Percentage of sewage treated before discharge into surface water bodies* *6.3.2: Proportion of Water Bodies with GoodAmbient Water Quality* *6.3.3 Proportion of waste water treatment capacity created vis-à-vis total generation* **Interlinked national indicators:** *3.9.3: Mortality rate attributed to unintentional poisoning, (per 1,00,000 population)* *8.4.1: Proportion of waste recycled vs. waste generated Source: CPCB, Ministry of Environment Forest and Climate Cha* *12.4.2: (a) Hazardous waste generated per capita (in MT/person); and (b) proportion of hazardous waste treated, by type of treatment*	***Sewage Treatment Technologies*** • Rotating Disc System, Activated Sludge Plant (ASP), Suspended Media Filters (SMF), Submerged Aerated Filter (SAF), Non-Electric Filter, Trickling Filter ***(Can be shared with other countries)*** • Sequencing Batch Reactor (SBR), Moving Bed Biofilm Reactor (MBBR) ***(Deficit)*** • Decentralized "Johkasou" technology for sewage treatment ***Waste Water Treatment technologies*** • Wastewater sludge gasification • *Wastewater recycling technology* • ***CSIR's Aqua Rejuvenation Plant*** *purifies Waste Water for irrigation/farming purposes*

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity UN Global Indicator: *6.4.1 Change in water-use efficiency over time* *6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources*	**National Indicator:** *6.4.1 Percentage ground water withdrawal against availability* *6.4.2 Per capita storage of water, (in m3/person)* *6.4.3 Per capita availability of water, (in m3/person)*	*Water-efficient technologies* • Efficient irrigation technologies (like Drip irrigation, solar pumps) ***(Can be shared with other countries)*** • Precision agriculture applications ***(Can be shared with other countries)*** • Electromagnetic desalination processes for brackish waters such as electro-dialysis (ED) and capacitive deionization (CDI) ***(Deficit)*** *Reliable data gatherings* • Extensive mapping exercises like aquifer mapping, GIS-mapping of surface water using Remote sensing • ISRO's digital platform, Bhuvan makes use of satellite remote sensing for mapping water resources, pipeline grid, etc. *Emerging Digital Solutions* • AI-enabled water-use monitoring system • Smart meters • **Groundwater Estimation and Management Software (GEMS)** tool is developed by India's Central Ground Water Board that digitises groundwater level and quality data for India ***(Can be shared with other countries)*** • The National Aquifer Mapping and Management (NAQUIM) Program

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate UN Global Indicator: *6.5.1 Degree of integrated water resources management* *6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation*	**National Indicator:** *6.5.1 Percentage area of river basins brought under integrated water resources management*	• NRSA Bhuvan Technology for water resources assessment of river basins in India using satellite inputs • GIS mapping has been incorporated in the planning process of many water resources in India
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes UN Global Indicator: *6.6.1 Change in the extent of water-related ecosystems over time*	**National Indicator:** *6.6.1 Percentage of blocks/mandals/taluka over-exploited* *6.6.2 Percentage sewage load treated in major rivers* *6.6.3 Biological assessment information of surface water bodies* **Interlinked national indicators:** *14.1.1: Coastal Water Quality Index* *15.1.1: Forest cover as a percentage of total geographical area*	• Sewage load treatment plants in rivers • **Remote sensing technologies** for better monitoring and other spacio-temporal analysis
6.b Support and strengthen the participation of local communities in improving water and sanitation management UN Global Indicator: *6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management*	**National Indicator:** *6.b.1 Proportion of villages with Village Water & Sanitation Committee [VWSC]*	• ICT-based platforms can help in assessment and monitoring of the village water and sanitation committee

Source: Complied by RIS.

2020). This implies that even with regard to increasing water-use efficiency, it is crucial for Indian agriculture to shift to crops of higher productivity. Therefore, this challenge of SDG-6 is also inextricably connected to targets of productivity enhancement under SDG-2. Apart from this, programmes like Integrated Watershed Management Programme (IWMP) which have been active since a long time in rural areas, need to be encouraged.

Finally, the fourth challenge where most progress has been made in recent times owes to technological intervention. The Swachh Bharat Mission's aim was to achieve universal access to sanitation facilities. Since the start of SBM, the proportion of households having sanitation has increased dramatically as the Mission has been quite successful in disseminating an emerging technology (twin pit toilets) widely across rural India. It would also be relevant to mention that introduction of new technologies has to be complemented with effective communication and campaigning so that people can adapt themselves more readily.

2.3.4 SDG-7: Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for Sll

Target 7.1 aims to achieve universal access to affordable, reliable, and modern energy services for all by 2030.
The UN Indicator identified in this regard is:

- 7.1.1 Proportion of population with access to electricity

The corresponding National Indicator Framework identifies the following indicators:

- 7.1.1 Percentage of households electrified (similar to 1.4.3)
- 7.1.2 Percentage of household using clean cooking fuel

The challenge of affordable and clean energy monitor from this target-indicator combination guiding the STI intervention is linked with providing affordable energy and access to clean cooking fuel particularly among rural communities. Some possible barriers to the provision of electricity and clean cooking fuel in a specific location can have regional dimensions to it which would require varied solutions to be developed.

There are other targets also within this goal that try to reinforce these efforts. Target 7.2 seeks to increase

substantially the share of renewable energy in the global energy mix. For target 7.2, the NIF identifies the following indicator:

- 7.2.1 Renewable energy share in the total installed electricity generation

For target 7.3 which aims to double the global rate of improvement in energy efficiency and the suggested indicators in NIF are:

- 7.3.1: Energy intensity measured in terms of primary energy and GDP

Finally, Targets 7.a and 7.b talk about linkages at the international and local levels respectively. NIF Indicators for Target 7.a aims to 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 is under development.

On the other hand, NIF indicators for Target 7.b i.e. 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 are:

- Installed renewable energy generating capacity in the country (in watts per capita) (Similar to 12.a.1)

This means that an energy source that is accessible, dependable, sustainable, and modern in one location may essentially be recreated in another location as well. To start a STI for SDGs Roadmaps, it is essential to identify the development challenge and break it down into particular product and process components.

II. Mapping of Technology Needs for Achieving SDG Targets

It can be observed from the previous section that the challenges broadly encapsulated under Goal 7 are the following:

- Accessible electricity (Availability of electricity at a affordable price in the villages)
- Accessibility of clean cooking fuel particularly among rural communities)

Table 2.4 STI for SDGs Roadmaps: Indicative Technology Mapping: SDG-7

SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all		
Global Targets and Indicators	**NIF 3.0 Indicators**	**Mapping of Technologies as per NIF3.0 Indicators**
7.1 By 2030, ensure universal access to affordable, reliable, and modern energy services UN Global Indicator: *7.1.1 Proportion of population with access to electricity*	**National Indicator:** *7.1.1 Percentage of households electrified* **Interlinked national indicators: with NIF3.0** *1.4.3: Percentage of households electrified, 2019-20* *8.1.1: Annual growth rate of GDP (adjusted to price changes) per capita* *13.2.2: Achievement of Nationally Determined Contribution (NDC) Goals in post-2020 period*	• Decentralised non-fossils energy systems such as small-scale solar & wind generation units that use local resources and are environmentally sustainable. • *Biomass gasification, Family biogas plants* ***(Can be shared with other countries)*** • *low-cost Solar PV systems with Lithium□ion batteries* • *Digital tools to improve supply and consumption* ***Emerging Technologies*** • *Alternate solar panel systems (Perovskite cells* • *Alternate battery technologies - Zinc ion, Redox Flow, solid state etc.*
7.1 By 2030, ensure universal access to affordable, reliable, and modern energy services UN Global Indicator: *7.1.2 Proportion of population with primary reliance on clean fuels and technology*	**National Indicator:** *7.1.2 Percentage of household using clean cooking fuel* **Interlinked national indicators:** *13.2.2: Achievement of Nationally Determined Contribution (NDC) Goals in post-2020 period* *15.b.1: Percentage of government spending on environmental protection to total government expenditure* *12.1.1: Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies*	• *Improved biomass cooking stoves, biogas technologies* ***(Can be shared with other countries)*** • *Solar-based cooking, low-cost electricity-based cooking* • *Low□cost biomethane systems.*

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix UN Global Indicator: *7.2.1 Renewable energy share in the total final energy consumption*	**National Indicator:** *7.2.1 Renewable energy share in the total installed electricity generation* **Interlinked national indicators:** *9.4.1: Total CO2 emissions of power sector per unit of GDP (in Tonne/Rupees Crore)* *12.a.1: Installed renewable energy generating capacity in the country (in watts per capita)*	• *Indigenous solar systems for industrial, household, and agriculture uses.* • *Lithium□ion, Zinc-air batteries & alternate battery technologies **(Emerging)*** • *Windmills, Watermills* • *Biomass gasification, Bagasse cogeneration (**Can be shared with other countries)*** • *Solar & waste-to-energy* • *Waste-to-energy, and biomass gasification in rural and industrial areas* • *Solar water heating solutions* • *Mini□grids, and Decentralised Solar PV systems* • *Smart-grid systems*
7.3 By 2030, double the global rate of improvement in energy efficiency UN Global Indicator *7.3.1 Energy intensity measured in terms of primary energy and GDP*	**National Indicator:** *7.3.1 Energy intensity measured in terms of primary energy and GDP, (in megajoules per rupee)* **Interlinked national indicators::** *1.5.2: Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies, (similar to Indicator 11.b.2)* *8.2.3: Annual growth in the manufacturing sector, (in percentage)* *11.b.1: Whether the country has adopted and implemented national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030* *13.2.2: Achievement of* *Nationally Determined Contribution (NDC) Goals in post-2020 period*	Wide-ranging STI-interventions for SDG-7 should cumulatively help achieving progress on this indicator

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 UN Global Indicator: *7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems*	*National Indicator is under development*	
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 UN Global Indicator: *7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)*	**National Indicator:** *7.b.1 Installed renewable energy generating capacity in developing countries, in watts per capita* **Interlinked national indicators:** *9.4.1: Total CO2 emissions of power sector per unit of GDP (in Tonne/Rupees Crore)* *12.a.1: Installed renewable energy generating capacity in the country (in watts per capita) (Similar to 7.b.1)* *12.1.1: Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies* *13.2.2: Achievement of Nationally Determined Contribution (NDC) Goals in post-2020 period* *15.b.1: Percentage of government spending on environmental protection to total government expenditure*	• *a) Indigenous solar systems for industrial, household, and agriculture uses (solar pumps)* ***(Can be shared with other countries)*** • *Lithium□ion & alternate battery technologies* • *Windmills &Biomass gasification* ***(Can be shared with other countries)*** • *Bagasse cogeneration, solar & waste-to-energy, biomass gasification in rural and industrial areas.* • *Solar water heating solutions* ***(Can be shared with other countries)*** ***Emerging Technologies*** • *Alternate solar panel systems (Perovskite cells)* • *Alternate battery technologies* • *Smart-grid systems* • *Hybrid sources - Aero generators/hybrid systems* • *Watermills, Tidal wave systems*

Source: Complied by RIS.

These challenges open two different areas of intervention. Given that there are several technology solutions available that might overcome these needs, it is crucial to assess and categorize these alternatives first as existing, emerging and new. We may also assess loopholes in the current technological landscape through this categorization. This knowledge may be very helpful in directing research funds toward cutting-edge solutions that fill these gaps.

Target Specification Illustration: Identifying the nature of Technology Needs

Based on the above mentioned mapping SDG Targets and Indicators the key areas of intervention with regard to STI inputs are accessible electricity and access to clean cooking fuel, particularly among rural communities. The upcoming technologies have made it much easier for the population to have accessible electricity and clean cooking fuel. Emerging technologies like sensors, Smart Grid, etc. are gradually put up in use in this area.

Target 7.1 states to achieve universal access to affordable, reliable, and renewable energy services for all. To increase the supply and consumption of renewable energy, biomass gasification, household biogas plants, decentralised non-fossil energy systems, low-cost solar PV systems with lithium-ion batteries, and digital tools are being used. Alternative solar panel systems (Perovskite cells), alternative battery technologies including Zinc ion, Redox Flow, solid state, biomass cooking stoves, and low-cost biomethane systems are some other supporting technologies that will support to achieve the target.

Target 7.3 aims to double the global rate of improvement in energy efficiency. Wide-ranging STI-interventions for SDG-7 should cumulatively help achieving progress on this indicator. The introduction of new technologies has to be complemented with effective communication and campaigning also so that people can adapt themselves more readily.

To illustrate this process PM KUSUM can be taken as an example. This mission is set out to address one of the challenge discussed earlier i.e access to clean and renewable energy (Availability of electricity at

affordable price in the villages). In terms of technological intervention, solar powered pumps are made available to our farmers, as are sources for de-dieselised irrigation to the agricultural sector. The Mission looks for new and emerging technology like smart grid, Internet of things, and Sensor to achive this target. The Ministry of Power, New and Renewable Energy established a Technical Committee to give technology suggestions for building solar projects smaller than 500 kW in Indian states. Furthermore, the Ministry has been sponsoring R&D initiatives in these areas.

2.4 Conclusion

After distilling the scope of the indicators and careful interpretation of the targets, further value addition needs to be undertaken in terms of selecting key indicators that can be directly linked with STI interventions. It has to be understood that achievement of a specific SDG and fulfillment of a related target may be dependent on several factors including conducive legislative, legal and policy action; good governance; deployment of institutional resources; better planning and administrative management; inculcation of scientific bent of mind, enhanced use of scientific monitoring methods focused on outcome and impact; ushering social behavioural change; and mainstreaming outreach and participatory approaches. While ICT tools are increasingly ubiquitous that may help all of the above, the same may not be accessible to all implementing agencies across countries. This is certainly an area that needs to be considered for robust STI for SDGs roadmaps.

As explained above, indicators are linked with both quantitative and qualitative measures covering a substantial part of what each target seeks to achieve. Initially we select those indicators that highlight development/sustainability parameters, which throw up significant scientific challenges emerging out of the nature of the development gap and the complexity of the problem based on considerations of access, equity and inclusion as well as sustainability dimensions. In other words, there should be reasons to argue that with use/availability of existing or potential STI solutions the indicator should achieve desired values at a much accelerated pace. It could also be the case that diffusion of already available STI solutions should be a big

factor in achievement of the indicator as well as the target. In certain cases, it is obvious that given the enormity or the complexity of the challenge, existing STI solutions may be grossly inadequate and all countries may not be in a position to develop, acquire or access STI solutions.

Endnote

[1] UN Guidebook for preparation of STI for SDGs Roadmap


RFID Reader
Camera
Weighbridge (existing integration)
Vehicle GPS
Mobile Tower
MGI Data Center
Fuel Level Sensor

3 Accelerating Achievement of SDGs through STI:
Transformative Role of Flagship Initiatives

India's Flagships programmes are instrumental in achieving the Sustainable Development Goals and narrowing down the gaps in terms of demand and last mile delivery.

3.1 Introduction

India's Flagships programmes are instrumental in achieving the Sustainable Development Goals and narrowing down the gaps in terms of demand and last mile delivery. Science, Technology and Innovation has been a major component in operationalisation, monitoring and evaluation of the flagship schemes which are directly linked with four goals namely, SDGs 2,3,6 and 7. The following chapter provides a detailed overview of the Flagship schemes in terms of its purpose, targeted beneficiaries, alignment with SDGs and the technological ecosystem of the programme.

