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EDITORIAL

This issue of *Science Diplomacy Review* comes out at a critical time when COVID-19 pandemic is widespread, across the world. Globalisation has accelerated its spread and brought in pressing challenges for economic growth and sustainable development. While governments are devising measures to control the spread, there is no definite solution to solve the issue. Both the developed and developing countries are witnessing a sharp increase in cases and deaths. We continue to face multiple and simultaneous challenges in the area of health sciences, economic and social stability, and international cooperation, perhaps the most serious in over a hundred years. 'Diplomacy for Science' has never before faced such a formidable task of forging international scientific cooperation to understand and fight this viral disease, especially in the area of vaccine development and antiviral therapy. This crisis is an eye opener that we need to strengthen global health crisis management, for dealing with future emerging and re-emerging diseases, in times to come.

This issue covers a number of interesting themes related to science diplomacy. The first paper on Science Diplomacy and SDGs by Luisa Echeverría, Karina Aquino and Claudia Widmaier, explores the interrelationship and potentials of Science Diplomacy in Latin America. It asserts that Science Diplomacy has a big role in helping countries of the global South to achieve the SDGs, through sharing of science and technology, joint research and development efforts, and strategic cooperation in Science and Technology for development. Moreover, South-South and triangular cooperation could bring considerable benefits in applying STI for the SDGs.

Another paper by Kapil Patil examines the India-US relationship through the lens of Science and Innovation Diplomacy. The paper highlights the evolution of India-US relationship, which went through ups and downs since the Cold War period, reflecting diverging strategic interests. Ultimately, through difficult negotiations, scientists, diplomats and policy makers on both sides were able to reconcile differences, and since 2005 cooperation has expanded greatly covering practically all areas of S&T.

In the perspectives section, the paper on Clean Energy Transitions and Role of Science Diplomacy by Malti Goel, elucidates on the vital role of Clean energy transitions in addressing climate change issues and achieving sustainable development goals. It stated that science diplomacy initiatives have enabled India to foster clean energy transitions collaborations with advanced economies. However, the potential of science diplomacy is yet to be realised with neighbouring countries and developing nations. Citing the case of Hydro energy development on Indus River, the paper shows that science diplomacy can resolve disputes relating to water management and use. It will to help to address real problems, which require mutual trust, cooperation, engineering skills and diplomacy among participating countries.

Dr. Anil Kakodkar's book, Fire and Fury: Transforming India's Strategic Identity, is highlighted in the Book Review section. The book is a unique personal and insider's view of the development of India's nuclear sector, covering many years of challenges and breakthroughs, including India's nuclear weapons development, as well as managing and overcoming constraints on India's nuclear power plants. The India-US negotiations on nuclear technology find prominent place in this book, as the author was personally involved in it. It is relevant for science diplomacy in understanding the important benefits of scientists, diplomats, and policy makers working together to overcome obstacles related to international cooperation.

The review of the Global Sustainable Development Report 2019 brings out the importance of Science, Technology and Innovation in achieving the SDGs. The report underlines the importance of STEM human resources and their deployment, the full integration of science and technology into the national policy making and execution, and the key role of collaboration between stakeholders at the national and international levels, and especially South-South and triangular cooperation.

The news update section covers some important developments in science and technology in India and a few developments that have potential for wider application. The next issue will cover some of the potential activities in R&D associated with finding solutions and managing the COVID-19 outbreak. In such critical times, I wish all the readers a safe and healthy life, with the hope to overcome the pandemic outbreak.

ARTICLE

Science Diplomacy and Sustainable Development Goals: A Latin American Perspective

Luisa Echeverría*
Karina Aquino**
Claudia Widmaier***


Luisa Echeverría


Karina Aquino


Claudia Widmaier

Introduction

It is a fact that Science Diplomacy is an important aspect of international relations that has increasingly gained visibility in recent years, as a strategy to promote the interests of countries in international spaces. Aquino (2020) states that there is definite association between science and international cooperation. One of the areas related to Science Diplomacy is Science in Diplomacy, that provides enough knowledge and understanding regarding Science and Technology-related issues, required to equip international decision-makers.

On the other hand, the 2030 Agenda for Sustainable Development, signed by the world's governments in 2015, is a plan of action that involves a global roadmap designed to eradicate poverty, improve the living standard and well-being of people, promote more inclusive societies and universal peace, and protect the planet to ensure no one is left behind. The 17 Sustainable Development Goals and 169 targets to assess the progress are integrated and indivisible and balance the three dimensions of

* Internationalization Advisor, SENA, Colombia. She holds a Masters in Linguistics from Universidad de Antioquia, Colombia. She is also a; Masters in German Language from the University of Education, Freiburg, Germany.

** Career Diplomat and Coordinator in-charge (Multilateral Cooperation), Ministry of Foreign Affairs and International Cooperation, Honduras. She holds a Masters in Project Management from Central America Technological University (UNITEC), Honduras.

*** Specialized Technician in Foreign Trade at Uruguay National Customs. She holds a Master's degree in International Relations from UDELAR, Uruguay.

sustainable development: the economic, social and environmental. However, even with this well-established plan of action, there are no concrete results and there is a warning of the delay in achieving the SDGs.

The SDGs represent global challenges that need multilateral solutions and South-South Cooperation to create knowledge and build a bridge between diplomats and scientists. In this Decade of Action, it is necessary to innovate and improvise the way governments drive foreign policies. Science Diplomacy becomes a tool of power for the promotion of national interests and common welfare, without leaving anyone behind, even when diplomatic relations are blocked and Science and Technology offers an opportunity to address these multifaceted challenges, which are now global.

In light of all this, policymakers and diplomats should act in collaborative partnerships, work between researchers to improve strategies in solving these international issues. Sharma (2017) explains that South-South Cooperation is a process used by policymakers and academics to further the exchange of resources, technology, and knowledge among developing countries. Nevertheless, researchers from countries located in the "global south" often do not recognise themselves as diplomats. Meanwhile, science diplomacy requires the infrastructure by way of scholarly networks and associations.

International cooperation needs to bring about changes and governments' need for technology and finance to face the challenges of this decade of action. Further initiatives are needed to achieve the SDGs through Science Diplomacy, which could be reached through the alignment of National Development Plans, National SDGs Plans, and National STI Plans. The role that suitable diplomatic efforts, including the use of Science Diplomacy, can play in this field is quite relevant to achieve the ambitious SDGs. With this in mind, it is important to promote, guide and encourage scientific, technological and innovation advancement, to formulate medium and long-term plans that boost the environmental, economic and social development of the country. Balakrishnan (2017) indicated that today's diplomacy has to deal with a host of subjects, such as consular affairs, economic and business affairs, media and information, education, culture, security, defense, and science & technology.

This article will delve into the concepts of Science Diplomacy, Global South and South-South Cooperation, and describe two successful initiatives to achieve the SDGs. It will use the Science Diplomacy framework, explaining how Science Diplomacy acts as a catalyst for the promotion of joint work between Southern countries.

Conceptual Framework on Science Diplomacy

Science Diplomacy is a way of addressing situations or interests of countries through negotiations with peers, which should be horizontal and based on mutual respect and responsibility. Some authors explain quite well how Science Diplomacy is suitable for international relations. Fedoroff (2009) expressed that the central purpose of Science Diplomacy is often to use science to promote a state's foreign policy goals or inter-state interests. Copeland (2016) states that the Science

Diplomacy enables the release of science and technology from institutional and national barriers for serving the problems of underdevelopment and insecurity. According to Birang *et al*. (2017), Science Diplomacy empowers and accelerates the development, progress, and generation of wealth for the countries. Sege (2020) explains that Science Diplomacy's goal should be the generation of constructive partnerships among countries. Flink & Schreiterer (2010), on the other hand, comment that Science Diplomacy should be understood not only as a challenge for the management of international conflicts and foreign policy but also as a catalyst for the scientific policy of a nation. According to these authors, Science Diplomacy involves various stakeholders, such as governments, international community, non-governmental organisations, civil society, and the private sector.

Science Diplomacy is an important element to achieve political decisions and the design of public policies that take into account scientific evidence, technology, and innovation. Mosquera (2020) explains the importance of interdisciplinary teams for the solution of problems through the hand of Science Diplomacy. According to Echeverría (2020), some Science Diplomacy schemes depend on their own co-financing by governments or other institutions; this is why it is necessary to propose more financing programs that promote the internationalisation of research, as well as improve the relationship between scientists, politicians, and civil society.

Gluckman *et al*. (2017) explains that there are three categories for Science Diplomacy actions. These actions relate to processes for national, cross-border or international interest. Among the actions proposed for national interests, 'soft power' exercises can be generated to advance in strategic spaces with international partners. There are also actions to move forward and contribute to national security and emergencies that arise, like disease outbreaks and actions proposed to advance in the economic interests of a country, opening spaces and agendas for collaboration with partners that support the development in this area. Likewise, a country can use Science Diplomacy to provide a solution to bilateral challenges and problems between countries or across borders, such as issues on migration, the use of shared natural resources or the protection of threatened fauna and flora. There is the last category for Science Diplomacy that seeks to contribute to global problems, such as the Sustainable Development Goals, which represent a shared challenge between countries.

Finally, Flink & Schreiterer (2010) state that there are three objectives for Science Diplomacy: Access, Promotion, and Influence. *Access* refers to the attraction of researchers, research results and infrastructure for science and technology; *Promotion,* on the other hand, refers to attracting the best researchers, students, and companies in the world, which can support a given country to be more competitive and develop innovations; finally, the *Influence* is about seeking spaces in international agendas, as a tool for "soft power" to attract political support to initiatives at the national or transnational level and improve international prestige and recognition.