The Flagship Programmes of Government of India studied for their role in deepening STI for SDGs are as follows:

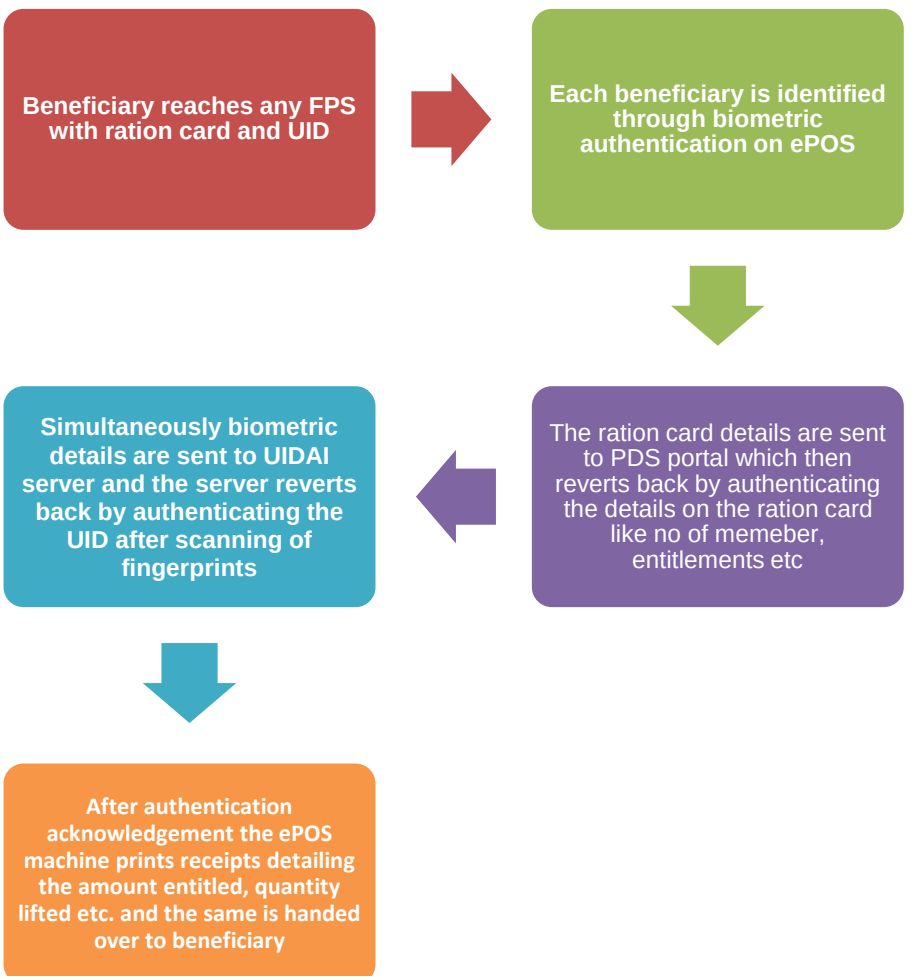
3.2 SDG 2 - Zero Hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

3.2.1 One Nation One Ration Card (ONORC)

India began focusing on the issue of hunger and food security in 1960s when it launched the programme for Universal Food Distribution, which gradually

transformed into Targeted Public Distribution System (TPDS) in year 1997, with special focus on poor and disadvantaged section of the population (MoCAF&PD, 2022). Subsequently in 2013, Indian Parliament passed National Food Security Act (NFSA), making "Right to Food" a justifiable right whereby the beneficiaries were legally entitled for receiving their share of subsidized food grain. NFSA covers approximately 81 crores individual throughout the country and has been instrumental in addressing the issue of hunger and food security. As per the NFSA 2013, the Union government is in charge of procuring, storing, transporting, and allocating food grains across States and UTs, while the respective State governments and UTs are in charge of beneficiary identification, distribution of food grains from Fair Price Shops (FPS), licencing and overseeing FPS (MoCAF&PD 2022).

Figure 3.1: Flow Chart of PDS Biometric Authentication



Source: Developed by RIS.

Over the years, the constant push towards increasing digitalization in PDS has ensured transparency and better monitoring of a large scale programme. Till December 2021, 23.5crore ration cards covering around 80crore beneficiaries are fully digitalized and 31 States and UTs are operating on computerized end-to-end supply chain management of food distribution from purchasing of food grain to allocating the grains in FPS. Similarly, for the withdrawal of food grain by beneficiaries has been digitalized through installation of electronic point of sale machines (e-PoS). As of December 2021 around 5.13 lakh FPS out of 5.33 lakh FPS are operational through ePoS machines (MoCAF&PD, 2022)

However, one of the major shortcomings of the PDS mechanism was that, it allowed entitled individual/ household to withdraw their share of food grain only from a designated Fair Price Shop (FPS) allotted in their respective domicile city. This made the PDS technically inoperative for large number of beneficiaries- migrant workers, daily wage labourers, domestic workers etc who frequently migrate due to employment and livelihood concerns. The issue particularly came at the forefront during the Covid-19 pandemic and subsequent nation-wide lockdown.

The unprecedented circumstances paved the way for the nationwide rollout of the One Nation One Ration Card scheme (ONORC) which enabled the beneficiaries particularly the migrant workers, daily wage labourers, domestic workers etc. to withdraw their share of entitled food grains from any FPS shop across the country. The scheme also allows the family members of the migrant worker listed in the same ration card to lift the balance or required share of food grains from any Fair Price Shop across the country (MoCAF&PD, 2021).

The ONORC was operationalised by synchronizing the technological component already present in the PDS scheme and innovating new platforms for data assembling, transmission and monitoring. The data from the PDS server was made available from the FPS automation sales application to the ePOS machines installed with biometric scanner. The PDS server will in turn verify the beneficiary's identity through biometric authentication from the UIDAI server in real time. The transactions data records and support system is provided by two portals – Integrated

During the Covid-19 period of April 2020 to June 2021 around 640 million portable transaction amounting to INR 360 billion equivalent of food grain were distributed under ONORC

Management of Public Distribution System (IM-PDS) and *Annavitran* where the former hosts the record of inter-state transaction the latter host the record for intra-state transaction.

The roll out of ONORC is a promising step in achieving the targets of Sustainable Development Goal 2 "Zero Hunger" particularly;

Target 2.1: By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

During the Covid-19 period of April 2020 to June 2021 around 64 crore portable transaction amounting to RS 36,000 crore equivalent of food grain were distributed under ONORC (MoCAF&PD, 2022).

3.2.2 Poshan Abhiyaan

On March 8th, 2018, the Indian government introduced Poshan Abhiyaan. The objective of Abhiyaan is to improve the nutritional status of teenage girls, pregnant women, breastfeeding mothers, and children aged between 0 and 6 through targeted intervention. It brings convergence in the approach of several programs such as National Rural Health Mission, Mid-Day meals, Integrated Child Development Scheme, Sarva Shiksha Abhiyan and others to target the specific needs of the nutrition and health (MoW&CD, 2022).

Poshan Tracker is one of the major ICT based components of the programme which enables the authorities to monitor and assess the reach and efficacy of the Poshan Abhiyaan. The Poshan Tracker, was earlier known as the Integrated Child Development Services-Common Application Software (ICDS-CAS) developed by the National e-Governance Division, Government of India. The Poshan tracker will give real-time data of beneficiaries (children in particular) to the authorities on factors like their height, weight, and immunisation status. This data, when followed over time, would indicate a child's growth trajectory and notify officials if the child is stunted, wasted, or underweight. Apart from the growth status the application also records attendance of children, daily distribution of cooked meal, vaccination and nutrition status of pregnant women/lactating mothers among other important indicators (MoW&CD, 2021).

The government hosts a Poshan Tracker dashboard online which provides details at National, State and District level. This includes total beneficiary registered, take-home ration delivered and hot cooked meals served. The dashboard also has Poshan calculator to measure the growth of a child based on WHO standards.

The Poshan tracker application and its inbuilt technological component will be instrumental in monitoring the progress towards Sustainable Development Goal 2 particularly;

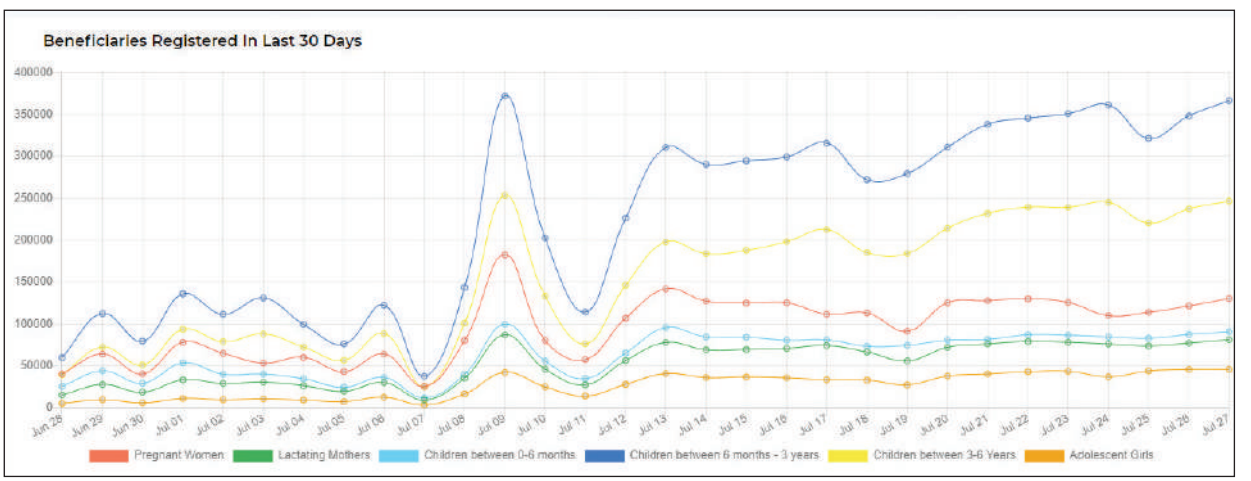
Target 2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older person.

Through the Poshan Tracker mobile application, about 1.26 million Aganwadi Centers (AWCs) are updating daily data on child and women's health.

The SDG targets are monitored through various indicators developed by MoSPI linked to stunting and wasting among children, nutritional status of adolescent girls, pregnant women and lactating mothers. In this direction Poshan tracker will help the authorities to narrow down the targeted intervention at the individual or block level to address challenges of nutrition in child and maternal health.

Through the Poshan Tracker mobile application, about 12.63 lakh Aganwadi Centers (AWCs) are updating daily data on child and women's health. The States and UTs

Figure 3.2 Snapshot of Poshan Tracker Dashboard



Source: Poshan Tracker Dashboard (MoW&CD, 2022).

have procured around 11.03 lakh smartphones and 11.94 lakh growth monitoring devices through the Government e-Marketplace (GeM) Portal. Furthermore, government has provided training to more than 10 lakh frontline functionaries on thematic modules at state, district and block level (MoW&CD, 2022).

3.2.3 Electronic-National Agriculture Market (e-NAM)

Scattered agriculture markets in India apart from being a major bottleneck in realizing the remunerative prices of agriculture produce which mostly affect small and marginal farmers and has also been a significant contributor towards volatility in agricultural prices which translated into the inflationary pressure affecting the poor and vulnerable sections of the society. The spread and number of agriculture markets –commonly known as "Agriculture Mandis"- in India has been widely inadequate which act as a barrier in price discovery for agriculture produce (National Commission on Farmers, 2006).

The Electronic National Agriculture Market (e-NAM) provides a platform to address such anomalies in agricultural markets. The e-NAM is a "virtual" market but it has a physical market (agriculture mandi) at the back end from where the regular market process takes place. It is a Pan-India electronic trading platform which brings all the registered agriculture mandi's into a common network and provides extensive services online to both buyers and sellers for example – details of commodity arrivals, quality testing, electronic payment settlement.

Through e-NAM traders would be able to choose from a wide variety of agriculture produce available in the registered Agriculture Produce Market Committees (APMC) mandis reducing the possibility of food shortages/ surplus leading to price stability. The farmers are expected get fair and better remunerative prices for their produce due to online bidding and real time price discovery.

The Small Farmers Agribusiness Consortium (SFAC) has been mandated to serve as the Lead Implementing Agency of e-NAM by the Department of Agriculture Cooperation and Farmers Welfare (DoACFW). With the assistance of a Strategic Partner, currently Nagarjuna Fertilizers and Chemicals Limited, SFAC runs and maintains the e-NAM

platform (NFCL). The DoACFW's technical partner, National Informatics Centre (NIC), is in charge of hosting the e-NAM platform on the *Meghraj* cloud. NIC is also mandated to provide and maintain the entire necessary digital and physical infrastructure including virtual machines (servers), base operating systems, firewall, load balancers, SMS and email services etc.

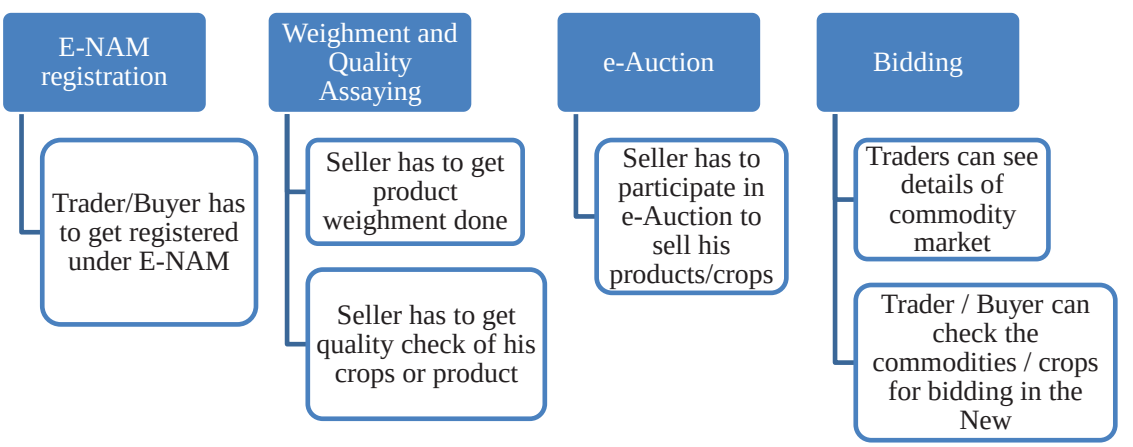
Around 17.2 million farmers have registered themselves in E-NAM and agricultural trade of around INR 1820 billion have been done through the platform

Apart from the necessary virtual market instruments various modules were also added in e-NAM to enhance the supply chain management operations of agricultural produce namely, Negotiable Warehouse Receipt to facilitate the trade from warehouse itself. Next to this, there is a Logistic Module where the information regarding logistic vehicles operating in the area is provided. Recently Farmer Producer Organization's (FPO) trading module has been launched where FPOs can sell their produce from their collection centre without bringing the produce to agriculture mandi.

e-NAM addresses informational asymmetries and regional constraints with respect to agriculture markets and thus has been an important contributor in achieving "Sustainable Agriculture" under SDG 2 particularly;

Target 2.c: Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

Figure 3.3: Workflow of E-NAM



Source: Developed by RIS.

Target 2.c is monitored through the indicator directly related to the reach of e-NAM i.e. Indicator *2.c.1: Percentage of agriculture mandis enrolled in e-market.*

As of March 2022 about 1000 APMCs (15.10 percent) of the total 6946 APMCs have been enrolled in E-NAM across 18 states and 3 UTs. Furthermore, around 1.72 crore farmers have registered themselves in E-NAM and agricultural trade of around 1.82 lakh crores have been done through the platform (MoA&FW, 2022). The participation of FPO are encouraging within just one year its inclusion as many as 1,856 FPO are registered on e-NAM.

3.3 SDG 3 - Good Health and Well-being: Ensure healthy lives and promote well-being for all at all ages

3.3.1 The Pradhan Mantri Jan Arogya Yojana (PM-JAY)

Around 170 million people have received Ayushman cards as of March 2022, and the programme has allowed more than 36 million hospital admissions, worth INR 370 billion

The challenge of affordable healthcare has been a major policy issue which required multi-layered interventions and collaboration of technological components with the existing health infrastructure. To address the issue of affordability in healthcare, Government of India announced the Pradhan Mantri Jan Arogya Yojana (PMJAY) also known as Ayushman Bharat scheme which seeks to provide health cover of up to Rs. 5,00,000 per family per year and 3 days of pre-hospitalization and 15 days of post-hospitalization expenses to the bottom 40 percent of poor and vulnerable population; this is close to 10.74 crore households (MoH&FW, 2021).

The inclusion of households is based on the deprivation and occupational criteria of the Socio-Economic Caste Census 2011 (SECC 2011) for rural and urban areas, it also includes families that were covered in the Rashtriya Swasthya Bima Yojana (RSBY) but were not present in the SECC 2011 database. The beneficiary can avail the benefits across the country, irrespective of domicile state - in hospitals empanelled with PM-JAY (MoH&FW, 2021)

The technology deployed through PMJAY has been the identification and request approval mechanism known as PMJAY Beneficiary Identification System (BIS) which collects the data from four different databases namely; entitled SECC database, entitled RSBY database, additional data collection drive database and state health scheme

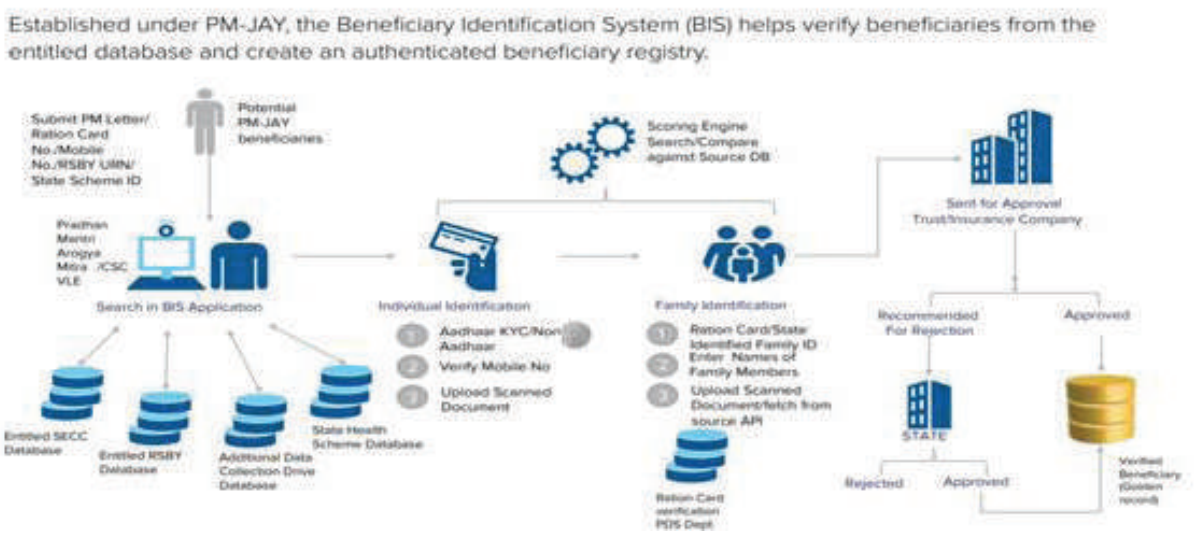
database. The subsequent request is then forwarded for the individual verification through Aadhaar number or mobile number which also subsequently is verified from the family details accessed through ration card verification department. Lastly the request is sent to the insurance company for approval.

The entire platform operates on a sound IT ecosystem which is an API gateway platform with 3 layers operating at a time namely the access layer, business support and data management layer and security and system support layer.

Health is a State subject under the Seventh Schedule of the Constitution. PMJAY has enabled convergence in aligning the state schemes with that of the Union government. Many States are already implementing their own health insurance schemes with a set of beneficiaries already identified. Thus, States have been provided the flexibility to use their own database for PM-JAY. However, they will need to ensure that all the families eligible based on the SECC database are also covered. PM-JAY provides the States with the flexibility to choose their implementation model. They can implement the scheme through assurance/trust model, insurance model or mixed model.

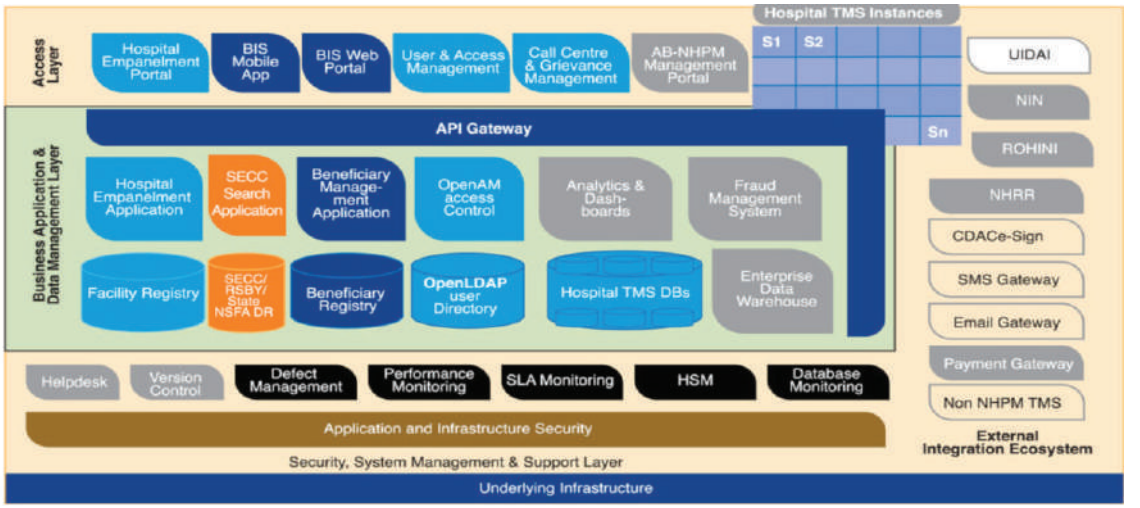
The flagship programme also encompasses varied interconnected health services through technology both

Figure 3.4: Flowchart of BIS under PM-JAY



Source: National Health Authority, 2022.

Figure 3.5: Technological Ecosystem of PM-JAY



Source: National Health Authority, 2022.

for proper monitoring by authorities and availing services by the beneficiary. PM-JAY Dashboard is effective for monitoring transactions, understanding utilization trends, datasets integrated into PM-JAY Data warehouse, Hospital Empanelment System to allow the hospitals to registers and request for empanelment under the scheme, National Portability (an IT ecosystem system) to allow beneficiaries to avail the scheme benefits throughout the country.

PM-JAY Scheme covers the mandate of SDG 3: Ensure healthy lives and promote well-being for all at all ages. The following is the subsequent SDG target;

Target 3.8: Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.

Around 17 crore people have received Ayushman cards as of March 2022, and the programme has allowed more than 3.6 crore hospital admissions, worth Rs 37,000 crore (MoH&FW, 2022).

3.3.2 National Digital Health Mission (NDHM)

India over the years has developed a multi-layered health infrastructure with primacy health centres being the first respondent to any health emergencies or treatments at panchayat or block level for a significant percentage of the population. Above that there are community health centres at village or taluk level and then district hospitals

The components of NDHM consist of Health ID, Personal Health Records, Health Professional Registry, Health Facility Registry (HFR), e-Pharmacy, and Telemedicine.

or multi-specialty hospitals as the uppermost layer of health infrastructure, majorly concentrated in urban metropolis. The asymmetrical spread of quality health infrastructure in terms of its geographical concentration has resulted in constraining the access to quality health services.

In this backdrop, GOI launched National Digital Health Mission (NDHM) in 2020, as a digitally empowered health ecosystem to streamline the access towards quality health services. NDHM is a digital health ecosystem under which every citizen will have a unique health IDs, digitized health records with identifiers for doctors and health facilities. The technological structure is based on a federal architecture that will consist three layered applications, based on the usages starting from the district level to state and national level. The technological ecosystem will be an Open API based ecosystem developed by adopting India Enterprise Architecture Framework (IndEA). All the building blocks and components of NDHM will conform to open standards, be interoperable and based on Open Source Software products and open source development (National Health Authority, 2020).

The components of NDHM consist of Health ID, Personal Health Records, Health Professional Registry, Health Facility Registry (HFR), e-Pharmacy, and Telemedicine. Brief descriptions of components are as follows:

- Health ID – Every individual who voluntarily enrolled will be provided with a unique Health ID issued against their Aadhaar numbers or any other government ID. The Health ID will be linked to multiple data consent managers in order to allow proper consent while sharing the health data.
- Personal Health Records – (PHR) will consist of health records of the individuals comprising all health data, lab reports, treatment details, hospitalization and post hospitalization treatment summaries etc. However, various consent manager applications will be linked to the PHR when and wherever the records needs to be shared.
- Health Professional Registry – A registry of all doctors across the country enrolled along with their specializations and other details.
- Health Facility Registry – It will be the master open registry with public data of all the health entities in the ecosystem including hospitals, clinics, laboratories,

India has taken initial steps of implementation of eVIN-like systems in Malawi, Sudan, and Afghanistan as part of South-South and Triangular Cooperation

pharmacies, and insurance companies. Each health facility (hospital, clinics, laboratories etc.) will be identified with a unique ID.

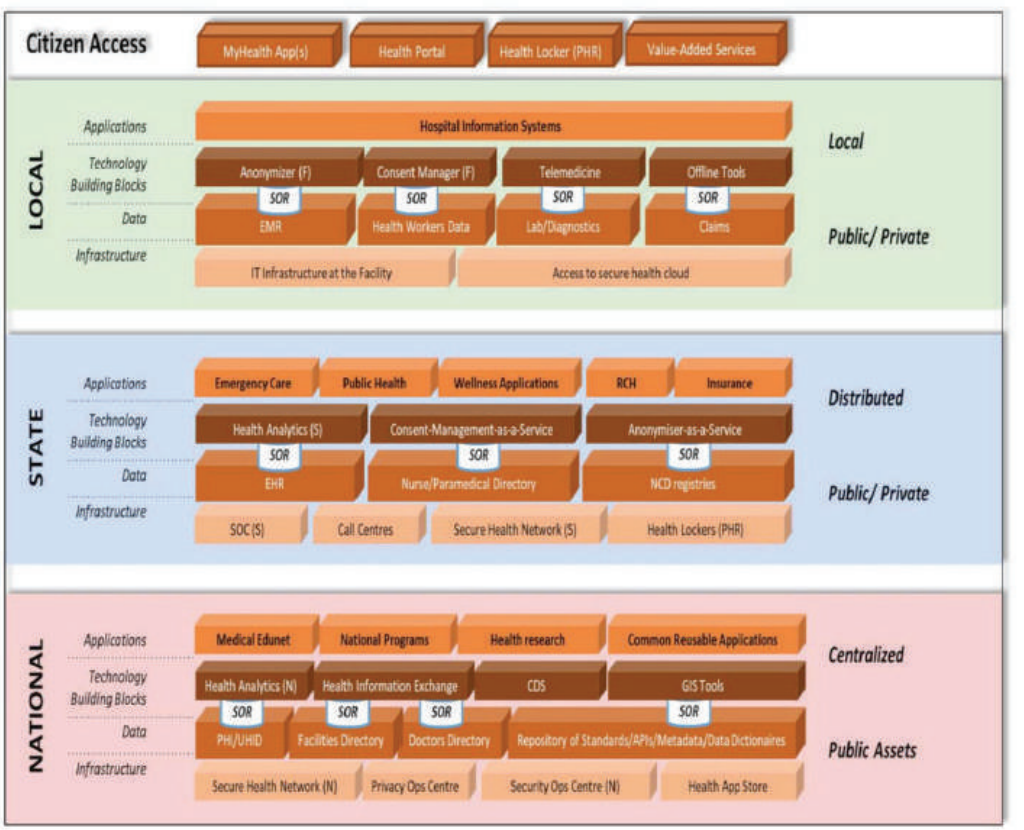
- E-pharmacy and Telemedicine – NDHM has enabled technological platforms that are centralized, government created, owned, operated and managed engines to standardize and provide better utilization of e-pharmacy and telemedicine services with participation from small sized pharmacies, individual doctors, etc.

The rollout of NDHM covers the mandate of SDG 3: Ensure healthy lives and promote well-being for all at all ages. The subsequent target corresponding with National Digital Health Mission:

Target 3.8: Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.

Around 6000 doctors and 15000 health facilities have registered themselves in their respective health registries

Figure 3.6: Technological Layers and Ecosystem under NDHM



Source: National Health Authority, 2020.

as of January 2022, and around 15 crore individuals had created digital health IDs, popularly known as ABHAs (Ayushmaan Bharat Health Accounts) (MoH&FW, 2022).

3.3.3 Mission Indradhanush

Vaccinations of pregnant women, newborns and infants play an important role in ensuring healthy lives by protecting them from life threatening diseases and viruses. India since 1985 has rolled out the Universal Immunization Programme (UIP) that targets nearly 2.7 crore new-borns and 2.9 crore pregnant women per year. About 1.2 crore routine immunization (RI) sessions are planned annually, with vaccines stored across ~29,000 cold chain points and distributed to the session sites through Alternate Vaccine Delivery Systems (AVDS) in cold chain. UIP offers vaccines against 11 Vaccine Preventable Diseases (VPDs) nationwide including Polio, Measles, severe form of Childhood Tuberculosis and Hepatitis B among others and Japanese Encephalitis (JE) in endemic districts (MoH&FW, 2022)

GOI launched Mission Indradhanush, a special vaccination drive and upgraded version of UIP in December 2014. The mission targeted unvaccinated and partially vaccinated children less than 2 years of age to reach more than 90 percent full immunization coverage and unvaccinated pregnant women.

The Immunization Supply Chain and Logistics (ISCL) system provides technological support to the Mission by ensuring the proper storage of vaccines at appropriate temperatures and timely delivery of vaccinations from producers to peripheral health facilities.

The network ecosystem used in storage, transportation and delivery of vaccines under Mission Indradhanush is Electronic Vaccine Intelligence Network (eVIN), which is an innovative technological solution aimed at strengthening immunization supply chain systems across the country implemented under National Health Mission (NHM) by the Ministry of Health and Family Welfare. It aims to provide real-time information on vaccine stocks and flows, and storage temperatures across all cold chain points in the country and has reached 32 States and Union Territories (UTs).