Dimensions for Science Diplomacy

Balakrishnan (2017) stated that Science

Diplomacy is still a fluid and evolving concept but can be usefully applied to the role of science, technology and innovation in three dimensions: (1) scientific advice and inputs into foreign policy-making (science in diplomacy) (2) Promoting international science cooperation (diplomacy for science) and (3) Using science cooperation to improve relations between countries (science for diplomacy). To this, one may add a fourth important dimension, using science and technology cooperation for sustainable development (science for sustainable development).

In light of this, these dimensions are being analysed and it is understood that the Sustainable Development Goals are related to all of them, since actions can be designed for each dimension. Taking this into account, a graphical representation of government-led activities to achieve Sustainable Development Goals is presented below:

Table 1: Dimensions from Science Diplomacy and Actions related to the Sustainable Development Goals

Dimensions	Actions
1. Science in Diplomacy	• Collect data from research conducted for the Sustainable Development Goals. • Socialise data with policymakers, to support them in decision making. • Support initiatives of individual researchers and networks to find solutions to the challenges, to achieve the objectives.
2. Diplomacy for Science	• Generate exchange programs between researchers, professors, and students for the development of solutions to achieve the Sustainable Development Goals. • Develop spaces, networks, and events for the discussion and socialization of research projects that aim to find solutions to the challenges. • Attract the diaspora to seek resources, advice, and support for the implementation of projects and programs related to the Sustainable Development Goals.
3. Science for Diplomacy	• Facilitate programmes to promote the incoming mobility of researchers and experts, to support the development of initiatives for sustainable development objectives generated at the national and cross-border level.
4. Science for sustainable development	• Generate joint agendas with countries, promoting follow-up and monitoring strategies for sustainable development. • Articulate efforts with multilateral organizations to make needs visible, find resources and make promote actions carried out

Source: Compilation by authors.

The next section will describe the concept of the Global South and its relationship with Science Diplomacy, keeping in view the concept regarding South-South cooperation.

Science Diplomacy and the Global South

Vessuri (2013) speaks of Science Diplomacy from the approach of "co-design" or "co-construction" of knowledge, deepening in the approach of collaborative work between researchers from different latitudes. In this sense, Science Diplomacy requires the infrastructure of networks of researchers. Researchers from countries located in the "Global South" often do not recognise themselves as diplomats; however, they should recognise that in international spaces they represent their countries and their interests. According to Harutyunyan (2020), diplomatic relations should not be unknown to science makers. Science should open the doors between countries in this regard and allow an exchange. Further, the mobility of highly qualified scientists and staff is an effective indicator of the development of science. The scientific relations of the countries are formed mainly as a natural result of the joint work of scientists, assuming roles of ambassadors of science technology and innovation. Countries with a technical deficit of human capital have been able to develop their capacities, thanks to scholarships and capacity building courses (Aketch, 2018).

According to Dados & Connel (2012), the term Global South refers to the countries located in Latin America, Asia, Africa, and Oceania region. These authors also use the terms "third world" and "periphery" to highlight their economic underdevelopment. The collaboration established between countries of the Global sSuth receives the technical term of "South-South Cooperation". Sharma (2017) explains that South-South Cooperation is a process used by policymakers and academics to further the exchange of resources, technology, and knowledge among developing countries. The Southern countries have a particular strength: cultural aspects and challenges that unite them. They have the opportunity to emerge from a history of colonialism through Science Diplomacy strategies, such as the establishment of collaborative networks, either bilateral or multilateral. The proactive, horizontal and dedicated work of the Southern Countries for the solution of the problems that afflict them is a form of resistance. It is also a strategy to set agendas and issues of joint interest in the international stage historically led by countries from the North.

South-South cooperation is a good illustration to exchange opportunities related to the global south to achieve the 2030 Agenda for Sustainable Development. Science is considered in its broadest sense to encompass not only scientific research but also the whole range of international scientific cooperation activities including capacity building. Within this framework, there is an association between science and South-South cooperation one of the areas related to Science Diplomacy is Science in diplomacy that provides enough knowledge and understanding regarding Science and Technology-related issues, required to equip international decision-makers.

Nieto et al. (2020) referred that it is necessary to strengthen internal capacities together with international cooperation to face challenges and opportunities in the region when the world environment is more complex. In the framework of SDGs when there are human resources trained and understood in the subject of Science Diplomacy, it is better for negotiations about international trade as well as technology and science, in the framework of south-south cooperation (Widmaier, 2020).

Looking at current challenges, such as those related to global health, climate change, inclusive societies, just to mention a few, it must be acknowledged that science, technology, and knowledge have a central role to play in providing possible solutions and the design of realistic and measurable initiatives to face the ambitious 2030 Agenda for Sustainable Development. The next section will show some of the initiatives undertaken by Latin America.

Science Diplomacy through Latin American SDGs initiatives

The initiatives and efforts being undertaken in Latin America to achieve the 2030 Agenda, usually carry obstacles and challenges. Mitra (2020) refers to the challenges like an opportunity for underpinning Science, Technology, and Innovation for SDGs and he also expresses that they are 'international' and no country will be able to solve these problems on its own. Consequently, it is required to pay special attention to these international issues, which could be solved by Science Diplomacy.

From the perspective of the United Nations through information expressed by the Economic Commission for Latin America and the Caribbean (CEPAL in Spanish), explain that eightcurrent obstacles prevent the 2030 Agenda from being achieved, and it proposes to create policies focused on rights and equality. Obstacles are (CEPAL, 20):

1. The persistence of poverty;
2. Structural inequalities and the culture of privilege;
3. The gaps in education, health, and access to basic services;
4. Lack of work and uncertainty in the labour market;
5. Partial and unequal access to social protection';
6. The institutionalisation of the social policy still under construction;
7. Insufficient social investment; and
8. Emerging obstacles: Violence, natural disasters, and climate change, demographic transition, migration, technological changes: Technological transformations are having significant effects on education and training.

Despite the obstacles mentioned before, the initiatives to achieve the SDGs through Science Diplomacy can be reached by the implementation of the National Development Plans, National SDGs Plans and National STI Plans in a regional and multilateral dimension. This is perhaps understandable in light of all the above explanations; it is required to align the plans to make possible positive results to contribute to achieving the SDGs.

Source: Mitra, 2020

The initiatives in the field of South-South cooperation in the region have been connected between the international spheres, with national action plans in three areas: development, sustainable development, as well as science, technology, and innovation. Taking into consideration the objectives of Science Diplomacy proposed by Flink & Schreiterer (2010) - Access, Promotion, and Influence - two initiatives are presented below for the development of the 2030 Agenda in Latin America.

Initiatives of CODS

This initiative refers to the Objective for Science Diplomacy Access, which means the attraction of researchers, research results and infrastructure for science and technology related to the Sustainable Development Goals. This initiative points to SDG number 17, which is related to promote the creation of alliances to achieve the objectives.

In Colombia, the Universidad de los Andes in Bogotá has created a center for multidisciplinary work for the implementation of the SDGs, called *The Center for Sustainable Development Goals for Latin America and the Caribbean*. This center is part of the United Nations Sustainable Solutions Network (SDSN), led by Jeffrey Sachs of Columbia University. The process of establishing the Center has been guided by a committee made up of professors from the Faculty of Administration and the Faculty of Economics from the Universidad de los Andes and members of the SDSN. This initiative is a Think Tank about SDGs in alliance with universities of excellence and research centers in Latin America and the Caribbean (CODS, 2020).

The main objective of the Center is to become a meeting place about the SDGs in alliance with recognised universities, companies, governments and civil society organisations in Latin America and the Caribbean. The Center is a platform for the dissemination of knowledge and to contribute to the training of the next generation of leaders in sustainable development in the region and to monitor and evaluate policies and programs in the region, to contribute to the achievement of the SDGs. Also, it seeks to contribute from the experience of the region to global discussions of the SDGs, as well as to design and lead a research agenda related to the SDGs most relevant to the region (CODS, 2020). To achieve these objectives, CODS has identified the following key aspects of its mission (CODS, 2020):

- Emphasis on the interconnection between the social, the economic and the environmental issues and on the understanding of synergies, trade-offs, and relationships between different SDGs.
- Permanent search for alliances, connecting existing efforts and enhancing the role of academia and knowledge for the fulfillment of the SDGs in the region.
- Creation of inter-university teams and new networks in the region with the capacity to produce high-quality interdisciplinary research in the countries of Latin America and the Caribbean (regional and sub-regional research)
- Generation of new ways of measuring progress in the implementation of the SDGs
- Incorporation of sustainability in the daily life of partner universities

The Center carries out the following activities (CODS, 2020):

i) *Research*: The research area seeks to create alliances and networks between researchers, universities, think tanks and research for the production and dissemination of knowledge about the priority SDGs for the region. In addition, it is responsible for promoting and coordinating the financing of a regional research agenda. International seminars are planned to establish research priorities and networks and to launch research calls for interdisciplinary teams in the region.

ii) *Training*: The training area focuses on creating spaces to deepen the understanding of the SDGs in the context of Latin America and the Caribbean. This is done by offering a training portfolio made up of international seminars to establish the priorities of the area, formal and non-formal education spaces, the realisation of virtual courses of free access and the creation of postgraduate programs in areas of sustainable development.

iii) Advocacy: The advocacy area seeks to contribute to improving decision-making in public and private spheres to advance compliance with the SDGs in the region. It includes the creation of an observatory of regional public policies aimed at the fulfillment of the SDGs and aimed at mobilizing action to change the behaviour of a society that contributes to achieving the objectives set for 2030. It also includes the promotion and holding of seminars, forums, etc. that seek to influence public opinion and decision-makers.

iv) *Sustainability*: The sustainability area on campus focuses on promoting a more sustainable environment. It promotes the commitment of the universities to the campus and its environment through basic training in sustainable development for all the students of the allied universities, as well as the promotion of research in SDGs. Also, it emphasises that the campus is governed by the principles of sustainable development through good practices in its behaviors such as the use of energy and its relationship with suppliers, and special projects within each university for the promotion of the SDGs.