Electronic Vaccine Intelligence Network (eVIN) was indigenously developed by the Immunization Technical Support Unit (ITSU) in collaboration with UNDP and

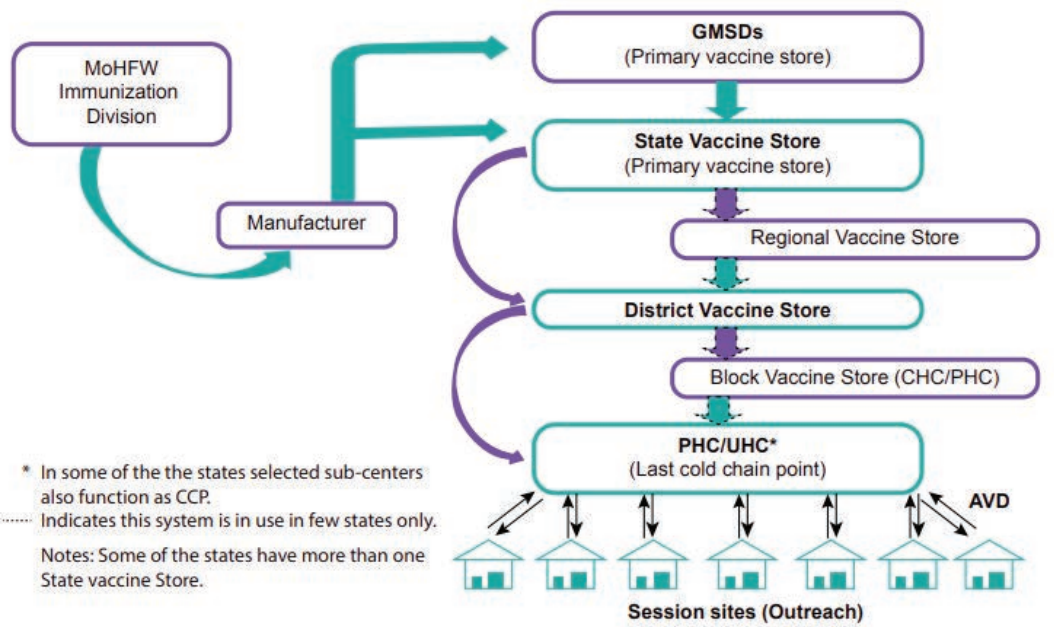
In 61 districts impacted by the Japanese Encephalitis-Acute Encephalitis Syndrome, more than 11.5 Million households (38 per cent) now have access to clean drinking water.

was rolled out using GAVI Health System Strengthening (HSS) support. The e-VIN network provides real time info on vaccine stock inventory and storage temperature from every vaccine storage and cold chain point situated in peripheral government health facilities using cell phones, web-based applications, temperature loggers, and a cloud-based server. The National Cold Chain Management Information System is available to track the availability of vaccine, cold chain equipment inventory, availability and functionality (MoH&FW, 2018).

The broad objective of the Mission Indradhanush covers the mandate of SDG 3: Ensure healthy lives and promote well-being for all at all ages. The SDG 3 targets which the scheme specifically covers are the following:

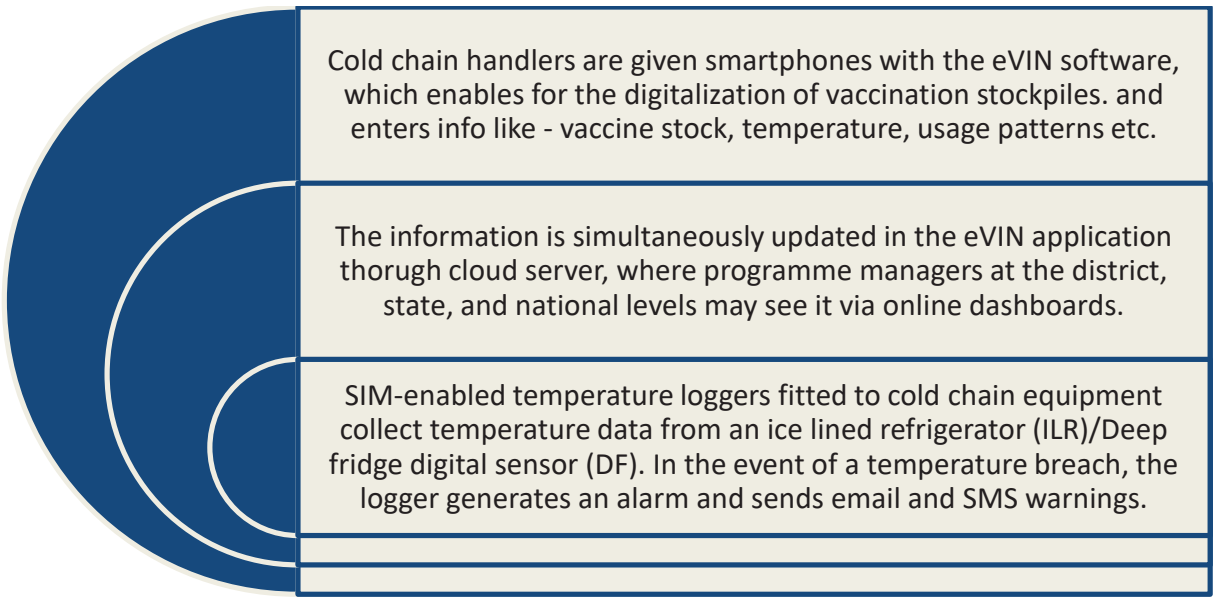
- Target 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 1,00,000 live births
- Target 3.2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births

Figure 3.7: Flowchart of Distribution System Under Mission Indradhanush



Source: Handbook for vaccine & cold chain handlers, India 2016.

Figure 3.8: e-VIN Operating Flowchart Mission Indradhanush



Source: Developed by RIS.

- Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, waterborne diseases and other communicable diseases

The eVIN system is being routinely used in 23,507 cold chain sites spread over 585 districts in 22 States and 2 UTs to manage vaccination logistics effectively. More than 41,420 vaccine cold chain handlers have been exposed to digital record-keeping and about 23,900 electronic temperature recorders have been put on vaccine cold chain equipment (MoH&FW, 2020).

Integration of an end-to-end supply chain solution initiated from the manufacturer till the vaccination session site is envisaged in eVIN Advance Edition (AE). The eVIN AE complies to the security protocols and best practices mandated worldwide and also that of the Government of India. eVIN AE is a wholly open-source platform, to provide integrated supply chain digital solution from the producer to the immunization sites.

Sistem Monitoring Imunisasi Logistik secara Elektronik (SMILE), Indonesia implemented India's eVIN technology in 2018 and was successful in digitizing their nation's immunisation supply chain. Likewise UNDP India has

assisted with the initial steps of implementation of eVIN-like systems in Malawi, Sudan, and Afghanistan as part of South-South and Triangular Cooperation (UNDP India, 2022).

3.4 SDG 6 - Clean Water and Sanitation: Ensure availability and sustainable management of water and sanitation for all

3.4.1 Jal Jeevan Mission (Grameen)

Access to clean and drinking water is one of the policy challenges that require innovative technological solutions pertaining to the constraints posed by natural resource availability and geographical diversities. Moreover the problem gets exacerbated due to the excess or unrestrained use of water resources available at the sites which are naturally endowed with water resources. The challenges are not only about affordability and accessibility but also monitoring, evaluation and recycling of natural resources.

In this background Jal Jeevan Mission (JJM) was rolled out to provide Functional Household Tap Connection (FHTC) to every rural household by 2024. Every FHTC will receive 55 litres per capita per day (lpcd) of water of prescribed quality (BIS:10500). Providing functional tap connections to schools, Anganwadi centres, health centres, wellness centres, and community buildings, as well as monitoring the functionality of tap connections, are some additional objectives (MoJS, 2019). The scheme mandates ensuring the sustainability of the water supply system, which includes the identification, monitoring and assessment of water source, water supply infrastructure among others.

The Department of Drinking Water and Sanitation (DDWS) has developed in collaboration with other institutes – a number of instruments for identification and monitoring of water resources and water quality and overall evaluation of JJM. Few innovative instruments deployed under the JJM are use of Hydro-Geo-Morphological (HGM) Maps developed in collaboration with National Remote Sensing Centre (NRSC), Hyderabad for locating groundwater sources; GIS technology for finding locations of existing water source; village digital 3D contour maps prepared by MeITY for location of drinking water infrastructure; digital inventory of existing assets and

overlaying them on GIS map; sensors for monitoring water level, discharge, water quality, automatic motor operation, data logger for capturing the date; Supervisory Control and Data Access (SCADA) system in Multi Village Scheme (MVS) for monitoring treatment plants and distribution system; IoT for capturing and transmitting the above data using mobile networks for analysis; GIS technology and IoT based sensors to monitor the status of functionality of assets and Solar Energy based stand-alone water supply systems for scattered/ isolated/ tribal/ hilly villages. (Operational Guidelines For The Implementation of Jal Jeevan Mission Har Ghar Jal- Government of India Ministry of Jal Shakti Department of Drinking Water and Sanitation National Jal Jeevan Mission (MoJS, 2019)

Monitoring and evaluation is one of the major component under JJM. The monitoring mechanisms comply with the global standards, viz. Global Competitiveness Index (GCI) its two indicators namely exposure to unsafe drinking water and reliability of water supply. The functionality, regularity, appropriate quantity and at the required quality of every Functional Household Tap Connection (FHTC) and other water sources provided or established under the scheme will be recorded on a real-time basis through IoT-based sensors and iCloud servers and the information will be updated and displayed on a dedicated JJM IMIS dashboard.

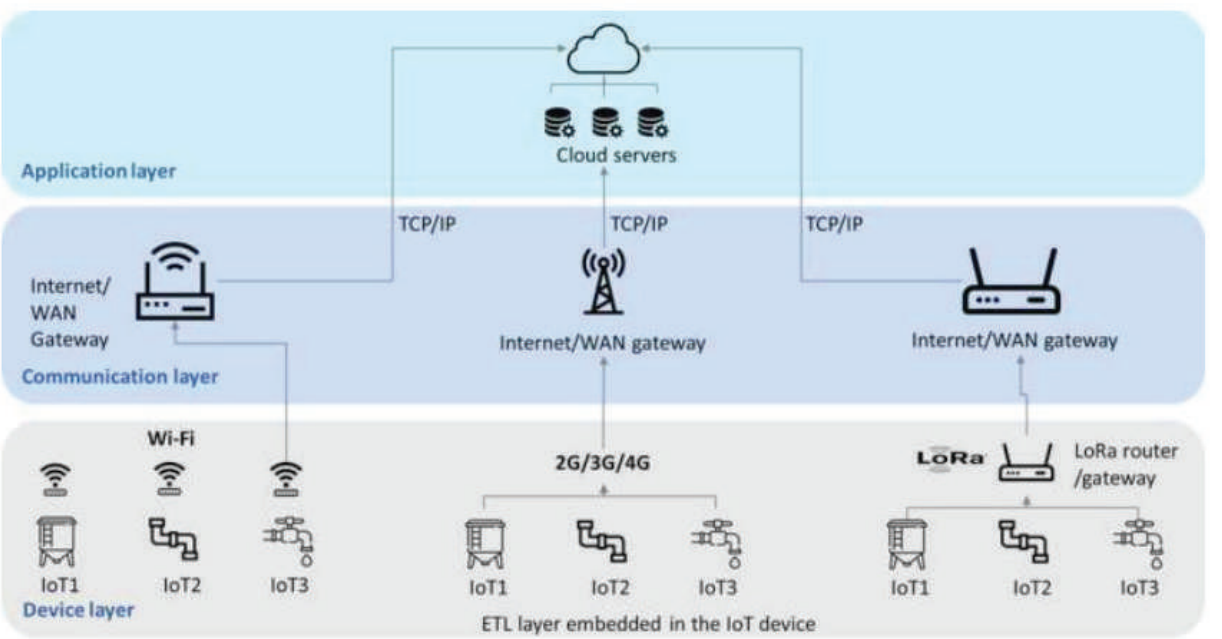
A Data and Documentation Center will be established to oversee the mission's implementation. The National Informatics Center (NIC), will serve as the center and state governments primary service provider and function as an IT consultant. NIC will also be in charge of managing the Integrated Management Information System (IMIS).

The objectives of Jal Jeevan Mission broadly cover the mandate of SDG 6: Ensure availability and sustainable management of water and sanitation for all. JJM mission is directly linked with the following SDG target along with its monitoring indicators.

- *Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all*
  - » Indicator 6.1.1: Percentage of Population getting safe and adequate drinking water within premises through Pipe Water Supply (PWS)
  - » Indicator 6.1.2: Percentage of population using an improved drinking water source (Rural)

As of August 2022, 10 crore (51 percent) rural households out of the total 19.27 crore rural households have access to FHTC, among these FHTC around 6.5 crore (31 percent) FHTC was installed since the beginning of JJM. (MoJS, 2022). In 61 districts impacted by the Japanese Encephalitis-Acute Encephalitis Syndrome, more than 1.15 crore households (38 percent) now have access to clean drinking water. More than 9.13 lakh women have received training to assess water quality using Field Test Kits (FTKs) that measure pH, alkalinity, chloride, nitrate, total hardness, fluoride, iron, residual free chlorine, and H2S to check for water quality. Around 8.46 lakh schools (82 percent), and 8.67 lakh (78 precent) Anganwadi Centers in the country now has access to potable tap water for drinking, cooking midday meals, handwashing, and bathroom use. Likewise, 93 thousand rainwater harvesting facilities and 1.08 lakh grey water reuse structures have been developed in schools across the country (MoJS, 2022). Household having access to tap water in 117 Aspirational districts has been now been increased to 48 percent which was only 7.57 percent prior to the launch of the mission. To ensure the water quality around 2070 water testing laboratories has been developed and empaneled across the country (MoJS, 2022).

Figure 3.9: Flowchart of Data Collection and Cloud Computing Under JJM



Source – Technical Expert Committee Report (MoJS, 2021)

3.4.2 Swachh Bharat Mission (Grameen)

Swachh Bharat Mission – Grameen (SBM-G) was launched on October 2, 2014, with the objective of making villages in the country Open Defecation Free (ODF) by October 2, 2019. Between 2014–15 and 2019–20, more than 10.28 crore toilets were built as part of the initiative (MoJS, 2021)

Phase-II of the SBM(G) was initiated by the Indian government on February 19th, 2020. It is scheduled to be implemented from 2020–21 to 2024–25 with an aim to develop ODF Plus villages that integrate ODF sustainability with solid and liquid waste management (SLWM) (MoJS, 2021).

There is comprehensive web-based online monitoring mechanisms in place for SBM(G). For incorporating household level data obtained from the Baseline Survey, the Online Monitoring System of the Swachh Bharat Mission (Gramin) is being developed.

The SBM made great use of digital solutions for thorough monitoring. For a real-time update, each toilet was geo-tagged and was mapped on Integrated Management Information System (IMIS) to ensure that the process is transparent. A module for monitoring ODF is also available on the IMIS. Further, the IMIS provides for a module, whereby, the States/districts can transfer incentive funds directly to the community as a whole.

The technology and innovative instruments being used for Swachh Bharat Mission is very localised and can be leveraged through community participation on their installation and monitoring. Innovative technological solutions for biodegradable waste management include - Earthen pot composting, Permanent tank composting and Rotary drum composting.

Similarly, technological solutions for bio gas generation includes - Floating Drum type/KVIC Model Biogas Plant, Deshbandu Model Biogas Plant, Fixed Dome PAU Janta Model biogas Plant. Technological solutions deployed for Greywater management includes - Community Leach pit, Water stabilization ponds, Constructed Wetlands, Decentralized Wastewater treatment system and Phytorid technology (MoJS, 2017).

Swachh Bharat Mission covers the mandate of *SDG 6: Ensure availability and sustainable management of water and sanitation for all* and is directly linked with the subsequent SDG target and its monitoring indicator.

- *Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations*
  - » 6.2.1: Proportion of households having access to toilet facility (Urban & Rural)
  - » 6.2.2: Percentage of Districts achieving Open Defecation Free (ODF) target.
  - » 6.2.3: Proportion of schools with separate toilet facility for girls

A total of 53,066 community compost pits and 10.4 lakh household-level Solid Liquid Waste Management assets have been built, and 1249 villages have identified themselves to be ODF plus. So far 34 bio gas plants have been completed in order to have waste disposal facilities (particularly cow dung and organic farm waste) at village level (MoJS, 2021).

3.5 SDG 7 - Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable and modern energy for all

3.5.1 Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM)

The Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) Scheme has been introduced by the Ministry of New and Renewable Energy (MNRE) to assist farmers in installing solar pumps, grid-connected solar, and other renewable power plants. By 2022, the scheme seeks to install 30.8 GW of solar and other renewable energy capacity.

Farmers can sell surplus power generated by solar power plants to State DISCOMS at pre-determined tariffs which enables the farmers to have an alternative source of income (MoNRE, 2021).

The Scheme consists of three components:

- **Component A:** 10,000 MW of Decentralized Ground Mounted Grid Connected Renewable Power Plants of individual plant size up to 2 MW to be set up by individual farmers of FPO or other organizations. In order to reduce the high cost of transmission cables and losses, the solar power plants will ideally be positioned within a five km radius of the sub-stations.

- **Component B:** Installation of standalone Solar Powered Agriculture Pumps of individual pump capacity up to 7.5 HP. This component will provide accessible clean energy to farmers in off-grid regions, where there is no source of electricity. Since the agricultural pump is required only during the farming season (approx 150 days a year), the excess energy stored in the Pump will be utilized for operating other machineries like Chaff Cutter, Floor Mill, Cold Storage, Dryer through Universal Solar Pump Controller (USPC). The Solar pumps will be equipped with remote monitoring technology to monitor the functioning on a real time basis.
- **Component C**: Solarisation Grid-connected Agriculture Pumps including through Feeder Level Solarisation. This will enable the farmers to get day-time reliable energy free of cost or tariff fixed by state governments. States may also choose solarisation at the feeder level, where a single solar plant is installed using the Renewable Energy Service Company or thorugh DISCOMs own expenditure (CAPEX) method to supply electricity to a single or a number of agriculture feeders.

States have played an important role in bringing in innovative technology to commercialize the surplus energy generation under PMKUSUM which not only address the energy deficit for the region but will also be remunerative to the farmers

PMKUSUM covers the mandate of SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all. The following are the corresponding SDG targets aligning with PMKUSUM

- *Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix*
- *Target 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*

States have played an important role in bringing in innovative technology to commercialize the surplus energy generation under PM-KUSUM which not only addresses the energy deficit for the region but, will also be remunerative to the farmers (MoNRE, 2021). Some of the initiatives are:

- Brush Less Direct Current (BLDC) Pilot in Andhra Pradesh
- Suryashakti Kisan Yojana - SKY, Gujarat
- Surya Raitha Scheme, Karnataka

In year 2019-20 and 2020-21 Union government has approved construction of 4909 MW of small solar power plants, the installation of 3.59 lakh standalone solar pumps, and the solarization of more than 10 lakh already-existing grid-connected pumps based on the request from the states. Solarization of existing Grid connected pumps has been sanctioned for 10 lakhs pumps. Under component C Rajasthan has completely solarize three pilot feeder, and 9.25 lakh feeder level solarize pumps have been distributed across states (MoNRE, 2021).

Table 3.1: A Summary Statistics of Progress made through Flagship Schemes

One Nation One Ration Card (ONORC)	
Ration cards fully digitalized	23.5crore (235 million) – Covering 80 crore (800 million) Individuals
Installation of electronic point of sale machines (e-PoS) in FPS	5.13 lakh (0.51 million) Fixed Price Shop out of 5.33 lakh (0.53 million) Fixed Price Shop
Number of ONORC Transaction	Approx 64 crore (640 million) portable transaction (between April 2020 to June 2021)
Poshan Tracker	
Anganwadi's Covered	12.63 lakh (1.3 million approx)
Smart phones with Poshan Tracker application distributed	11.03 lakh (1.1 million approx)
Growth monitoring devices procured	11.94 lakh (1.2 million approx)
e- NAM	
Agriculture mandi's enrolled under e-NAM	1000 APMCs (15.10 percent) of the total 6946 APMCs
Farmers Enrolled under e-NAM	Approx 1.72crore (17.2 million)
Agriculture Trade through e-NAM	Approx INR 1.82 lakh crores
Farmers Producer Organizations (FPOs) registered on e-NAM	1,856 FPOs
The Pradhan Mantri Jan Arogya Yojana (PM-JAY)	
Beneficiaries enrolled	Approx 17 crores (170 million) individuals
Authorized hospital admissions	6.2 crores (62 million)
Medical expenditure covered	Approx INR 37000 crores
National Digital Health Mission (NDHM)	
Digital Health Ids	15 crore individuals (150 million)
Health Facility Registry	15000 Health Facility
Health Professional Registry	6000 Doctors

Mission Indradhanush	
Cold Chain sites covered	23,507 sites in 585 districts
Personnel trained at cold chain sites	41,420 vaccine cold chain handlers
Electronic temperature recorders put up in use	23,900
Targeted population	Approx 2.7 crore (27 million) new-borns and 2.9 crore (29 million) pregnant women per year
Jal Jeevan Mission (Grameen)	
Total rural household with FHTC	10 crore (100 million)
Household covered since JJM launched	Approx 6.5 Crore (650 million)
Water Testing laboratories developed and empaneled	2070
Schools and Anganwadi's with tap water connection	8.46 lakh (0.85 million) schools (82%), and 8.67 lakh (0.87 million) (78%) Anganwadi Center
Rainwater harvesting and Water reuse facilities	93000 and 1.02lakh (0.1 million)
Training received for Water quality tests (FTKs)	9.13 lakh (0.91 million) women
Swachh Bharat Mission (Grameen)	
Toilets built under SBM	10 crore (100 million)
Solid Liquid Waste Management assets	10.4 lakh (1.04 million) household level
Biogas Plant	34
Villages Declared themselves ODF Plus	1249 villages
Rural sanitation coverage	100 per cent
Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM)	
Stand alone solar power pumps (approved)	3.5 lakh (0.35 million) pumps
Solarization of feeder	3 pilot feeder in Rajasthan completely solarized
Solarization of existing Grid connected pumps	10 lakhs (1 million) pumps (Sanctioned)
Feeder level solarization pumps	9.25 lakh (0.92 million) pumps allocated

Source: Complied by RIS.


Solar Power Plant, Vadodara, Gujarat, India

4 Positioning and Role of International Agencies and India's Contribution to the TFM

4.1 Introduction

The UN has called for a "Decade of Action" in respect of SDGs, to "accelerate sustainable solutions to all the world's biggest challenges — ranging from poverty and gender to climate change, inequality and closing the finance gap" (UN 2021). The importance of S&T and availability of innovation driven solutions, particularly to mitigate and address sustainability challenges globally has been a central theme in all important global platforms in the last decade including the Rio+20 process that led to the 2030 Agenda for Sustainable Development, the Third International Conference on Financing for Development (FfD3) leading to the Addis Ababa Action Agenda, the Climate Change negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) including COP 21 and the Istanbul Plan of Action (IPoA) for the Least Developed Countries (LDCs) (Chaturvedi and Saha, 2021). The FfD3's emphasis on S&T delivery may be a collective signal of willingness to address challenges with resource availability and funding for a worldwide framework to support and facilitate the process.

The Addis Ababa Action Agenda documents the final decision on part of world leaders to establish a Technology Facilitation Mechanism – TFM. This was officially adopted at the UN Sustainable Development Summit in September

2015 for the implementation of the 2030 Agenda for sustainable development. India (along with Brazil) has been enthusiastically promoting the cause for TFM under the Post 2015 Development Agenda. The Group of 77 at the UN long held an unambiguous position on the establishment of a TFM which it considers as one of the most transformative means to implement sustainable development. India through its submissions during the negotiations for post-2015 development agenda highlighted that immediate and urgent delivery of technology development, deployment, dissemination and transfer to developing countries require suitable responses, including a continued emphasis by all countries on the enhancement of enabling environments, facilitating access to technology, and financing that leverages private sector financial resources (Chaturvedi and Saha, 2016). Current institutional arrangements are insufficient to provide immediate and urgent technology development, deployment, dissemination, and transfer to developing countries.

4.2 Technology Facilitation Mechanism (TFM) and Global Pilot Programme on STI for SDGs – Role of UN-Inter Agency Task Team on STI for SDGs

A global technology facilitation mechanism (TFM) was envisioned in Agenda 2030 as a way to unify international support for financing and delivering technology to LMICs. Agenda 2030 recognised STI as one of the most crucial ways to fulfil the SDGs (Chaturvedi and Saha, 2016). Despite discussions taking place since 2016 through a yearly STI Forum at the UN and the creation of a high-level international expert group, a full-fledged TFM has not yet been operationalized, and challenges remain in mainstreaming this mechanism into international commitments. A global pilot programme on STI for the SDGs was launched in 2019 with backing from a few G20 members, notably the EU and Japan, and Six pilot nations, including India (Chaturvedi and Saha,2021). Delay in operationalizing a global TFM would have adverse impact on the fulfilment of Agenda 2030 (Chaturvedi, Rahman and Srinivas, 2019). The adoption of an UN-driven global Technology Facilitation Mechanism (TFM), as a component of the SDGs, was negotiated. It was anticipated that the TFM would encourage multi-stakeholder partnerships

Six pilot nations, viz Ethiopia, Ghana, Kenya, Serbia, Ukraine and India, have been selected for the Global Pilot Programme for SDGs Roadmaps. To assist the pilot nations in their SDG Roadmaps project, the European Union and Japan have joined this endeavour.

and collaboration through the sharing of knowledge, best practises, lessons learned, and policy recommendations among Member States, the private sector, civil society, the scientific community, United Nations agencies, and other stakeholders. While the first steps in this direction were mostly deliberative in the form of the annual STI Forum, since 2016 and the formation of the UN Interagency Task Team (IATT) along with a global advisory body (the 10-Member group), concrete operational steps have now begun to emerge, as is evidenced by the adoption of the Global Pilot Programme on STI for SDGs.

India and Japan have joined forces and are working together based on a shared interest in promoting the STI for SDGs Roadmaps in their own nations as well as intensely supporting the replication of this initiative in African countries, including those that are already participating in the exercise as pilot countries. The Office of the Principal Scientific Adviser to the Government of India (PSA) is incharge of the initiative and collaboration from the Indian side. The Cabinet Office is in charge of the partnership from the Japanese side (CAO).

For the pilot nations participating in the execution of the STI for SDGs Roadmaps, IATT has proposed appropriate agencies. As a result, the World Bank and UNESCO are supporting Kenya; OECD, UNESCO, and WB are supporting Ghana; UNCTAD, World Bank, UNESCO, UNDP, and UNIDO are supporting Ethiopia; World Bank, ESCAP, OECD, and UNDP are supporting India; EC/JRC with UNIDO are supporting Ukraine and the EU/JRC, UNIDO, and UNESCO are supporting Serbia.

The G20 Summit in Osaka, which captured the larger aspirations of inclusive and sustainable economic growth, has made the most significant contribution in recent times in acknowledging the importance of science, technology, and innovation (STI) for achieving Agenda 2030 and the Sustainable Development Goals (SDGs). The draft UN

India is keen to collaborate with African nations and other developing countries within the framework of South-South and Triangular Cooperation (in spirit of SDG 17) for sharing its experiences in boosting STI for the SDGs. India's partnership with Japan under this programme is crucial in that direction.

"Guiding Principles for the Development of STI for SDGs Roadmaps" was supported in this regard by the G20 Summit declaration in 2019 (Box 4.1).

The Global Pilot Programme for STI for SDGs Roadmaps, launched in 2019, is considered to be the most crucial vehicle for operationalizing the Technology Facilitation Mechanism (TFM) approved as part of Agenda 2030/ SDGs and is supported by an evidence-based conceptual framework. Access, equity, and inclusion must be ensured in order to promote sustainability and wellness. Based on their close collaboration in science and technology, India and UN-IATT are collaborating to create STI for SDGs roadmaps for four specific goals (SDGs 2, 3, 6 and 7) through the Global Pilot Programme. It is envisaged that it will grow into a very useful tool to support national efforts to plan out STI for the SDGs and international cooperation on knowledge, technology transfer, capacity, networks, and finance for countries to better address global concerns.

To make a substantial contribution to the 2030 Agenda for Sustainable Development, the TFM must be strengthened. This will not be possible without funding channels, needs assessments, stakeholder participation, and, most critically, STI value chain partners who are well-positioned to develop and spread global public goods (that address public health, climate change, food security, watershed management, environmental pollution, etc.). Developed countries must play a key role in facilitating the above by promoting appropriate global regimes and meeting desired official development assistance commitments, whereas developing countries must make significant efforts to implement technology-driven approaches in development and sustainability interventions. Many developing countries, such as India, have previously gone through large-scale, technology-driven development revolutions, as well as policy lessons on how to overcome long-standing access restrictions.

Box 4.1: Guiding Principles for the Development of STI for SDGs Roadmaps

1. Structure of Roadmaps

- STI for SDGs roadmaps function as policy action plans, aligned to national development strategies and take a holistic approach to the SDGs. In light of the interdependences and interlinkages of the SDGs, STI for SDGs roadmaps may be used to pursue synergies among SDGs, while managing possible tradeoffs between them. They may also assist short- to long-term planning and priority-setting by serving as communication tools for co-ordination among stakeholders.
- There are various layers on STI for SDGs roadmaps, which could involve cooperation at the international, regional, national and sub-national levels, and along different thematic areas. Each roadmap should specify tangible actions in order to ensure practical impact, and allowing monitoring of the progress at each stage of implementation. Governments that wish to develop roadmaps, should take account of this structure, keeping in mind the relevant discussions at various fora, such as the United Nations Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (UN STI Forum).

2. Role of the Government

- For governments seeking to develop a roadmap, their role is to set strategic direction to the roadmaps through dialogue and input from all relevant stakeholders, while aiming for policy implementation coherence. Where possible, roadmaps on all levels should be assembled for monitoring overall progress and identifying underlying issues with political, social, economic, and scientific ramifications. Progress should be measured, as much as possible, using various reporting measures, in line with national processes and priorities.
- Promotion of "STIs for SDGs" should be aligned with the national development strategies and STI policies for achieving a sustainable and inclusive development.
- Governments should consider necessary preconditions for encouraging the advancement of science, technology and innovation, including mechanisms that protect intellectual property rights. The G20 should promote development of the underlying infrastructure that will enable STI for SDGs (e.g. digital infrastructure, ICT networks, research and development infrastructure among others). Due consideration should be given to investment in STEM and promoting the active role of women and girls in STEM fields, as agreed in G20's-eSkills for Girls.
- To this end, governments should, as appropriate, allocate resources and encourage private sector investment to facilitate and implement the roadmaps.

Source: G20 (2019).

4.3 Role of International Agencies in Promoting TFM and Global Public Goods

4.3.1 Assessing country priorities

The need for a fully functional TFM is still within the operational purview of UN agencies, but its global significance is only being slowly realised. It is widely known that previous arrangements for global technology transfers under different agreements/ protocols have produced less-than-ideal outcomes. As the world has quickly adapted to the realities of the fourth industrial revolution and the emergence of frontier technologies, questions of wider technological divides have sharply entered the scene (Chaturvedi and Saha,2021). Often, deficiencies in technology assessment and weaker institutional preparedness have hampered technology absorption in most developing countries, despite the fact that some of the technologies may eventually find widespread use and be more affordable. Access clearly depends on ownership issues, absorption abilities, and appropriateness in light of national requirements. These are important consideration given the fact that underdevelopment is pervasive even as increased heterogeneity among LMICs renders standard policy and institutional remedies less effective.

4.3.2 Supporting the Global Pilot Programme on STI for SDGs Roadmaps

The present UN programme called the Global Pilot Programme on STI for SDGs Roadmaps, if properly directed and managed, may provide answers to various issues about how similar technical interventions have varied consequences, both positive and negative, across countries. This should lead to a better understanding of how to construct a roadmap that is suitable for each individual country, taking into account its context, needs, institutional readiness, and alternative pathways for avoiding irreversibility of the resource and time constraints. As a starting point, the Decade of Action on SDGs serves as a dismal reminder of the seriousness and scope of the challenges. The COVID-19 pandemic worsened the challenges in a number of areas.