Solar Energy Program in Uruguay

The programme is related to the three objectives of Science Diplomacy proposed by Flink & Schreiterer (2010) - Access, Promotion, and Influence. . The Uruguayan Energy Policy is part of the Agenda for the period 2005-2030. This initiative points to SDGs number 7 for affordable and clean energy, nine industry, innovation and infrastructure, 11 sustainable cities and communities, 12 responsible production and consumption and 13 to achieve climate action (MIEM, 2014).

One of the programme's objectives is to diversify the energy matrix by calling for the incorporation of indigenous and renewable sources. In this sense, the project is directly related to the concept of access according to the authors Flink & Schreiterer (2010), due to the internationalisation of the project, attracting international researchers and considerable infrastructure in the field of science and technology. One of the examples in this framework is the creation of the largest solar park for industrial self-consumption in Uruguay operating to date. It is the largest Solar Photovoltaic Park for industrial self-consumption in Uruguay of the company Cristalpet, a leader in the manufacture of preforms for packaging in the country.

According to Flink & Schreiterer (2010), this Solar Energy Program has advanced towards highly relevant institutional aspects such as the creation of the Solar Table in 2008, a multidisciplinary field that brings together public and private actors from the sector; the Solar Chamber, in 2010, bringing together companies working in the energy industry sector, the opening in 2014 of a Solar Energy Laboratory (LES) that works on the estimation of the solar resource in Uruguay and also in 2008, they create the Sectoral Fund for the Promotion of Research, Development, and Innovation in the Energy Area (MIEM, 2014).

Other objective is to influence and is directly involved with the Vth LATAM Renewable Energy Congress held in LATU Technology Park in Uruguay, on July 22 and 23, 2019. The event organised by the Uruguayan Association of Renewable Energies (AUDER) has already been declared of national interest by the Ministry of Industry, Energy, and Mining (MIEM). In this latest edition, participants from 12 countries attended, including Argentina, Brazil, Chile, Mexico, France, Spain, Italy, and Germany (LATAM, 2019).

During the 2-day conference, debates were held on mergers and acquisitions, electric mobility, the market, plans, distributed photovoltaics, and global warming. Participating actors included specialized consultancies, investment banking, tax analysts, financial advisers, and independent engineering.

Conclusion and Recommendations

When referring to the country's initiatives with the purpose to achieve the SDGs in Latin America, it should be moved ahead in the direction of using Science Diplomacy. The implementation of Science Diplomacy in Foreign Policies to address international cooperation has been identified as the result of the alignments within, National development plans, STI plans, and National SDGs plans to reach the 2030 Agenda for Sustainable Development. Although diverse realities converge in Latin countries at the same time, there is a common axis: they all belong to the "Global South". Science Diplomacy requires an infrastructure of research-networks to develop and support projects related to it. Likewise, the creation of capacity building projects through the exchange of human resources specialized in research and science plays an important role.

A quite important aspect related to the initiatives undertaken in Latin America to achieve the 2030 Agenda for Sustainable Development, is to create enforcement and efficient Monitoring and Evaluating systems that contain actions to develop the ability to monitor and assess the progress. It is relevant that the initiatives have been prioritised and aligned to the strategic needs of the countries. The actions in the reference should be created dynamically and flexibly that include efforts to resolve global challenges, such as climate change, inclusive societies, migration, energy transition, just to mention a few.

Finally, perhaps the most important challenge to achieve the 2030 Agenda is the creation of sustainable alliances over time, including governmental and non-governmental actors, research centers, policymakers, and civil society, with action plans and resources to support the implementation.

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ARTICLE

Indo-U.S. S&T Cooperation and the Role of Innovation Diplomacy

Kapil Patil*

Kapil Patil

Introduction

The governments of the United States and India have been cooperating in areas of science and technology (S&T) for several decades now. In the past, bilateral cooperation mainly focused on promoting scientific collaborations to address multiple failures in the supply of public goods. The PL-480 programme, for instance, has been the classic example of such collaboration, which unleashed the so-called 'green revolution', and made India self-sufficient in the production of food grains. While India and the United States continue to support cutting-edge scientific research by promoting collaborations among individuals in universities, government laboratories, and non-governmental institutions, in the recent decades the two sides are increasingly working to promote "innovation" through extensive public-private partnerships. The core objective of such partnerships is not only to commercialise and diffuse new technologies developed via national and bilateral S&T efforts but also to generate enhanced socio-economic values. Furthermore, the two countries also aim to leverage bilateral S&T linkages to build 'regional innovation networks' and to enhance their geostrategic influence in regions such as Indo-Pacific.[1] As a result, the S&T cooperation between the two counties has acquired a more commercial and strategic dimension and is creating a web of relationships among industries, academia, NGOs and individuals of the two countries.

Some of the important events, in the recent past, have served to bring science, technology and innovation (STI)

* Research Assistant, RIS. He holds Ph.D. in Science Policy from Centre for Studies in Science Policy, Jawaharlal Nehru University, New Delhi.

initiatives at the centre stage of the Indo-U.S. bilateral ties. During the U.S. President Donald Trump's visit in February 2020, New Delhi and Washington elevated the bilateral ties to the level of 'comprehensive global strategic partnership', and vowed to strengthen innovation linkages in a diverse array of fields such as energy, outer-space, earth-observation, defence and civil nuclear technology, healthcare, disease surveillance, cyber-security and innovative digital ecosystem, etc. Before that, in December 2019, the representatives of U.S. and Indian government signed a new umbrella S&T cooperation agreement, which calls for deepening bilateral scientific and technological ties, foster high quality 'research' and 'innovation' partnerships and promote economic growth (MEA, 2019; PIB, 2019).[2] From the growing trend of STI-related engagements, the two countries have many potential opportunities to expand bilateral collaboration and to pursue win-a-win outcomes. At the same time, several institutional challenges, and differences over key policy issues such as intellectual property regimes, trade and tariff conditions, and more recently, the issues related to data localisation, are significantly affecting the speed and direction of bilateral cooperation. This is evident from several pending issues in the WTO's dispute settlement and in other forums, which require early negotiation and resolution.

In this backdrop, the article seeks to examine the extent to which 'innovation diplomacy' as policy tool can help the two countries to address various institutional challenges and to create favourable framework conditions for furthering innovation cooperation. The first section of this article lay down the 'innovation diplomacy' framework to understand the interface between foreign and innovation policies at the bilateral and multilateral levels. The second section discusses the key development in Indo-U.S. S&T cooperation over the past two decades and maps the changing trends and priorities. Thereafter the third section examines the prospects for innovation diplomacy to address policy barriers and foster cooperation. The concluding section discusses the policy implications of this research.

Innovation Diplomacy: A Frame of Reference

During the past two to three decades, policymakers across the globe are implementing a host of policies to support 'innovation' in recognition of its role to promote economic growth and competitiveness of firms. The quest to stimulate industrial innovation is also shaping the bilateral and multilateral engagements as more and more countries are including innovation as one of the key foreign policy objectives. As a consequence, the concept of 'innovation diplomacy' has gained much traction among academics as well as policy and business leaders around the world. Although there is no single agreed definition of 'innovation diplomacy', the concept continues to evolve as it takes into account different practices such as hosting regional business summits, appointing attaches in embassies, launching international programmes, and so on used for marshalling innovation through external economic and security policies of the states. In this context, the extant innovation policy literature offers a useful analytical reference to conceptualise innovation diplomacy practices of the states. Edler and Fagerberg (2018) outline three important innovation policy types, namely, the mission-oriented, invention-oriented and system-oriented innovation policies. Based on these policy categories, a typology of innovation diplomacy can be developed to understand various diplomatic practices used by states at both bilateral and multilateral levels.

First, the 'mission-oriented innovation diplomacy' would entail providing new solutions to specific challenges that are high on the policy agenda. The emergence of certain 'grand challenges' such as global warming, pandemics, etc. requires bilateral as well as multilateral innovation diplomacy efforts to find solutions that may be relevant to all the stakeholders. Interventions through 'innovation diplomacy' have become popular more than ever before in finding sustainable solutions to these challenges. Second, 'invention-oriented diplomacy' focuses on bilateral R&D projects to generate novel technological breakthroughs. Although these approaches have a strong overlap with traditional science diplomacy practices, what distinguishes the former from the latter is its focus on commercialisation of innovation by the market players. In other words, the elements of commercialisation and diffusion of the invention to the market is central to invention-oriented diplomacy approach. Third, the 'innovation diplomacy for strengthening national innovation system' is a major agenda for policymakers today. Also, known as the system-oriented policies, they are primarily oriented towards supporting a countries' or region's innovation system by addressing many market and system failures, which hinder the commercialisation and diffusion of innovations. The innovation literature identifies many such failures ranging from the poor articulation of demand to the lack of network effects to the absence of knowledge networks, or the poor interaction between users and producers required to define innovative solutions, etc. In this context, the bilateral or multilateral innovation diplomacy can contribute to not only addressing gaps in the respective national innovation systems but also help to build new technological capabilities.

This is more so, as innovation has become a global phenomenon through the emergence of trans-national R&D linkages and the globalised value chains (Bound, 2016). With innovation increasingly blurring the national boundaries, creating knowledge networks has become an important issue in the relations between states. Innovation diplomacy thus creates avenues to exploit collaborative opportunities, assess risks across every link in the innovation value chain, and promote economic growth through diversifying production and businesses. Leijten (2017) takes this point further by linking innovation diplomacy as part of the overarching economic diplomacy, which aims to secure national gains in trade, investment, technology, etc. Consequently, the issues such as trade in high tech products, ownership and protection of intellectual property, promoting technology standards, etc., which often prove to be contentious, are increasingly regarded as crucial from the standpoint of innovation diplomacy. In this sense, innovation diplomacy as a concept and practice is aiding policymakers to serve diverse innovation policy goals and promote national and global well-being (Leijten, 2017). The innovation diplomacy framework outlined here can be useful to understand the dynamics of Indo-U.S. S&T

cooperation and to examine challenges and opportunities associated with it.

The Contours of Indo-U.S. S&T Cooperation

The Indo-U.S. S&T cooperation has a rich legacy spanning over the past several decades (Mitra, 2002).[3] Started in the 1950s at the governmental levels, the S&T cooperation has fostered extensive academic partnerships between scientific and technical professionals of the two countries. These partnerships played a pivotal role in envisioning and supporting some major initiatives. The 'Green Revolution' in India facilitated by U.S. PL-480 rupee funds, the setting-up of Indian Institute of Technology (IIT) at Kanpur, Tarapur nuclear power plant, the Satellite Instructional Television Experiment (SITE) are some of the popular examples of this longstanding cooperation (Mitra, 2002). Over time, there has been several bilateral agreements and protocols signed between scientific departments, ministries and agencies. Nearly five decades of bilateral cooperation has led to progress across a broad range of scientific fields and the delivery of public goods, especially in India. In 2005, the two countries, for the first time, signed an umbrella S&T cooperation agreement, which set the new direction for advancing bilateral cooperation in various technological fields. The agreement called for strengthening technological cooperation in their respective countries for promoting economic growth, and outlined certain core principles such as the 'symmetrical and reciprocal basis of cooperation', 'information exchange between partners', and 'the protection of intellectual property rights'. It identifies specific modalities of cooperation such as the participation of Indian research institutions and scholars in joint projects, mobility of researchers, and the exchange of information and equipment. Under the aegis of this agreement, a joint S&T committee is engaged in planning, coordination, and review of the bilateral S&T endeavours (TIAS, 2006).

Under the framework of such institutional agreements, the U.S.-India S&T cooperation has progressed at a rapid pace. The two countries have undertaken cooperative projects in the diverse array of fields such as particle physics, space, atmospheric, biomedical sciences, health, transport, energy, agriculture and civil industrial technology. In many ways, the government-to-government S&T cooperation has led to creating webs of relationships between the universities, professional societies, nongovernmental organisations (NGOs), and among the people of two countries. For example, the Indo-U.S. 21st Century Knowledge Initiative has created as many as 32 partnerships between the universities in the fields of "energy, climate change and environmental studies; education and educational reform; public health; sustainable development and community development; and international relations and strategic studies" (The White House, 2016). Similarly, the NGOs such as Gates Foundation are working to complement various governmental programmes in the areas of 'healthcare', 'rural financial services', sanitation, women empowerment and so on. The key mechanisms used for S&T cooperation include collaborative R&D, transfer of technology, experimental and demonstration projects, exchange of information through technical meetings, personnel and academic exchanges, etc. Also, there exist more than 15 different fellowships and grant schemes to train the next generation of Indian scientists and engineers (See, Table 1). Various governmental and other channels for S&T engagement have been valuable to identify newer areas of cooperation and, in turn, reinforced the commitment to expand bilateral S&T relationship.

Innovation Partnerships and Changing Patterns of S&T Interactions

Over the past decade and a half, the shift from traditional scientific collaborations towards explicit technology and knowledge-driven innovation activities has increasingly become evident in the Indo-U.S. relations.[4] During the joint press address with President Trump in February 2020, the Indian Prime Minister Narendra Modi noted that "innovation and enterprise are setting new positions of India-US partnerships", and that the two countries are committed to promoting strong cooperation in these areas (MEA, 2005). From the Indian standpoint, innovation partnerships are critical to support India's growing

Table 1: Indo-U.S. S&T Forum Projects and Schemes

Innovation and Entrepreneurship	Joint Research & Development	Fellowships and Visitation
• Smart Grids and Energy Storage • Realtime River Water and Air Quality Monitoring • DST-Lockheed Martin India Innovation Growth Program (IIGP) • One-Breath: Affordable Mechanical Ventilator	• Joint Clean Energy Research and Development Center (JCERDC) • Affordable Blood Pressure Measurement Technologies for Low-Resource Settings in India and the U.S. • Indo-U.S. PACE-setter Fund; • Research Initiative for Real-time River Water and Air Quality Monitoring; and • Partnerships for International Research and Education (PIRE).	• Water Advanced Research and Innovation Fellowship • Bhaskara Advanced Solar Energy Fellowship • SERB Indo-U.S. Postdoctoral Fellowships for Indian Researchers • Building Energy Efficiency Higher & Advanced Network Fellowships • IUSSTF–American physical Society Fellowships • ASM-IUSSTF Indo-U.S. Professorship in Microbiology • Khorana Program for Scholars • IUSSTF-Viterbi Program S.N. Bose Scholars Program • Genome Engineering/ Editing Technology Initiative (GetIn) Program • Women in Science (WIS) Fellowship Program

Source: IUSTTF Reports (2002-2019).

number of tech start-ups dealing with various new and emerging technologies. The start-ups constitute an important source of job creation and attracting foreign investments. In the areas of strategic and emerging technologies, much of the cooperation will take place between American and Indian companies through commercial channels. Currently, many U.S. companies have made large investments and technological alliances with companies in India, while several Indian companies provide technological services in the United States.

Further, in the contemporary global trend of innovation and cross-border R&D, the potential exists for both the countries to leverage 'complementary strengths' in S&T, and to enhance the share in global value chains. With the growing significance of innovation in Indo-U.S. bilateral partnership, the goals and modalities of traditional S&T diplomacy too are changing. For instance, traditional science diplomacy instruments have considerably evolved in order to foster innovation and securing national gains in trade, technology, and investments. Such instruments include traditional dialogue mechanisms, and initiatives such as Indo-U.S. Science and Technology Forum (IUSSTF), the United States-India Science & Technology Endowment Fund (USISTEF), and Defence Technology and Trade Initiative (DTTI), which have been pivotal in bridging the gaps between public and private enterprises between the two countries.

IUSSTF as a Model of Invention/ Innovation Oriented Diplomacy

The IUSSTF has traditionally served as an important forum to promote bilateral S&T cooperation in support of various national missions and to meet specific societal needs. In recent times, however, the IUSSTF and its endowment fund (USISTEF) are promoting many socially relevant innovation projects, and facilitating the commercialisation of technologies through private industry. The IUSSTF has helped to forge strong links between public laboratories, universities, as well as the private sectors of the two countries via joint R&D support, innovation, and programmes. It has funded several projects in the areas of affordable biomedical devices & diagnostics, preventive & curative measures for health improvement, and food and nutrition products. The bilateral S&T and innovation exchanges have become more salient, especially in the areas of clean energy and the environment. Currently, the USISTEF is implementing two major R&D initiatives namely, *the smart grids and energy storage* and *real-time river water and air quality monitoring*. Jointly funded by the U.S. Department of Energy and India's Department of Science and Technology, these ambitious projects represent unique public-private partnerships (PPP), which bring together researchers from academia, national laboratories, industry, and private multinational companies, and developed novel approaches to sharing intellectual property. Furthermore, the IUSSTEF supports the development of information and communication technologies (ICTs) with societal impact in the areas such as water, agriculture, financial inclusion and education. Some of the tangible results of these collaborations include joint work on the development of artificial limbs, drought-resistant seeds, off-grid solar systems, medical devices, mobile health apps, e-markets for artisans, and so on (Verma, 2017). The aforesaid examples clearly point that changing patterns of bilateral cooperation which focuses on generating new innovation opportunities and to provide for their early market introduction. The IUSSTF thus mainly serves as an important instrument of innovation diplomacy by providing an overarching framework for cooperation by bringing various state and non-state actors together for promoting innovation.

DTTI as Mission-Oriented Innovation Diplomacy

Policymakers around the world widely regard defence and security as important public goods to be secured through national and regional technological missions. In this context, the Indo-U.S. defence trade and technology initiative (DTTI) presents an important case of mission-oriented innovation diplomacy. Since its inception, the DTTI has played an important role in transforming defence technology cooperation from donor-supplier to a more constructive bilateral partnership with the expressed intent of building India's domestic defence industrial base. In pursuit of this goal, the U.S. and Indian companies are co-producing mega-platforms like the C-130 transport aircraft, F-16 fighter planes and Apache helicopters at joint facilities in places like Hyderabad (Behera & Balachandran, 2018). The growing defence cooperation, especially among the private giants through models like joint research, co-development, and co-production of advance military platforms, and weapons has spurred the emergence of cities like Hyderabad and other innovation centres across India as major aerospace and defence production hubs (Reifman, 2019). Similar collaborations can also be identified, albeit on a smaller scale, in the areas of technological solutions for mitigating climate change and to meet the sustainable development goals, etc.

Public-Private Partnerships as Innovation Oriented Diplomacy

Building public-private innovations partnerships to serve national innovation policy goals has drawn the attention of policymakers in both India and the United States. One of the major programmes in this respect includes the India Innovation Growth Program (IIGP), a tripartite initiative between India's Department of Science and Technology, Tata Trust, the Lockheed Martin Foundation. Launched in 2007, the IIGP is the longest-running PPP to support start-ups and address specific challenges faced by innovators in scaling their innovations. In 2017, the second phase of the programme (IIGP 2.0) was launched and together it generated over 400 commercial agreements and over one billion US dollars in economic value. Over time, hundreds of collaborative projects between U.S. and India- scientists and entrepreneurs have been completed, which resulted in the "delivery of affordable technologies based on neonatal resuscitation, prosthetics, water purification and clean cookstoves, among others" (State Dept., 2015). Another important initiative includes the joint programme between the United States Agency for International Development (USAID) and India's Department of Biotechnology (DBT) to "support Indian innovators and entrepreneurs to pilot, test and scale-up innovations in India" (White House, 2016). The programme has supported research partnerships in the areas of "diabetes research, low-cost medical devices and vaccine development" (Ibid). The development of Rotavac vaccine is an important example of an innovative public-private partnership involving government, private sector and academic partners. The vaccine has been launched in the Indian market. Further, the USAID too has adopted the public-private partnerships model to leverage S&T and innovation capacities to address major development challenges. Lastly, in 2016, the two countries launched the 'U.S.-India Innovation Forum' as a platform to "identify best practices in promoting a culture of innovation and highlight the leading role that innovation partnerships can play in the U.S.-India economic relationship". The forum offers a useful avenue for private entities to identify the challenges for generating and diffusing innovations and to demand state interventions to resolve potential regulatory and institutional problems.