Understanding a country's degree of preparedness as well as its technological surpluses and deficits is anticipated to come from a STI for SDGs Roadmap. To

Although developing nations have made great strides in using technology to catch up, they have yet to take the lead in innovating for a diverse range of technologies. The localization of the SDGs would require the proper technology, but this is not taking place due to existing obstacles and the low absorptive capacities that have hampered innovation systems. STI Roadmaps are, therefore, crucial for expanding the options for STI solutions. It is important to build local talent and skills while considering STI capabilities and SDG gaps. Beyond technologies, cross-country collaboration that quickly increases absorptive capacities is crucial, especially in light of the fact that knowledge transfers about policy and ecosystems for best practices go hand in hand with technology transfers. Regarding the development of digital public goods and their wider applicability in other emerging nations, India holds enormous promise.

match supply and demand, paradigm transformations in bilateral, regional, and international collaboration on technology are required. This won't be easy unless we have a deeper knowledge of how nations actually collaborate on technology, how science diplomacy is actually used, and how market-mediated delivery mechanisms may be impacted to bring innovators and end users closer. Although the main obstacles to technology transfer have been extensively studied over time, they have not been compared to the nature of current global problems and the demand for global public goods. This is especially true in the pandemic era, when the drive towards Global Public Goods in the form of COVAX is falling short of the broad demand and vaccine equity is becoming a significant concern (Gavi, 2020).

The capacity of the Global Pilot Programme on STI for SDGs Roadmaps to generate different forms of bilateral and regional engagements on technical cooperation on STI for global public goods is another significant aspect of it. This can be used not only to boost alignment, review, and resource mapping efforts for national STI for SDGs activities, but also as a conscious agenda to drive international cooperation on knowledge, technology transfer, capacity, network, and finance for TFM operationalization.

4.3.3 Strengthening TFM modalities

The proposed TFM modalities should be implemented in two stages. One is that national roadmaps for the SDGs are developed using inter-ministerial and multi-stakeholder processes. Second, inter-governmental organisations (predominantly the UN) will coordinate efforts at the global level to both strengthen and develop already existent global public goods. STI interventions must take into account the multifaceted character of challenges at both levels and be aware of a variety of scientific challenges related to recognised development gaps and sustainability requirements. To meet the prerequisites for local and global public goods, the normative frameworks guiding such interventions should be grounded in principles of access, equity, and inclusion. The framework for achieving these objectives should serve as the central element of any analysis of deploying STI resources for global public goods. To put it another way, there should be verifiable models that suggest that in the absence of particular STI interventions and resources, full-scale global public goods in a given area might not be obtained, which would delay the global realisation of SDGs.

4.4 Development Cooperation to Enable LMICs to leverage the TFM, Bridge Capacity Gaps, and Access STI for SDGs

4.4.1 Support for the Localization of Development through STI

Accelerated distribution of established technology is a critical component in the faster production, consolidation, or transmission of global public goods. The issue of access, equity, and inclusion is critical in this case. When mapping SDG gaps and tallying those with STI resources, it is common to discover that the magnitude or complexity of the task is intimidating and pre-existing STI solutions are insufficient (and all necessary solutions are not sufficient). This makes STI enterprise even more complex and localization efforts more challenging.

4.4.2 Bridging Capacity Gaps to Leverage the TFM

A practical approach to solving such issues could be international cooperation. As ICT technologies spread more quickly, confidence and expectations have increased, but digital divides continue to impede progress. This is also

true of ICT-based user interfaces that are based on local customization, even though several LMICs still lack access to the key technologies that define Industry 4.0, which benefits both producers and consumers. The industry 4.0 cohort of technologies and a more comprehensive ecosystem approach to Research and Development would allow the SDGs to be fully realised (Chaturvedi, Rahman and Srinivas, 2019). Currently, disparities in progress on these fronts are resulting in suboptimal outcomes in LMICs. The promotion of global public goods using technological resources will significantly reduce search and transaction costs for various developing nations, freeing up significant resources for the localization of SDGs in these countries.

In this context, the development of a TFM that would enable greater access to and availability of technology, as well as the complete implementation of STI for SDGs Roadmaps, is expected to influence policy choices in LMICs on realistic deployment roadmaps. Following this, an assessment of the existing gaps in technology availability and stock of STI resources might be conducted. This assessment could help guide proper acquisition decisions for products and processes that aren't necessarily innovations. Finally, these roadmaps have a great deal of potential to produce effective TFM where, outside of centralised institutions, distributed initiatives on bilateral and multilateral collaboration on technology can emerge for making technologies available and for TFM to play a facilitator role.

Development cooperation would enable low and middle income countries to leverage the TFM, bridge capacity gaps and access, and STI for SDGs should lead to greater confidence in TFM and address some of the above-mentioned concerns. Under North-South, South-South, and Triangular Cooperation frameworks, development cooperation modalities must be directed toward building capacities that directly supplement national STI Roadmap initiatives while institutionalising a range of initiatives to enable resource sharing and technology access through the TFM. Without explicit acknowledgment under development cooperation initiatives, TFM will continue to be illusory for many LMICs, who frequently turn to ad hoc and case-specific modalities of technology procurement and implementation with low institutional strengthening.

4.5 India- Japan Workshop on STI for SDGs

RIS and Cabinet Office of the Government of Japan organized a virtual workshop on "Developing STI Partnerships for Sustainable Development: Accelerating International Cooperation and Actions Through the Global Pilot Programme on STI for SDGs Roadmaps" on 23rd June 2020. Representatives from line ministries, the scientific ministries, various think-tanks, Japan Science and Technology Agency (JST), MEA India and other international implementing agencies and stakeholders including the private sector participated in this workshop. The thematic workshops led to drawing on insights from India- Japan GPP imitative on STI for SDGs. The workshops explored the following dimensions:

- The Global Pilot Programme on STI for SDGs Roadmaps as an initiative that integrates the national aspirations and goals with selected SDGs, inspired by the commitment of Government of India in harnessing S&T for inclusive development, keeping in mind the needs, dreams and aspirations of the people, particularly women, youth and the rural population.
- How the pilot countries are viewing the Global Pilot Programme initiative towards bringing STI for the achievement of SDGs, which is important in post-pandemic reality.
- Need for creating a robust institutional architecture that can deliver innovative technological solutions and the need for mobilising resources.
- Other important aspects were STI for SDGs mapping and the exchange of ideas, both among Indian stakeholders and with IATT on how we can make the engagement of the Global Pilot Countries mutually supportive.
- How to share the technologies and experiences, learn from each other and develop indicators to be used within the TFM.

4.6 India-UN IATT Workshop

RIS, Cabinet Office of the Government of Japan (CAO) and the United Nations Interagency Task Team on Science, Technology and Innovation (STI) for the Sustainable Development Goals (UN-IATT) co-organized the virtual Workshop on "Developing STI Partnerships for Sustainable

Development" on June 29, 2020. This meeting was part of the official UN-IATT Technology Facilitation Mechanism process. The main theme of the workshop was Accelerating International Cooperation and Actions through the Global Pilot Programme on STI for SDGs Roadmaps. The workshop built on the preparatory dialogues between India, Japan, invited pilot countries, IATT partner agencies participating in the Global Pilot Program, and other interested stakeholders. The two countries are deepening their collaboration in applying frontier technologies in the above mentioned areas and in collaborating with the UN-IATT in supporting pilot countries from Africa in particular, and other LDCs in formulating and implementing their STI for SDGs Roadmaps by sharing of experience, knowledge and capacities with them, in the spirit of South-South and Triangular Cooperation as mandated under the TFM. The workshop saw participation by senior policy makers and experts from the pilot countries including India, and Japan and other partner agencies including UN Agencies and International Organisations UN-IATT (DESA, UNDP, ESCAP etc.), World Bank, International Solar Alliance, and among others.

The main theme of the workshop was "Accelerating International Cooperation and Actions Through the Global Pilot Programme on STI for SDGs Roadmaps". The meeting was joined by high level representatives of the pilot countries and UN-IATT partner agencies participating in the Global Pilot Program, and other interested stakeholders.

The workshop deliberated on the following themes: Formulation of STI for SDGs Roadmaps

- Current initiatives on STI for SDGs in Pilot Countries and Key Partners
- STI for SDGs Partnership in the Multilateral Arena
- COVID-19 Pandemic and STI for SDGs
- Building Partnerships and Networks for Acceleration and Expansion of the Pilot Programme: Role of Think Tanks/ Academia, Foundations and Private Sector

The workshop covered initiatives to promote STI for SDGs on both sides, with focus on digital transformation, AI and other key technologies which are commonly applicable for STI for SDGs. Some of the major issues like Synergizing Strategies in STI for SDGs SDG 2, 3, 6 and 7

Box.4.2: Key Messages from the Workshop on Developing STI Partnerships for Sustainable Development, co-organized with India and Japan (June 29)[1]

The key messages and conclusions of the workshop are the following:

1. In order to operationalise the Technology Facilitation Mechanism (TFM) adopted as part of the Agenda 2030/ SDGs, the Global Pilot Programme on STI for SDGs Roadmaps initiated in 2019 is considered the most important vehicle, backed by evidence based and robust conceptual framework and is expected to evolve into a very useful tool to strengthen national efforts on STI for SDGs mapping and international cooperation on knowledge, technology transfer, governance, capacity-building, networks and finance for countries to better address global challenges including COVID-19 pandemics, by ensuring access, equity and inclusion leading to sustainability and wellness.
2. Based on the existing close partnership in science and technology between India and Japan, the both sides have expressed strong interest in extending their collaboration in STI for SDGs, particularly in cooperating in formulating STI for SDGs Roadmaps on 4 specific goals (SDG 2, 3, 6 and 7) through the Global Pilot Programme. The two countries are willing to deepen their collaboration in applying frontier technologies in the above mentioned areas and in collaborating with the UN-IATT in supporting pilot countries from Africa in particular, and African and other LDCs in formulating and implementing their STI for SDGs Roadmaps by sharing of experience, knowledge and capacities with them, in the spirit of South-South and Triangular Cooperation as mandated under the TFM.
3. It was suggested that UN-IATT accelerate the Global Pilot Programme by launching "Partnership in Action" and by leveraging more dedicated resources through emerging partnerships among research organizations and leading think tanks based in Japan, India and select African countries, as reflected in the collective expression of interest among those participating in the workshop.
4. The participants acknowledged the importance of multi-stakeholder engagement that includes academia, think tanks and the private sector in formulating and implementing STI for SDGs roadmaps.

Source: Compiled by RIS.

were highlighted and ways to develop frameworks for action through bilateral partnership, triangular cooperation and collaboration at multilateral forums was discussed.

Key messages emanated from the Workshop are provided in the Box 4.2. The Key Messages has been presented as a Joint Statement by India and Japan on STI delivered at the 2020 High Level Political Forum on Science, Technology and Innovation by India's Scientific Secretary on 10th July 2020

4.7 International Workshop on STI for SDGs

RIS organized an International workshop on "STI for SDGs" on 11th October, 2022. Representatives from Pilot Countries, PSA office, line ministries, the scientific ministries, various think-tanks, EU-JRC, World Bank, UN-DESA, Japan COA and other international implementing agencies and stakeholders including the private sector participated in this workshop. The workshop was focus on internationalising the STI for SDGs Roadmaps going beyond the pilot countries and the need to explore how G-20 can further support and strengthen the TFM as well as other global public goods that anchor technology cooperation to support implementation of the SDGs in low and middle income countries. The workshop highlighted the roadmaps and approaches needed for mainstreaming STI for SDGs in our development thinking, particularly challenges related to the key focused SDG goals of zero hunger (SDG 2), health and well-being (SDG 3), water and sanitation (SDG 6), and affordable and clean energy (SDG 7) and also the focus that should be placed on affordable technology in order to lower the cost of adoption, which may then be shared through UN procedures. The following dimensions were investigated throughout the workshops:

- STI for SDGs will be critical not only for India and the six pilot countries, but also for creating a roadmap for the entire global community.
- Digital public goods have been used in national projects, such as the National Mission on Sustainable Agriculture and Poshan Abhiyaan, to ensure food security. PM-STIAC proposed 'One Health Mission,' which will integrate disease surveillance and control in India's wildlife, livestock, and human systems.
- In the area of sanitation, the customised amphibious excavator for cleaning urban drains clogged with mixed solid waste, including construction and demolition trash that can help local governments manage and regulate sanitation systems.
- India's commitment towards south-south cooperation under which India has created technology such as an oil extraction system, a soil organic carbon detection kit, and an ergonomically designed treadle pump which have been implemented by Namibia, Zambia, Sudan, and Ghana.

- Some measures of state governments, such as Gujarat's Wind Policy (2016), Maharashtra's Unconventional Energy Generation Policy (2020), and Karnataka's Renewable Energy Policy (2022), were critical in meeting our energy targets. Sustainable financing mechanisms, such as the Smart Cities Mission and NABARD's Green Financing, were mentioned that will be critical for the development of STI for the SDGs.
- Taking forward the STI for SDGs programme in the upcoming India's G-20 presidency that has been listed as a key area by the G-20 countries.

The Tables 4.1 and 4.2 highlights the progress and experiences of Pilot Countries in developing

Table 4.1: Implementing STI for SDGs Roadmaps- Experiences of Pilot countries

India	Ghana	Kenya	Serbia	Ethiopia
Shaping of STI pathways informed of India's developmental needs Leveraging digital technology solutions, digital public goods and potential low-cost tech applications across SDGs The SDGs should create the necessary external push for integrated and inclusive innovations to drive STI for SDGs efforts	Leveraging STI for addressing complex societal challenges Developing a framework for common guidance principles and possible methodologies	Implementation of STI policy and support for delivery of President's Big Four Agenda, which focuses on agriculture, manufacturing, health, and housing Promoting use of IPR and enhancing technology transfer	Foster socio-economic development and transformation based on 6 knowledge-intensive priority sectors Developing the start-up ecosystem for entrepreneurship and economic transformation	Prioritizing STI for agriculture development and technology transfer. Strengthening the infrastructure-science cities based on smart cities and human resource development.
Focus SDGs – 2,3,6 and 7 Build STI Ecosystem beyond science departments Indicative Technology Mapping Tool based on SDG indicators and technology cohorts Foster new innovation ecosystem with the private sector for Flagship Schemes	Focus SDGs – 1 2, 3, 4, 6, 8 and 9 Develop new infrastructure and create capacities in new technologies Establishment of STI Indicators for impact and outcome measurement	Focus SDGs – 1,2 and 8 STI Public Expenditure Review Promoting R&D and technology adoption Scaling up access to Financial Services for farmers through Digital Technologies	Focus SDGs – 2, 7, 8 and 9 Documentation of action plan related to the smart specialization strategy Catapult Accelerator for boosting Serbian startups with funding, mentoring, peer-learning and exposure to investors.	Focus SDGs – 1, 2, 3, 8 and 10 Technology roadmaps at the national level- 12 priority areas- coffee processing, textile, leather, cement among others.

Source: Compiled by RIS.