Innovation Diplomacy: Agenda for Indo-U.S. Cooperation

At the enterprise level, the U.S. firms are continuing to express strong interest in India's huge domestic market by utilising their advanced technologies and marketing expertise to capture greater market share. Many leading American MNCs have registered impressive performance in the Indian market and their operations are regulated by a host of trade and investment-related laws such as foreign direct investment, intellectual property rights (IPRs), etc. Forging multiple STI-oriented partnerships, however, faces several challenges relating to institutions and policies which exist in both the countries. As more and more Indian and American companies join hands to exploit the commercial potential of certain high-technologies, the U.S. and Indian policymakers will have to provide a conducive policy framework to support investments and enable markets to determine the viability of such projects. A predictable policy regime along with transparent business conduct on part of private enterprises will be desired to foster lasting innovation partnerships between the two countries. Drawing from the conceptual framework outlined in section on Innovation Diplomacy: A frame of reference of this paper, innovation diplomacy framework can help to address these challenges effectively. In principle, the innovation diplomacy efforts contribute to creating: a) favourable policy conditions, which are crucial to shaping the context, in which firms innovate and determine their market success; and b) provide a mechanism to identify collaborative opportunities and assess risks in innovation chains. Among the favourable policy, conditions include creating the channels for a seamless flow of information and ideas through multiple networks, negotiating mutually agreeable trade, business, and IPR frameworks, fostering mutual trust.

First, various Indo-U.S. dialogue and exchange mechanisms, over the past decade, have sought to improve the flow of information to firms and enterprises about new opportunities and dynamics of innovation in India. While people-to-people contacts have been vital to improving the growing flows of information and ideas, innovation diplomacy instruments should provide for more focussed policy solutions to facilitate the exchange of information, assessment of opportunities and risks, discussions on trade, IPR and other regulatory issues and to foster greater trust among the concerned stakeholders. Through increased trust and partnerships, various stakeholders can make better strategic decisions about innovation investment and collaboration in India. This is crucial since policymakers on both sides seek to expand business opportunities in their respective countries.

Second, the U.S. industry and investors have long bemoaned about the gaps in India's IPR framework and called for tightening the regime. A robust IPR regime, according to the U.S. industry is a prerequisite for tapping the creative potential of innovators on both sides, whereas, from the Indian standpoint, a homogenised IPR regime considerably limits the opportunities for incremental innovation and technological catch-up of its firms. Also, with the U.S. putting India on 'priority watch list' in 2016 due to a lack of measurable improvement to its IPR regime has caused considerable friction between the two nations (PTI, 2016). While the IPR debate is a longstanding one in the Indo-U.S. relations, the latest S&T cooperation agreement resolves it partly by including a common framework on IPRs. Besides trade and IPR, the issues of technology regulation, development of technical standards, joint R&D on new products are likely to involve consultations among various stakeholders, which can be provided under the rubric of innovation diplomacy.

Third, innovation diplomacy can help to serve the strategic objectives of bilateral S&T cooperation. In recent years, India and the U.S. have launched several initiatives to deal with certain grand challenges such as climate change and energy security, etc. Also, the two countries seek to leverage innovation networks to create regional strategic influence, for example, in the Indo-Pacific region. In this context, innovation diplomacy engagements can help to build mutual consensus and ensure adequate funding and requisite policy support for such strategic initiatives. Similarly, India has placed a strong emphasis on the use of STI (science, technology, and innovation) to develop innovative solutions in the areas of clean energy, environment, water, agriculture, healthcare, etc. These are the priority areas for the U.S. too, and the cooperation between the two countries is likely to have implications for promoting 2030 sustainable development goals.

Fourth, through annual innovation policy workshops involving wider industry and academic participation, the two sides can map trends in the Indian STI system, identify new opportunities, and chalk-out strategies to enhance innovation cooperation. Further, the joint initiatives can add to the analytical capacities for mapping developments in Indian STI policy domain, scientific publications outputs and patents, etc. Finally, notwithstanding the growing Indo-U.S. strategic convergence, the national policy agendas like 'America First' might endanger the spirit of mutual innovation cooperation. In particular, the Trump administration's strong rhetoric over trade imbalances and restrictions of granting work visas threatens to disrupt longstanding links that the U.S. has forged with the Indian technological system through academic and industry-level exchanges. In this respect, sustained dialogue and engagement can help to minimise friction and foster innovation cooperation between the two countries.

Conclusion

This paper has attempted to map the changing contours of Indo-U.S. S&T cooperation and elucidates the role played by various innovation diplomacy instruments in furthering bilateral ties. Notwithstanding the problems confronted by India in building strong STI capabilities, its commitment and pursuit of cooperation with the U.S. have produced tangible results. The trajectory of India's development along with the creation of indigenous technological capabilities offers several interesting opportunities for the U.S. to promote innovation-based cooperation. Taking advantage of these opportunities and addressing policy challenges, however, requires skilful innovation diplomacy and requisite investments, on both sides. The future innovation diplomacy interventions should thus aim to not only augment India's R&D and innovation capabilities but also identify certain core sectors where country seeks to develop competitive advantages.

Endnotes

1 In recent years, the U.S. has been pushing for a broader role by India in the Indo-Pacific region. According to U.S. state department officials, the two sides are working to a launch a new clean energy initiative to fuel economic growth in the strategically-important Indo-Pacific region.

2 During the (2+2) ministerial dialogue held in December 2019, India and the United States signed a new S&T cooperation agreement as a successor to 2005 agreement. Signed in 2005 for a period of ten years, the agreement was extended for another three years in 2016.

3 In the 1960s, the Nobel laureate Norman Borlaug launched agriculture cooperation by developing a new wheat seed variety which transformed scarcities in food grains into abundance. The U.S. laws however imposed strict prohibitions on transfer of various civilian and military technologies, which were lifted only in the post-Cold-War years.

4 See, U.S.-India Joint Fact Sheet: A Remarkable Expansion of U.S.-India Cooperation on Science & Technology, June 24, 2013, at https://2009-2017.state.gov/r/pa/prs/ps/2013/06/211028.htm.

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PERSPECTIVE

Clean Energy Transitions and Role of Science Diplomacy

Malti Goel*

Malti Goel

Gaseous emissions, particularly carbon dioxide resulting from the combustion of carbon-rich fossil fuels, have contributed significantly to the increase in atmospheric greenhouse gases (GHG) emissions. Increased accumulation of GHG emissions is giving rise to global warming, which is leading to an accelerated climate change. The major greenhouse gases are carbon dioxide, methane, nitrous oxide and chlorofluorocarbons and minor greenhouse gases are sulphur hexafluoride and perfluorocarbons. Carbon dioxide (CO_2) accounts for almost 68 per cent of all GHG emissions on earth. According to WMO Greenhouse Gas Bulletin, the CO_2 concentrations have increased 146 per cent in the past 250 years as a result of excessive fossil fuel use (GHG Bulletin, 2018). The rise in methane is as high as 257 per cent and a rise in nitrous oxide concentrations is 122 per cent since the pre-industrial era. It is believed that GHGs concentrations are now at its highest level in 800,000 years, and became 412 parts per million (ppm) in 2019. The global temperature rise is likely to reach 1.5°C between 2030 and 2052 if the emissions continue to increase at the current rate IPCC (2019).

Energy no doubt is the backbone of economic and socio-economic development of a country. The energy sector is in a state of transition as there is a shift from fossil fuel-based economy to a greater dependence on renewable energy and the use of low-carbon emission technology. The Paradigm of the clean energy transition is largely driven by the recognition that to reduce global

* Former Adviser/ Scientist 'G' and Head Science & Technology Advisory Committee (STAC) under Ministry of Science & Technology, Government of India. She holds Ph.D. in Physics from Indian Institute of Technology, Delhi.

carbon emissions, we must change energy systems worldwide to replace fossil fuels. Clean energy generation and use can combat the negative effects of technology on the planet and its ecosystems by reducing not only air pollution, but also water and land pollution. Clean energy transitions are therefore vital for mitigating climate change. The various options are a set of technologies that either reduce the pollution from energy generation and/ or optimise the use of resources in energy demand.

India is currently the fourth largest CO_2 emitting country though accounting for only 7 per cent of global emissions. In India's energy basket, coal is a dominant fuel and has a share of 41 per cent in primary energy and 59 per cent share in the installed capacity. In 2017 it provided 79 per cent of the electricity. The share of renewable energy sources was 17 per cent in the total installed capacity of 329 GW. As an emerging economy, India has set ambitious renewable energy target of achieving 175 GW capacity from renewable energy by 2022. The Paris Agreement on Climate Change represents one of the biggest climate change milestones and a total of 196 Parties at the 21st Conference of the Parties (COP 21) in 2015 agreed to take drastic measures to fight against climate change (UNFCC, 2020). India's Nationally Determined Contributions (NDCs) under the Paris Agreement is to reduce the emission intensity of its economy by over 33-35 per cent by 2030, compared with 2005 levels. Another significant transition is achieving non-fossil fuel-based energy share of 40 per cent in the total installed capacity by 2030. The CO_2 sinks are expected to increase by 2-3 billion tonnes per annum.

While there is a global drive to adopt clean technology solutions due to the current and future impacts of climate change, barriers in energy transition can be removed by looking beyond national boundaries. Intra-regional cooperation through diplomacy requires international cooperation of different nature. In the context of clean energy, science diplomacy should be considered as a means to reduce the energy imbalances that exist among the countries having different energy baskets and different consumption patterns. Diplomacy for energy, which has been mainly driven by hydrocarbons import-export, is transitioning to low-carbon diplomacy, requiring more research & development (R&D) than the energy geopolitics of resources. Knowledge sharing of clean energy technology innovations would have a vital role in this. The export–import of electricity is emerging as another form of trade-based diplomacy.

To work for science diplomacy, one needs both human and financial resources. Governments are the most important stakeholders for the successful engagement of scientists with foreign policy. Financial support is critical to develop and maintain mechanisms, and R&D support must increase. A sustained organisational and institutional relationship is vital for science-policy interaction. It helps in developing joint research programmes to drive innovation, hold joint workshops and trainings for capacity building in peripheral areas. Science diplomacy tools also require incentives to acknowledge civic and public engagement by energy experts, scientists, engineers and diplomats having served in the government or policy-making institutions to attract participation and enable their dedicated focus (INGSA. 2018).

Bilateral, regional or multilateral instruments are proposed to cultivate science diplomacy professionals and participation from different countries. Key bilateral, multilateral or regional science diplomacy initiatives in India towards clean energy transitions are discussed as follows.

Bilateral Science Diplomacy Initiatives in Clean Energy Transition

In the early 1960s, US began Science (or public) diplomacy with India when US Public Law 480 (PL 480) money received by India for Agriculture research was treated as a fund to be utilised for the exchange of scientists from Indian Institutes of Technology and Universities. Dialogues with USA and Canada on reactor technology also began in the 1960s. Potential of nuclear energy has been recognised as non-greenhouse gas emissions technology as 'green' or 'clean' energy. US-India science diplomacy in the field of nuclear energy is '123 Agreement'[1] between the United States of America and the Republic of India signed on July 27, 2007. It is also known as Indo-US Civil Nuclear Agreement. Negotiated among the top *scientists* and *politicians* this strategic treaty, aided by the "growing strategic convergence between India and the US" made a beginning through the "Next Steps in Strategic Partnership" in 2003-04 (Rajagopalan & Biswas. 2016). The agreement aimed at energy security not only brought India to the global front of civil nuclear trade, but also expected to promote growth of nuclear energy as carbon free energy.

The Indo-U.S. Clean Energy Research and Deployment Initiative (CERDI) became a major step in this direction through a bilateral agreement in 2009. New Delhi and Washington worked together through sustained organisational and institutional relationships to develop a framework for cooperation on clean energy and climate change, designed as part of U.S.-India strategic dialogue. Joint collaborative PACE programme for research led disruptive innovations, as well as human and institutional capacity development was agreed. The two primary components of PACE aiming at Research and Deployment are; PACE-R and PACE-D to accelerate clean energy development. U.S.-India Partnership to Advance Clean Energy Research (PACE-R) began on November 24, 2009. Indo-U.S. PACE committed US$ 25 million with the matching share coming from the Government of India. Joint Clean Energy Research & Development Centre (JCERDC**).** It came up to work on three priority areas viz., solar energy, second generation biofuels and energy efficiency of buildings. The JCERDC is supported by collaborative research through one or more consortia involving university, private sector and national laboratories as partners. Investment in low-carbon research & technology in the energy sector must grow to address climate risks. The PACE-R in its phase II is further expanded to include the UI-ASSIST (U.S.-India coll<u>a</u>borative for smart di<u>s</u>tribution system w<u>i</u>th storage) programme to address energy storage priorities.

The 2009 initiative has been instrumental in developing national research competence, reducing the cost of clean energy through pre-competitive translational research and research led disruptive innovations as well as human and institutional capacity development. The Indo-U.S. Science and Technology Forum had its genesis in 2000 using part of the remaining Public Law 480 Rupee Funds. An umbrella Science & Technology (S&T) agreement between India and the United States was signed in 2005. The DST also initiated Clean Energy Research Initiative (CERI) in 2009 to support India-centric innovations and develop a critical mass of researchers to meet the requirement of R&D professionals for clean energy upstream end of research (DST. 2020).

The other component of PACE viz. PACE-D, U.S.-India Partnership to Advance Clean Energy Deployment of Technologies has been launched in June 2012 for the deployment of clean energy technologies. Conceived as a US$ 20 million clean energy deployment programme, with matching share from collaborators, efforts focusing on financing and creating an enabling environment were proposed, in particular. With a focus on deployment, the PACE-D teams helped develop the regulatory frameworks, skilled labour pool and business models needed to scale up rooftop solar projects and promoted adoption of energy-efficient building standards (*Donovan, 2017*). Innovative examples are access to electricity in rural areas, solar rooftops in urban areas and solar water pumps in agriculture fields.

Bilateral science diplomacy with European Union (EU) has also begun to take shape in the clean energy transition. Though an EU-India strategic partnership in S&T was launched in 2004, in 2008 EU took a lead in announcing its 20-20-20 clean energy targets aiming at; (i) reducing the emissions of greenhouse gases compared to 1990 levels by 20%, (ii) increasing the energy efficiency by 20% and (iii) reaching 20% share of renewables in total energy consumption, by 2020. The EU-India Strategic partnership has grown big in 2016, and a joint declaration 'Clean Energy and Climate Partnership' was adopted to ensure clean, affordable and reliable energy supply. Joint Agenda for Action 2020 has been evolved through joint research support to drive innovations and accelerate the clean energy transition. The key areas of joint research included; offshore wind energy, solar energy, biofuels, sustainable urbanisation, smart grids, storage and modelling for climate and energy transition. In a landmark development in 2017, India joined membership (associate) with International Energy Agency, Paris which is an organisation having OECD countries as its members and working to shape energy policies for a secure and sustainable future, to have a greater say in global energy transitions.

Multi-lateral Science Diplomacy in Clean Energy Transition

ITER for Nuclear Fusion Energy

Science diplomacy facilitates participation in big scientific endeavours aiming at long-term objectives for the well-being of humanity. India's full-fledged participation in an ambitious international programme to demonstrate the S&T feasibility of nuclear fusion energy has been acclaimed widely. The world's largest International Thermonuclear Experimental Reactor (ITER) is an example of 500MW capacity fusion energy plant being built near Cadarache in France for the generation of pollution-free energy. Achieved through magnetic confinement of nuclear plasma, it makes use of 'Tokamak', a toroidal chamber with a huge magnetic coil, an area where Indian expertise is already endured. Initially, an agreement between the USA, former Soviet Union, France and Japan on the available design of a big size reactor was reached in 1988. It took almost two decades of negotiations and science diplomacy interventions, to finally come to an understanding about the legal, policy and operational issues among the partner countries. The journey between the conceptualisation to the final signing of the ITER Agreement in November 2006 has gone through many ups and downs with U.S. withdrawing and then rejoining, financial obligations of members and agreement on construction site selection, etc. (Sharma & Varshney, 2019). The ITER agreement was signed in 2006 by seven member countries, which included three new members with India, China and South Korea; in addition to USA, Russia, EU (in place of France) and Japan, which were already there. The cost is to be shared by the member countries and the project is likely to be completed in 2024-25. For capacity building of youth as future operators, training programmes are being held every year. Institutions from as many as 37 countries are participating in ITER, a future source of clean energy.

Mission Innovation for Clean Energy

Global energy demand is expected to rise by 30-35 per cent in 2030. To accelerate the march towards clean energy, another global initiative is Mission Innovation (MI) launched during the Paris Conference of Parties (COP) meeting held in 2015 (MI, 2020). The MI is driven by science diplomacy towards sustained public investment in research and development (R&D), joint funding and business leadership. For clean energy innovations with 24 countries and EU as members, India is a founder partner in it. The seven innovation challenges of MI are dealing with renewable energy, its integration with the electricity grid and also carbon capture research & innovation. These are: (i) Off-Grid Access to Electricity Innovation Challenge, (ii) Smart Grids Innovation Challenge, (iii) Carbon Capture Innovation Challenge, (iv) Sustainable Biofuels Innovation Challenge, (v) Converting Sunlight Innovation Challenge, (vi) Clean Energy Materials Innovation Challenge and (vii) Affordable Heating and Cooling of Buildings Innovation Challenge.

Global strategies of MI have aimed at enhanced global energy security, drive towards economic growth, access to life-changing energy services to the poor, and increased ambition in combatting climate change. In a multi-country programme of this nature, achievements of stated goals require deep involvement of scientists from the participating developing countries. Science diplomacy and responsible research & innovation are the key ingredients. The focus is on developing joint projects and sustained investment by doubling the R&D investment from 2015 to 2020. Specific tasks of partners are evolved through greater participation in information sharing, joint research and analysis, business and private sector investment among others. Such international cooperation in goal oriented research would advance through science and diplomacy.

International Solar Alliance

International Solar Alliance is a major global initiative of India for installation of 1000GW (1TW) of solar energy capacity by 2030. A total of solar resource-rich 121 countries, lying fully or partially between the Equator and the Tropics of Cancer and Capricorn are prospective members of ISA. The Paris Declaration was signed by all countries on November 30, 2015 as a shared ambition to undertake joint efforts required to reduce the cost of finance and the cost of technology towards clean energy transition. The ISA was launched in partnership with France during the 21st meeting of Conference of Parties (COP21) to UN Framework Convention on Climate Change held in Paris in 2015. The trigger for the Alliance was the Paris Agreement on Climate Change, which itself came into being through prolonged negotiations and science diplomacy initiatives of France with other countries. The Alliance founded in Paris, France has its headquarters in Gurugram, India.