Table 4.2 : Role of International Organization in TFM/Global Pilot Programme on STI for SDGs Roadmaps

UNDESA	World Bank	EC-JRC	OECD	Japan
• Operationalization of the online technology platform, 2020. • Joint guidebook with UNITAR on STI for SDGs roadmaps 2021 • The rolling out of the Partnership in Action group and the launch of the Joint UN Fundraising Initiative for the STI Forum (2022) • The HLPF and SDG summit will be held in 2023 along with Mid-term review by DESA on SDGs.	• Provided Financial support to develop the UN Guidebook on STI for SDGs Roadmaps • Strengthening technological adoption, appreciation and absorption for public service delivery. • Developed regional ecosystems, within country and among countries • Improved the impact of STI expenditures on economic development through world bank PERs.	• Joint Research Centre coordinated with UN IATT for Technology Facilitation Mechanism • JRC developed pilot cases and methodological background for Smart Specialization Strategies approach for pilot methodology linking STI for SDGs. • Developed vision for sustainable socioeconomic development of territories and focussed on sub-Saharan Africa - Analytical assessment • Capacity reinforcement followed by roadmaps for development of STI for SDGs.	• International collobration and innovative financing of STI through blended financing. • Various financial instruments for the funding of various STI based Initatives. • Developed quantitative STI indicators plus in-depth analysis of specific sectors	• Collaboration and cooperation in formulating STI for SDGs Roadmaps • Three tracks of collaborative international initiatives- with WFP- innovation accelerator program, with UNDP accelerator labs to support UNDP projects in diffrent countries and with WB (Global pilot programme on STI for SDGs roadmaps) • Identification of issues from accelerator labs (eg: marine plastic waste, market access by small scale farmers, urban planning and post-harvest loss).

Source: Compiled by RIS.

the STI for SDGs Roadmaps and Role of International Agencies in TFM/Global Pilot Programme on STI for SDGs based on the outcome of International workshop.

4.8 India's Role in Supporting TFM – The Way Forward

Apart from providing intellectual leadership India can unilaterally initiate projects and activities to demonstrate how technology acquisition, development and transfer can be effective means to address sustainability challenges in many fields. India has also developed strong assessment frameworks that can be used to assess goal specific technology needs for India and South Asia. The knowledge and template of such assessment methods can be shared with other developing countries and UN agencies to help them achieve similar assessment in their countries. This would strengthen India's position and stake in the operationalisation of the TFM. India, a prominent player in the development cooperation arena can effectively utilise such avenues under the South-South Cooperation framework to work together with partner countries in the South in their national technology assessments.

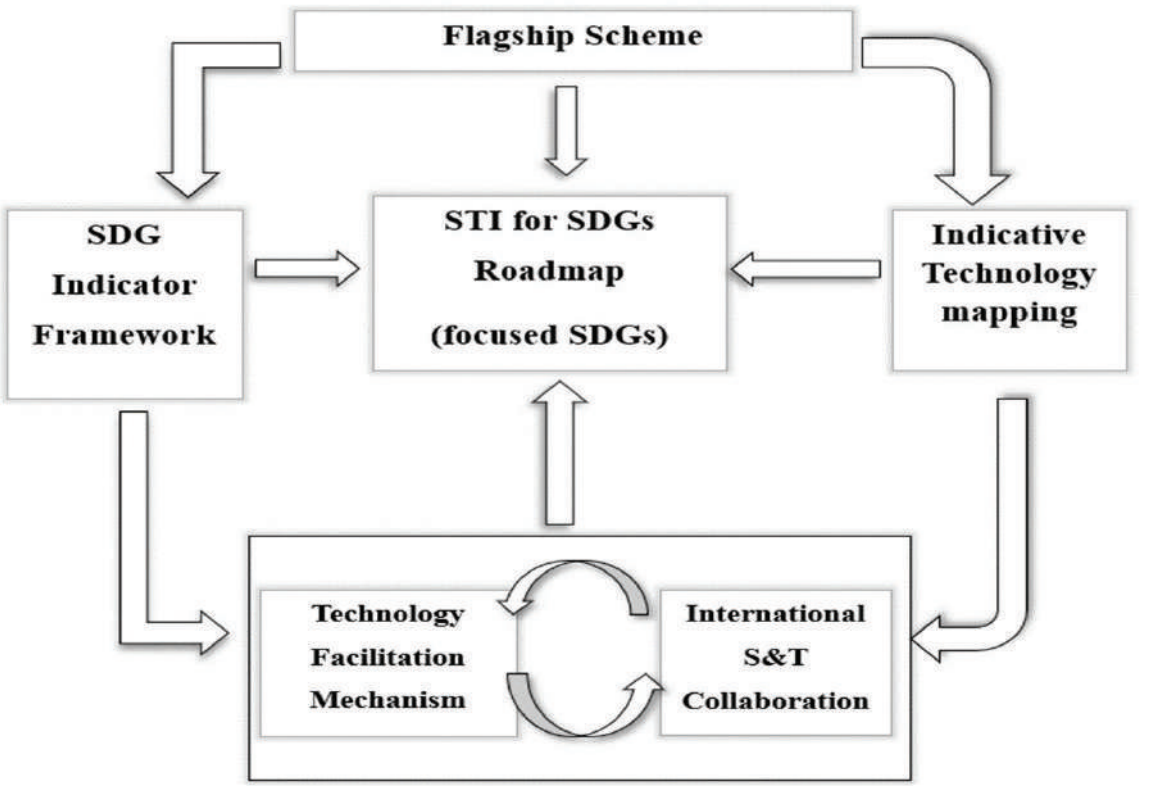
India's robust innovation network has evolved over the years primarily under public patronage. In the last two decades India has not only encouraged FDI and private sector R&D but has also experimented with several models of public-private partnership for joint R&D projects.

India has also seen spontaneous supply of cost effective innovations suited to local needs driven by individual innovators often outside formal innovation support systems. India has been mindful of the developmental gaps facing its citizenry and the growing sustainability challenges of resource intensive economic growth. India's approach to addressing sustainability has been rooted in aspirations towards leveraging new knowledge and innovations, not only to match local needs but also to overcome resource constraints in many cases. This has traditionally been pursued under the broad policy paradigm of 'self-reliance'. In recent years, India has emerged as powerhouse of digital technological solution for SDGs.

In order to illustrate, four areas that perhaps most strongly anchor and link developmental and sustainability needs in India and at the same time testify India's success at indigenous efforts for technological solutions. The four sectors are Food Security, Healthcare; Water and Water Resource Management; and Clean and Renewable Energy. India has historically demonstrated strong leadership abilities in South-South cooperation and technology transfer to address concerns in these areas (Chaturvedi and Saha, 2016).

India's policy framework for STI for SDGs Roadmaps (see Figure 4.1) has been one of the coherent strategies adopted, with the interrelated SDGs 2, 3, 6, and 7 designated as focal SDGs. Under the National Indicator Framework, the Ministry of Statistics and Programme Implementation (MoSPI) has created quantitative and comprehensive indicators to track progress toward these SDGs. The progress towards these SDGs has been accelerated by the implementation of flagship programmes such as ONORC, e-NAM, JJM, and NDHM, as well as the identification of new and emerging technologies through Indicative Technology Mapping (ITM). Multilateral organisations also support and work

Figure 4.1: India's contribution to TFM - Proposed Framework



Source: Developed by RIS

Box 4.3: Technological Solutions that India can share by way of South South Cooperation

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

- Public Distribution System using ICT Technologies (including One Nation One Ration Card)
- POSHAN Tracker app for monitoring of POSHAN Abhiyaan
- Soil Health Card using Soil testing technologies
- High-yield hybrid seeds variety and Bio-fortification
- Better Animal Vaccines and Nutritious Feed and Fodder; RFID and Micro-chips based Ear Tags for Livestock Tracking

SDG-3: Ensure healthy lives and promote well-being for all at all ages

- E-VIN(vaccine intelligence network)
- Covid Vaccines and CoWIN Platform for vaccine distribution
- Digilocker, Digital Health Registry under National Digital Health Mission
- Beneficiary Identification System (BIS) for PMJAY
- Medical devices like Ventilators for pumps oxygen-rich air into your lungs and Handheld Ultrasound Device for immediate ultrasonography during emergencies

SDG-6: Ensure access to water and sanitation for all

- Ozonation, Ultraviolet technology, Reverse Osmosis (RO), TERAFIL(Terracotta) water filter
- IoT-based real-time water quality monitoring systems in pipelines
- AI-enabled water-use monitoring system (to reduce pollutants in the water which in turn decreases water contamination and scarcity of clean water)
- Supervisory control and data acquisition (SCADA) monitoring system
- Extensive mapping exercises like aquifer mapping, GIS-mapping of surface water using remote sensing and HGM maps.

SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all

- Improved biomass cooking stoves, biogas technologies
- Smart-grid systems
- Indigenous solar systems for industrial, household, and agriculture uses (solar pumps)
- Solar water heating systems
- Standalone Solar Powered Agriculture pumps and decentralized ground mounted grid connected renewable power plants

Source: Compiled by RIS.

on interventions in key focus SDGs (e.g. UNDP for e-VIN). The Technology Facilitation Mechanism, which involves international S&T agencies and national agencies, allow for the sharing of the policy framework that India has created as well as the learning experiences gained via innovation and the wide-scale distribution of technology.

The Global Pilot Programme on STI for SDGs Roadmaps is the first clear operational strategy to document, improve, and encourage STI for SDGs actions. The pilot countries should make every effort to support the UN STI for SDGs process. By sharing their knowledge, resources, and repositories, specialised UN agencies can help develop such a platform (see Box 4.3). The UN Interagency Task Team should be in charge of organising this action (UN-IATT). This could help UN agencies recognise cross-agency competencies and how they can be used to improve current activities, as well as minimise duplication of ideas and efforts (Chaturvedi and Saha 2016). The UN guideline for creating STI for SDGs Roadmaps captures this approach in three action areas: improving country STI capabilities, expanding international STI flows, and brokering STI coalitions.

While the TFM is meant to be a global initiative, it is critical to comprehend the reasoning for focusing TFM efforts at the national level among member countries for two reasons. First, countries and their publicly funded research and development agencies, as well as international development finance institutions, are aware that development-oriented and sustainable technologies may continue to be owned by private intellectual property unless alternative innovation models are encouraged. Second, many technologies designed primarily for strategic goals can be used for both development and non-traditional security.

Way Forward

Milestones Achieved – A Summary

India's efforts are focused on formulating STI for SDGs roadmaps on four specific goals, that prominently includes SDG 2 (zero hunger: end hunger, achieve food security and improved nutrition and promote sustainable agriculture), SDG 3 (good health and well-being- ensure healthy lives and promote well-being for all at all ages), SDG 6 (clean water and sanitation: ensure availability and sustainable management of water and sanitation for all) and SDG 7 (affordable and clean energy: ensure access to affordable, reliable, sustainable and modern energy for all).

In 2018, the NITI Aayog created the SDG India Index to track the country's progress on the SDGs. NITI Aayog has classified States/UTs into Achievers, Front Runners, Performers, and Aspirants based on their performance, and has designated more than 100 aspirational districts for targeted interventions. The first edition of the NITI Aayog SDG India Index was released in December 2018, with 62 indicators drawn from 39 targets across 13 SDGs. The SDG Index 3.0 (2020-2) framework is comprised of 17 SDGs, 70 targets, and 115 indicators (with a qualitative assessment of SDG 17). The SDG Index intends to rank states and territories based on their achievement in the 16 SDGs.

India's SDG score increased by six points, from 60 in 2019 to 66 in 2020–21. Three SDGs out of the four STI for SDGs focused goals have shown remarkable progress- 3 (good health and well-being), 6 (clean water and sanitation),

India's Flagship initiatives have set global standards in terms of scale, access and inclusivity in fulfilling the aspirations of a welfare state. Leveraging cost effective digital and technological solutions for accelerating the achievement of SDGs; promoting access, equity and inclusion (AEI) among all sections of the society and bridging rural-urban divide through technology is expected to greatly complement India's transformative efforts currently underway through various flagship programmes, technology missions and localization of SDGs.

7 (affordable and clean energy), where India has scored between 65 and 99. Whereas, SDG 2 (zero hunger) required targeted interventions, as the overall country score is below 50. Nine States in Goal 2 have moved out of the Aspirant category this year as compared to 2019-20. In SDG 3 the country score has moved from the Performer category to the Front Runner category. Goal 6 has the highest number of Front Runners with 25 States in this category.

The Aspirational district initiative has put the spotlight on the most backward regions of the country and has charted out the priorities in multi-sectoral dimensions of health, education and public goods allocations based on their respective strength and attributes. The programme ranks the districts based on the incremental improvements made across 49 Key Performance Indicators (KPIs) spread across 5 major socioeconomic themes: health & nutrition, education, agriculture & water resources, financial inclusion & skill development, and infrastructure. States and local governance institutions have been the major player and enablers for the continued development and targeted intervention in the respective socioeconomic areas.

India's Flagship initiatives have set global standards in terms of scale, access and inclusivity in fulfilling the aspirations of a welfare state. Leveraging cost effective digital and technological solutions for accelerating the achievement of SDGs; promoting access, equity and inclusion (AEI) among all sections of the society and bridging rural-urban divide through technology is expected to greatly complement India's transformative efforts currently underway through various flagship programmes, technology missions and localization of SDGs.

The success story of India's flagship scheme in augmenting the country efforts towards achieving the SDGs is driven by leveraging of Science, Technology and Innovation at the grassroot level. One Nation One Ration Card, ensuring food security of around 80 crore individuals, is operationalized based on two portals - Integrated Management of Public Distribution System (IM-PDS) and Annavitran, with ePoS terminal or any computing devices with biometric scanner. Similarly, Poshan Tracker app providing daily data from 1.23 million anganwadi centres, with around 100 million beneficiaries including pregnant womens, lactating mothers, new born, and adolescent girls, has been a major source of real time information in mapping nutritional status, vaccinations and other maternal and child related policy interventions. The virtual agricultural market e-NAM connecting around 1000 APMCs in India is running through a virtual platform e-NAM portal providing real time transactions and bidding data throughout APMCs.

The PMJAY scheme, providing health cover of up to Rs. 5,00,000 per family per year and 3 days of pre-hospitalisation and 15 days of post-hospitalisation expenses to the bottom 40 percent of poor and vulnerable population approximate 10.74 crore households, use beneficiary Identification System (BIS) for collecting the data from four different databases which is later authenticated for individual details and family details. National Digital Health Mission (NDHM) is a digital health ecosystem under which every Indian citizen will have unique health IDs, digitized health records with identifiers for doctors and health facilities.

The technological ecosystem of NDHM will be an Open API based ecosystem developed by adopting India Enterprise Architecture Framework (IndEA). Mission *Indradhanush* targeted unvaccinated and partially vaccinated children less than 2 years of age and unvaccinated pregnant women to reach more than 90 per cent full immunization coverage. The technology used in storage, transportation and delivery of vaccines under Mission is Electronic Vaccine Intelligence Network (eVIN).

The Jal Jeevan Mission was rolled out to provide functional household connection to every rural household by 2024. As of August 2022, 100 million (51 per cent) rural households out of the total 192.7 million rural households

Towards formulating India's national 'STI for SDGs Roadmaps', there is an imperative to create a STI ecosystem in the country, comprising all the relevant stakeholders including government ministries/ departments, state government, academic and research institutions, public and private sector and civil society organizations. Implementation of STI for SDGs roadmaps in partnership with select state governments can be initiated as pilots.

have access to Functional Household Tap Connection (FHTC).

Prior to the launch of JJM only 32.3 million (16.90 per cent) of the households in villages had access to piped water connection. The Mission used IoT devices, HGM maps, GIS based technology for addressing the water scarcity and efficient water management. PM KUSUM Scheme for farmers for installation of solar pumps and grid connected solar and other renewable power plants in the country, aims to add solar and other renewable capacity of 25,750 MW by 2022. Swachh Bharat Mission (Grameen) achieved Open Defecation Free (ODF) status by 2nd October, 2019, Under the programme, more than 100 million toilets were constructed from 2014-15 to 2019-20 using the web-based online monitoring systems and innovative and localised solutions for waste and water management.

STI for SDGs Roadmaps for India – The Way Forward

Build STI ecosystem with role for line ministries and associated institutions in the public and private sectors

- Towards formulating India's national 'STI for SDGs Roadmaps', there is an imperative to create a STI ecosystem in the country, comprising all the relevant stakeholders including government ministries/ departments, state government, academic and research institutions, public and private sector and civil society organizations. Implementation of STI for SDGs roadmaps in partnership with select state government can be initiated as pilots.
- Such an ecosystem would facilitate close coordination among the relevant stakeholders and would help the line ministries in formulating their respective plans to integrate the application of STI for achieving the related SDG goals and targets.
- In this initiative relevant public and private sector bodies, firms, start-ups, and social enterprises also act as development partners.
- The indigenous technology development should not only address various market or systemic failures in the supply of socially relevant technologies but also ensure their faster diffusion. This will, in turn, help to

meet the considerations of access, equity and inclusion (AEI) as well as sustainability. Such efforts should also supplement the national R&D and innovation programmes and help to augment domestic industrial capacities as envisaged under SDG 9.

- India's approach to addressing sustainability has been rooted in aspirations towards leveraging new knowledge and innovations, not only to match local needs but also to overcome resource constraints in many cases. This has traditionally been pursued under the broad policy paradigm of 'self-reliance'.
- Financing such initiatives and the underlying innovation projects is critical for achievement of the SDGs. STI for SDGs Roadmaps must be widely adopted with the active participation of multiple stakeholders, including the government, international agencies, development finance institutions, and the private sector.

Create Indicative Technology Mapping Tool for SDGs based on SDG indicators.

- The Indicative Technology Mapping (ITM) presented in the report should be useful to assess the current situation of SDG-related technologies in India and to strengthen the overall STI capability through synergistic and cross-sectoral collaborations. Furthermore, it can be used as an input for national STI for SDGs roadmaps and should be helpful to reach out to line ministries, departments, and relevant agencies.
- The ITM takes into account the changing priorities for STI for SDGs and allows us to imagine an SDG-led innovation future and to guide STI policy interventions. Lastly, the ITM open-up the need to monitor technology readiness levels across technologies and to critically examine the impact of specific policy instruments to monitor progress as part of the overall SDG-led STI development strategy.
- Likewise, in various existing and emerging technologies, the perceived technological "deficit" identified in the roadmap underlines the need to foster technological catch-up by enhancing R&D intensity and policy coordination. The technology identification exercise thus opens up several pathways to initiate indigenisation.

At the next level, sector specific Indicative Technology Mapping (ITM) can evolve into a comprehensive data driven platform where all resource flows from the public and private sectors can be mapped and matched with STI for SDGs outcomes (and impacts) which would streamline decision making

- A sharp sectoral focus in India's progress towards achieving the SDGs in terms of regional asymmetries and gaps at National and State level is important. The indicator gap mapping and ranking framework put forward by the NITI Aayog based on selected targets and indicators has highlighted India's progress towards the SDGs.
- At the next level, sector specific ITM can evolve into a comprehensive data driven platform where all resource flows from the public and private sectors can be mapped and matched with STI for SDGs outcomes (and impacts) which would streamline decision making.

Promote technology adoption for SDGs at very large scale – Evolve policy tool for technology choices under Flagship schemes

- All key scientific ministries and departments through the Flagship schemes have to play a major role in providing direction to India's STI efforts and are therefore preeminent stakeholders in the process. Sub-national governments particularly, the state governments also form vital pillars for supporting formulation of India's national STI for SDGs Roadmaps.
- Line ministries are pivotal in the identification, procurement and deployment of technologies in the flagship schemes. Significant learning and experience is being generated on ways and means to leverage technology under flagship schemes. Therefore line ministries need to augment internal capacities to come up with coherent strategies for appropriate technology choices towards speedy and optimal outcomes in the delivery of development schemes.
- The push towards monitoring and evaluation of flagship schemes at micro level and household level

Line ministries are pivotal in the identification, procurement and deployment of technologies in the flagship schemes. Significant learning and experience is being generated on ways and means to leverage technology under flagship schemes. Therefore line ministries need to augment internal capacities to come up with coherent strategies for appropriate technology choices towards speedy and optimal outcomes in the delivery of development schemes.

Regional asymmetries in adoption and deployment of technologies in Flagship schemes need to be examined to avoid exclusions among the targeted population. State governments as the implementing authority must be supported to overcome the S&T capacity gaps in respective states. Under the proposed State level pilots, Line Ministries should be encouraged to work with the States under the 'STI for SDGs Roadmaps' approach to optimize resource utilization and customize state/ local level STI interventions.

through use of GIS, IoT, ICT, Geo-Tagging and other modern technologies needs to be strengthened and extended to monitor the quality rather than quantity of the outcomes through flagship schemes.

- Regional asymmetries in adoption and deployment of technologies in Flagship schemes need to be examined to avoid exclusions among the targeted population. State governments as the implementing authority must be supported to overcome the S&T capacity gaps in respective states. Under the proposed State level pilots, Line Ministries should be encouraged to work with the States under the 'STI for SDGs Roadmaps' approach to optimize resource utilization and customize state/ local level STI interventions.

Strengthening Technology Facilitation Mechanism (TFM) and partnership with developing countries

- In terms of giving technology options for achievement of the SDGs globally, the UN Technology Facilitation Mechanism (TFM) proposal's baseline premise has made little progress. While discussions among UN agencies and other stakeholders have made progress in recent years, the Global Pilot Programme on STI for SDGs Roadmaps is the first clear operational strategy to document, improve, and encourage STI for SDGs actions. This should lead to wider global partnerships on STI for SDGs roadmaps for strengthened technology facilitation as the world comes to terms with emerging challenges.
- India has been a leader in the negotiations that led to the launch of the TFM under the 2030 Agenda for Sustainable Development (see Annexure 2). India has time and again articulated that finance and technology would be the most critical pillars for implementing the Agenda 2030 across the SDGs. India's views have centred on concerns that the developing countries are at serious disadvantage when it comes to the availability of environmentally sustainable technologies and the current institutional mechanisms are inadequate to meet the full scale requirements or ensure timely delivery.
- Apart from providing intellectual leadership India can initiate projects and activities in partner countries as part of its South-South and Triangular Cooperation

Countries and their publicly funded research and development agencies, as well as international development finance institutions, should be aware that development-oriented and sustainable technologies may continue to be owned under private intellectual property unless alternative innovation models are encouraged.

Apart from providing intellectual leadership India can initiate projects and activities in partner countries as part of its South-South and Triangular Cooperation efforts to demonstrate how technology acquisition, development and transfer can be effective means to address sustainability challenges in many fields. Such technological efforts would consolidate India's leadership and adequately support the UN-TFM.

efforts to demonstrate how technology acquisition, development and transfer can be effective means to address sustainability challenges in many fields. Such technological efforts would consolidate India's leadership and adequately support the UN-TFM.

- Finally, the pilot countries should make every effort to showcase their efforts under STI for SDGs Roadmaps and widen cooperation and partnerships. UN-IATT can facilitate such platforms by sharing their knowledge, resources, and repositories. This could help to avoid duplication of ideas and efforts, and it could also assist UN agencies in recognising cross-agency capabilities and how they can be used to boost current activities. This approach is captured in the UN guidebook for preparing STI for SDGs Roadmaps through three action areas: developing country STI capability, increasing international STI flows, and brokering STI coalitions.
- While the TFM is meant to be a global initiative, it is critical to comprehend the reasoning for focusing TFM efforts at the national level. Countries and their publicly funded research and development agencies, as well as international development finance institutions, should be aware that development-oriented and sustainable technologies may continue to be owned under private intellectual property unless alternative innovation models are encouraged.

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Annexures

Annexure 1: Overview of the Main Methodologies to Support STI for SDGs Roadmaps

METHODO-LOGICAL STEP/ ORGANISATION	SMART SPECIALISATION (EC-JRC)	STI POLICY REVIEWS (OECD)	STIP (UNCTAD)	GO-SPIN (UNESCO)	SIIG (UNIDO)	TIP (TIPC)	PERs in STI (WB)
Define Objectives and Scope	Systemic approach: STI in the context of economic, societal and environmental challenges.	Modular approach: focus on STI policy data collection, analysis, reporting and dissemination	Systemic approach: STI in the context of economic, societal and environmental challenges	Modular approach: focus on STI governance, explicit and implicit STI policies, legal frameworks, policy instruments and indicators	Sectorial approach: focus on the STI component in the industrial policy, includes social inclusion, economic competitiveness and environmental protection	Systemic approach using innovation to address societal, economic and environmental challenges	Modular approach: main focus is on STI policy expenditure and its impact
Assess Current Situation	Based on existing policy frameworks, requires interinstitutional cooperation. Quantitative and qualitative analysis of economic, STI and SDG indicators	Detailed analysis of the STI performance in the macroeconomic context and societal needs. Quantitative STI indicators plus in-depth analysis of specific sectors	STI policies instrumental for economic growth and development. Wide collection of qualitative data supported by overviews of literature and quantitative analyses.	Description of the political, economic, social, cultural and educational contextual factors; analysis of the explicit STI policies, policy cycle and STI organizational chart; study of R&D and innovation indicators.	Based on existing development plans and strategies. Includes in-depth quantitative and qualitative analyses of the industrial landscape in the context of country's development goals	Based on wide qualitative process and review of existing policies. Case study approach and learning histories are used	The quality of public spending on STI and R&D is assessed based on a mix of qualitative and quantitative indicators with the objective to understand how governments can spend better on STI or how they can improve the impact of STI expenditures on economic development

Develop Vision, Goals and Targets	Vision for sustainable socioeconomic development of territories developed jointly by external and internal stakeholders	Vision developed individually by each country based on the analysis and recommendations	Synergic vision for transformative change developed jointly by internal and external stakeholders	Looking at impact of the existing STI policies and based on a survey allowing to create country profiles with comprehensive assessments of STI policies	Vision developed individually by each country with the wide participation of stakeholders	Wide vision for transformative change achieved with STI policies and other elements of systemic change	The development of vision for change can result from the PERs
Dialogue and Consultation with Stakeholders	Entrepreneurial Discovery Process requires permanent involvement of public and private sector, academia and civic society in the development, implementation and monitoring of the strategy and associated activities	Stakeholders are interviewed during the fact-finding missions. International community involved in reviews	Multiple stakeholders involved in the STIP review process	Internal and external stakeholders involved in providing the survey responses and discussing the results	Stakeholders are involved in a participatory policymaking process throughout the policy cycle	Wide stakeholder participation, including the local and grassroots innovators	Stakeholder involvement is a part of data collection, in the form of interviews, access to data etc.
Assess Alternative Pathways	Recommended foresight and similar exercises, yet not obligatory	Countries can develop scenarios for the enhancement of national STI ecosystem	Technology foresights are strongly recommended	This step can be included but is optional	Possibility of developing scenarios for industrial policy	Foresight and future studies activities are considered valuable but optional	Based on the analysis, the team discuss different options

Develop Detailed STI for SDGs Roadmap Document	Clear intervention logic with implementation action plan, policy mix and instruments, and financing instruments are required	Not explicit, recommendations provided	Specific guidance on implementation, policy instruments and financial instruments is provided	The methodology provides an overview of STI policy instruments but does not prescribe specific solutions – they can be developed at country's request	Developed individually by governments but based on recommended policy instruments	Strong focus on experimentation. The policy mix is a part of TIP development and the guidance on financing can be provided	The assessment results in a set of recommendations that support stronger alignment of innovation policy instruments with the national development objectives, improved quality and higher efficiency of instruments used, and an evidence based framework to track results and map expenditure to outputs and outcomes.
Monitor Evaluate And Update Plan	Monitoring and evaluation frameworks are essential in S3 approach, with clearly defined metrics and indicators	Monitoring and evaluation considered very important but not included. Post review analyses are possible on request	Monitoring and evaluation frameworks are strongly recommended, and additional support is possible on request	The regularly updated country profile can be a useful monitoring tool	Monitoring and evaluations are a part of the methodology	Monitoring and formative evaluation are required with the focus on learning and improvement	M&E is a core part of the methodology. A unique feature of PER in STI is the inclusion of impact evaluations in the effectiveness stage.

Source: UN DESA (2020)

Annexure 2

Keynote remarks by Ms. Sujata Mehta, Secretary (M&ER), Ministry of External Affairs in the High Level Side Event on 'Launching the Technology Facilitation Mechanism for achieving the SDGs' jointly hosted by Brazil and France, at New York on September 26, 2015

Your Excellency Mr. Laurent Fabius, Minister of Foreign Affairs and International Development of France,

Your Excellency Mr. Mauro Vieiro, Minister of External Relations of Brazil, Your Excellency Mr. Jan Eliasson, Deputy Secretary General,

Distinguished delegates, Ladies and Gentlemen,

I am honored and privileged to participate in today's event.

At the outset, I would like to warmly congratulate and thank the Governments of France and Brazil for taking this valuable initiative to celebrate the launching of the Technology Facilitation Mechanism.

This Mechanism is undoubtedly one of the most tangible and meaningful outcomes of this landmark Summit and we are glad that through this event, we are celebrating this achievement and by doing so, helping maintain the global spotlight on this issue.

It is of course only fitting that this event is being organized by Brazil and France, two delegations that played such a central role in incubating this issue and ensuring a successful outcome on it.

I would like to place on record our appreciation to the delegation of France for the special role they played in building bridges and bringing the two sides to a common understanding.

My own delegation has been one of the active participants in the debate leading up to the creation of the Mechanism. We played a central and constructive role in enabling an agreement on this important issue.

Excellencies,

India has long maintained that without meaningful international collaboration on the issue of technology, our dream for a sustainable world will remain a mirage. The multifarious and integrated nature of challenges confronting a relentlessly globalizing world only serve to enhance the importance of technology as the golden key for solutions.

If the world has to end poverty within a generation, if the world has to enable a life of dignity to every individual on the planet, if the world has to combat climate change and put itself on a sustainable pathway, then meaningful collaboration on developing and sharing technological solutions is not an optional luxury; it is a fundamental necessity.

We are happy therefore that for the first time perhaps, the discourse on sustainable development and on technology in particular is moving from platitudes to action.

While there are several sectoral initiatives on technology, it is for the first time that we are creating a space for meaningful discussion and collaboration on technology at a macro and integrated level at the UN.

This is in keeping with the 2030 Agenda itself, the hallmark of which is integration of the economic, social and environmental dimensions.

Going forward, we expect this Mechanism to become the home for technology discussions in the UN, convening all stakeholders and looking at the entire landscape of technology – needs, capacities, assessment, showcasing, financing transfer, dissemination, and match-making – in order to promote meaningful results.

We are hopeful also that through this Mechanism, we will be able to overcome the largely infructuous debates over technology transfer and IPRs.

Meaningful collaboration on technology has long been held hostage by the apparent fears, mostly unfounded, about protection of IPRs. The importance of IPRs, which is but one aspect to the issue of technology cooperation, cannot be allowed to prevent discussion on a subject that is much wider in scope and can lend itself to meaningful solutions provided there is political will.

The success of this initiative will be judged by the tangible and concrete results it is able to produce – information disseminated, projects launched, partnerships and synergies catalyzed, technologies disseminated and innovations fostered.

It will depend crucially on the work of the Secretariat, who we trust will put its best foot forward in making adequate and necessary preparations for the first meeting of the Mechanism.

The success of this initiative will also be judged by the extent to which we can foster a climate of trust among delegations to look for solutions not problems, to work for the common benefit of all and not just gains of a few.

It will depend crucially on our constructive spirit in order to forge workable long term arrangements.

If the trust and constructive spirit that led to the birth of this Mechanism is something to go by, then we surely have reasons to be hopeful.

I need hardly emphasize **Excellencies** that you can count on India's unstinted support

to the Mechanism in the months and years to come.

We look forward to working closely and constructively with all delegations to ensure that the Mechanism becomes a shining example of the spirit of common purpose that defines the 2030 Agenda for Sustainable Development.

I thank you.

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