Through ISA, India is striving to develop a model for science diplomacy with the member countries. India as a lead country would showcase India's strengths in solar energy development. The ISA would build a knowledge sharing network among the member countries to take coordinated actions through programmes and activities launched voluntarily and aggregating demand for solar finance, solar technologies, innovation, research and development, and capacity building. The ISA has defined its priority areas of work and has set a goal to invest $1 trillion (raised from public and private investors), for solar projects that will provide 1 TW of solar energy globally, thereby reducing dependence on fossil fuels (EXIM, 2016). To give further impetus to science diplomacy, India has launched ITEC capacity building programme in Solar Energy for Master Trainers from ISA member countries beginning September 2018. India proposes to provide 500 training slots for ISA member-countries and also start a solar tech mission to lead R&D investment.

Regional Initiative through Electricity Trade in South Asia

The export–import of electricity is emerging as another form of trade based diplomacy towards low carbon future (UNESCAP (2018). South Asia, with its diversity of energy resources and consumption, presents many positive opportunities for integrating its power grids and promoting cross-border energy transmission for sustainable development. The resource both renewable and non-renewable energy sources are unevenly distributed among the countries in South Asia. Cross-border trade in electricity not only provides access to electricity but can also help consumers to save the cost of energy. With this in view, enhanced energy cooperation between India and neighbouring countries through a number of bilateral agreements and MoUs has led to increased transmission and exports/imports of electricity. India exported around 600 MW to Bangladesh through 2nd cross border interconnection between Surjyamaninagar (Tripura) in India and South Camilla (Bangladesh). Nepal is now a major importer of electricity from India. India and Bhutan entered into bilateral arrangements in hydropower generation way back in 1961. Import of clean hydro-power from Bhutan has significantly increased in recent years. The Framework Agreement on Cooperation for Development between India and Maldives was signed in 2011 to support New and Renewable Energy development. In 2017, India exported around 5,798 million units to its neighbours; Nepal, Bangladesh and Myanmar and imported around 5,585 million units of clean energy from Bhutan (INFRALINE. 2018). An agreement has been signed between Sri Lanka and India on Cooperation in the Peaceful Uses of Nuclear Energy which included use of radioisotopes, nuclear safety, radiation safety, nuclear security, radioactive waste management and nuclear and radiological disaster mitigation and environmental protection. It is also envisaged to export excess electricity during off-peak hours from renewable sources which can be exported to India as clean energy. Several other exchanges are in the pipeline and require understanding, cooperation and engineering skills among participating countries.

There are socio-economic benefits from the adoption of science diplomacy tools to help the trade of clean energy. A proposal for South Asia Regional Initiative for Energy Integration (SARI/EI) was made by the US Agency for International Development (USAID) way back in 2000. South Asia Grid announced in 2004, envisaged boosting renewable energy development, enhancing affordability and access, while lowering emissions in the region. Among the countries in South Asia, a SAARC Energy Agreement on Electricity Cooperation has been formulated. India has issued guidelines with provisions for its cross-border electricity trade (CBET) in response to this in 2016. The Agreement is expected to facilitate electricity trade as well as transfer and exchange of knowledge and expertise, sharing of resources, capacity building and training of personnel. However, insurmountable challenges remain in realising the concept of a common South Asia grid.

Conclusion

Clean energy transitions have a vital role in the coming decades for meeting the climate change and sustainable development goals. Through science diplomacy initiatives on the part of the advanced economies, India has made strides toward clean energy transitions. The ISA and CBET has placed India on the lead, however, the challenges are in attracting partnership from participatory countries. In the hindsight, science diplomacy could also have a significant role in clean energy development of hydropower on the Indus River, for which an Indus Water Treaty between India and Pakistan was signed way back in 1960. The technologies and capabilities have advanced significantly since then. There is need to look through the lens of science diplomacy to resolve the disputes relating to water management and use. Both India and Pakistan should come together and find engineering win-win solution so that both countries are benefited from the generation of clean energy. Science and diplomacy go together for understanding the real problems and aspirations; which require mutual trust, cooperation, engineering skills and diplomacy among participating countries.

Endnote

[1] The proxy well documented has been named '123 Agreement' as Section 123 of the United States Atomic Energy Act of 1954, titled "Cooperation with Other Nations", establishes an agreement for cooperation as a prerequisite for nuclear deals. It provided for nonproliferation criteria for the parties.

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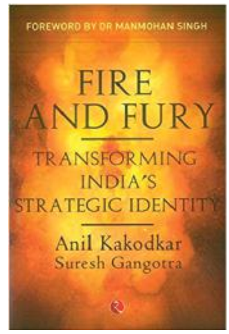
BOOK REVIEW



Fire and Fury – Transforming India's Strategic Identity

Bhaskar Balakrishnan*

Bhaskar Balakrishnan

The book, "Fire and Fury – Transforming India's Strategic Identity", traces the remarkable journey of Dr. Anil Kakodkar from his childhood days to the Head of India's Atomic Energy Commission and beyond that to his present day activities in the service of the community. Born in 1943 in Madhya Pradesh, into a family of modest means but committed to Gandhi's ideals, he imbibed the spirit of Gandhi's movement and the ongoing freedom struggle. His father, who struggled for the liberation of Goa was put in jail in Portugal for nine years, leaving his mother alone to raise the family. Her struggles, including getting educated and qualified as a teacher and opening a school in Khargone, Maharashtra left a deep imprint on young Kakodkar. As he recounts "my school and home taught me the virtues of self-service, discipline and being kind to others". After finishing school the family moved to Mumbai where he got his higher education and graduated in Mechanical Engineering from the prestigious Veermata Jijabai Technological Institute (VJTI). After a brief stint with a private company, he joined the Bhabha Atomic Research Centre (BARC) Training School of the Department of Atomic Energy (DAE), where as he puts it "found his wavelength". The challenges inherent in the atomic energy programme and the opportunities for learning new things drew in young Kakodkar who took to it like a duck to water.

* Science Diplomacy Fellow, RIS and Former Ambassador of India. He holds a Ph.D. in Theoretical and Mathematical Physics from State University of New York, Stony Brook.

He recounts many incidents of his career in BARC and some of the difficult moments he faced. Through all this, he comes across as a person deeply interested in learning new science and technology, and adapting and applying this knowledge to solve problems however complex and difficult. His special interest was in reactor design and engineering, an area which involves several streams of knowledge from different disciplines, given the operating conditions inside a nuclear reactor. His account of various experiences during a long career in BARC make fascinating reading and give a valuable insider's account into the work and management culture and evolution of BARC. Kakodkar's spirit of "can do" in the face of challenges, and the ability to innovate and get over problems comes through. With typical modesty, he gives credit to his early mentors.

Another aspect is his management style, marked by openness, accessibility, cutting across disciplines, leading a team from the front, never shirking responsibility, and the spirit of service to the community and nation. At one point Kakodkar mentions that he wanted to do a degree in management but circumstances did not permit it. Given his skills acquired through experience in managing teams and projects within a complex Research and Development organisation, subject to labyrinthine government rules, processes and regulations and financial audits, it would seem that he could easily have taught courses in management or written textbooks, especially for R&D organisations.

The book is full of technical nuggets and details about the history of BARC's efforts to develop India's indigenous nuclear programme despite numerous pressures and constraints. He mentions several colleagues and is generous in giving credit and praise to them even in cases where he felt they had not agreed with him. He rightly observes that the detailed history of India's nuclear programme and BARC should be preserved and kept for posterity. India's nuclear programme with its civilian and strategic dimensions is certainly unique in the world. One story is the repair and rehabilitation of a nuclear Pressurised Heavy-Water Reactor (PHWR) at Madras Atomic Power Station (MAPS), where Kakodkar worked with his team to reverse the direction of flow of heavy water coolant/moderator to get the reactor to operate though at lower power output. This was an "out of the box" solution that surprised the Canadian experts. Several other technical problems were overcome, and this account highlights Kakodkar's reputation as a problem solver. Later on, during the run up to the Indian nuclear tests in 1998, he became known as the "Ho Jayega (It will be done)" man.

Kakodkar's account on the nuclear tests of 1998 makes several key points. One, the whole set of tests were designed to get the maximum possible data for future nuclear weapons design, including the thermonuclear test. The last was kept down to a minimum yield in order to avoid impact on the community living near the site. He praises the local community for their understanding, support and cooperation during the tests. There was also recognition that future testing might be difficult due to international pressure. He mentions that it was expected that Pakistan would also conduct nuclear tests soon after India, taking advantage of the international focus on India and using the

Indian tests as justification. Besides this, his experience of secret "cloak and dagger" operations makes interesting reading.

On longer term and strategic matters, Kakodkar analyses the issue of Uranium fuel for India's nuclear programme, the constraints and how they were overcome, the impact in Nuclear Power Corporation of India Limited (NPCIL) and India's long term energy future. He also goes into the implications for climate change and argues that nuclear energy must remain an essential baseline power component of India's energy mix in order to stabilise the power grid. This, he rightly observes is because even though renewable energy has huge potential in India and should be exploited, the intermittent nature of this source makes it essential to have a strong baseline power source for the national grid. However, new technology could change the entire game if low cost and efficient energy storage devices such as batteries are developed.

Kakodkar discusses at length the international sanctions against India in the wake of the 1974 peaceful nuclear explosion and the May 1998 nuclear weapons tests. The DAE bore the brunt of the impact of international sanctions arising from these two events. The Nuclear Suppliers Group (NSG) was set up as a direct result of India's peaceful nuclear explosion in 1974 precisely to control and restrict access to nuclear materials and technology. These sanctions became more intense after the 1998 nuclear weapons tests. The most important effect was the cut-off of imports of natural and enriched Uranium for India's reactors especially after 1998 which resulted in Indian nuclear power plants operating at low capacity and delays in building more reactors. He describes the intense efforts to maintain the fuel supply and the efforts to stretch out the available Uranium resources. This required adjustment of the fuel cycle and reprocessing of spent fuel which posed formidable technical problems. The financial situation of NPCIL deteriorated sharply. During this extended crisis, operating capacity of India's civilian reactors had to be cut down and there was a real prospect of NPCIL going bankrupt with adverse consequences of the growth of India's nuclear power. The DAE embarked on a hunt for domestic Uranium deposits, but the exploitation of the large but poor quality deposits posed technical challenges in addition to local opposition to Uranium mining. By 2012, DAE scientists had developed a new alkaline leaching technology to enable extraction of Uranium from the low quality 0.2 % pitchblende content ores found in Telangana and Andhra.

During 2004-2008 the US and India conducted serious and intensive discussions on India's nuclear programme. This was due to US recognition that India was a useful strategic partner in the region, an emerging economy with a liberal democracy, and a responsible custodian of strategic and civil nuclear technology. Rather than have the entire Indian nuclear programme out of international safeguards under the existing regime, would it not be better to get India into the international nuclear regime, with a substantial part of its programme under safeguards? Especially since the programme had developed its autonomy and seemed to be going ahead despite the fuel constraints. Faced with this dilemma, the US administration under President Bush made a change in policy and serious discussions with India began, despite the presence of a strong pro-NPT and doctrinaire lobby within the US and abroad. The rising role of the Indian American community, its presence among the top echelons of corporate America, and its role in funding both political parties was another factor. This was the background against which India-US relations took off on a new trajectory.

Kakodkar describes his role in shaping the India-US nuclear agreement and eventual removal of nuclear related sanctions. He recounts the well known story of the "600 pound gorilla" that stood rock firm on safeguarding the autonomy of India's strategic nuclear programme despite internal and external pressures. In this, he acknowledges the support and trust he enjoyed from Prime Minister Dr. Manmohan Singh at the crucial moments. This whole episode has been the subject of books and articles by numerous participants in the negotiations including those from MEA. This author has also heard personally about Kakodkar's key role from one of the key negotiators who has not published his account. But Kakodkar's account of what happened, even though it must have been sanitised is riveting. This is a good example of science diplomacy, in which the technical and scientific agencies, various stakeholders, and the foreign ministry worked together and seamlessly, with the highest level political support in order to secure the national interest during the difficult international negotiations. India's science in diplomacy effort succeeded in producing a win-win India –US nuclear deal. India is indeed fortunate to have such a team including Kakodkar during this crucial period (2004-2008).

Kakodkar covers much ground in his book. His ideas on science, education, rural and urban development, India's energy future, and the sound management of organisations and governance are wide ranging and well considered, and reflect a Gandhian influence and deep commitment to service to the family, community, nation and the world. Many of these ideas are well worth expanding and developing, and I have no doubt that he will do so in the future. Apart from the biographical details enriched by chapters written by his wife and his sister, and by the co-author, the book has rich content in terms of thinking on social, management, and governance issues. It is written in an easy and direct style reflecting the personality of the author.

Global Sustainable Development Report 2019: *The Future is Now - Science for Achieving Sustainable Development*

Sneha Sinha*

Sneha Sinha

Science and Technology (S&T) plays a critical role in developing a nation. The technology-centered modern lifestyle has certainly improved the living conditions of people across the globe. S&T capabilities are central to the economic growth of a country. They help in achieving socio-economic goals and play a key role in industrialisation and the overall development of a country. The emergence of numerous modern scientific institutions from the seventeenth century attests to the growing importance attached to the advancement in various S&T fields. The international institutions and agencies have also increasingly realised the potential of S&T for development and economic growth. Therefore, during the early decades of its inception, the United Nations recognised the importance of S&T for development. In 1963, the UN Economic and Social Council decided to establish an Advisory Committee on the Application of Science and Technology to Development (UNGA, 1963). The Committee held its first meeting in 1964 and focused on mobilizing active cooperation between S&T institutions of developed and developing countries (ECOSOC, 1964). The outcome document of the World Commission on Environment and Development, 'Our Common Future', was brought out in 1987, asserting the need for fundamental change in the pattern of development and a move towards sustainable economic growth. It underlined a greater scientific understanding of natural systems and cooperation from the scientific community

* Research Associate, RIS.

(UN, 1987). Similarly, the outcome document of the UNCED conference held in 1992 also recognised the need for effective communication and cooperation between the S&T community and decision-makers for facilitating S&T knowledge-based policies and implementation of feasible pathways towards sustainable development (UN, 1992). The Earth Summits (1992, 2012) reiterated the importance of scientific evidence-based assessments for strengthening science-policy interface and fostering international research collaboration on sustainable development (UN, 1992; UNGA, 2012).

The adoption of the universal Sustainable Development Goals (SDGs) in 2015 is seen as a culmination of a long process, which began in 1972 with the UN Conference on Human Environment. At its 123rd plenary meeting, UN General Assembly endorsed the establishment of the High-Level Political Forum (HLPF) to follow-up and review the implementation of the 2030 Agenda on Sustainable Development. The Global Sustainable Development Report (GSDR) acts as a comprehensive scientific instrument to guide policy-makers, and to strengthen the science and policy interface (UNGA, 2012). Its importance has been reiterated in the Ministerial Declaration of 2014 (ECOSOC, 2014) and the resolutions adopted by the General Assembly in 2015 (UNGA, 2015). The scope, frequency, and methodology of the GSDR were specified in the Ministerial Declaration of the 2016 High-level Political Forum on Sustainable Development (ECOSOC, 2016). GSDR 2019 titled "The Future is Now: Science for Achieving Sustainable Development" is the first quadrennial integrated scientific evaluation of the progress and guidance on the 2030 Agenda (UNDESA, 2019).

GSDR 2019 has been prepared by a heterogeneous group of fifteen individual scientists from various geographical regions, appointed by the Secretary-General. The group included five women scientists from Finland, the USA, South Korea, Indonesia, and Denmark. The report is based on extensive and diverse knowledge and has been reviewed by various member states, stakeholders and scientists across the world. GSDR is an "assessment of assessments" which complements the annual Sustainable Development Goals Reports prepared by the Secretary-General in cooperation with the UN system. Based on the global indicator framework, the report provides regional and global status of targets set by Agenda 2030. At the outset, GSDR recognises the efforts made by nation-states in incorporating SDGs into their national plans and strategies. It also discusses the interconnected nature of the development of nations and their impact across the world. But, it notes there has been limited success. Based on the database used for the annual SDG report, the report assesses the progress made towards the achievement of SDGs. It shows that we are yet to meet many SDG targets, and that the progress in several cases is not in the right direction. The title of the report itself significantly points at the urgency, and calls for action on an immediate basis. It emphasises on the need for scaling up and accelerating the efforts during the present decisive decade for achieving the SDGs.

The 2030 Agenda is a globally accepted mandate for transformation. The report calls for a systemic integrated approach, taking into account the myriad interactions between various goals and addressing multiple goals simultaneously for achieving knowledge-based transformations for sustainable development. It highlighted the need for urgently scaling-up and multiplying transformations by addressing intrinsic trade-offs among goals and harnessing co-benefits. The report outlines the steps towards achieving the desired rebalancing and identifies entry points into the embedded systems of SDGs. The six entry points for transformation include human well-being and capabilities; sustainable and just economies; food systems and nutrition patterns; energy decarbonisation and universal access; urban and peri-urban development and global environmental commons. For achieving transformations through these entry points, the report discusses the deployment of four levers namely, governance, economy and finance, individual and collective action, and science and technology. It underlines the need for facilitating international global collaborations and cooperation between various stakeholders for finding critical solutions to the problems of sustainability. It also hints at diverging interests of powerful actors, differences in priorities and approach to SDGs across regions and adaptions to demographic changes. Therefore, the report suggests evolving context-specific lever combinations to achieve the transformations necessary for setting a pathway towards Agenda 2030.

The report highlights the importance of science and technology in finding pathways towards sustainable transformations. As mentioned above, it identifies S&T as a crucial lever for its implementation and recognises the role of scientists and engineers. It notes that technological innovation could provide solutions to several development challenges. However, it also suggests the need for addressing obstacles that hinder wide-scale deployment of technology, through initiatives like Technology Banks for Least Developed Countries and the Technology Facilitation Mechanism for sharing and transfer of technology. The report emphasises on triangular and South-South cooperation and collaboration between developing countries for better technology and access to knowledge. According to the report, technology could play a critical role in resolving trade-offs that arise as a result of addressing individual goals or targets in isolation. As a result, for realising its potential for application to sustainability transformations, there is a need for substantial investment in research and development. The report also points at the technology risks which unintendedly deepen existing inequalities and introduces new ones, setting back the vision of the 2030 Agenda. The report calls for comprehensive new technologies and the digital revolution which could integrate the social objectives of STI through equitable access to technology and international collaboration for achieving sustainability goals. S&T along with other lever combinations could work towards addressing impediments faced by various entry points, build capability and find multi-dimensional pathways for transformations.

The central theme of the report revolves around the role of science and the S&T community in sustainable development. A separate chapter discusses the role of science in sustainable development. It not just emphasises on the natural sciences but also humanities, social science, law, etc. The report acknowledges the interactions between scientists and the wider socio-economic and political context and calls for innovative direct collaborations between scientists, policymakers, civil society and business for addressing social and ecological crises. The report views science as a powerful actor of change which could address impasses and harness breakthroughs in the present understanding of human-environment systems. It highlights the importance of evolving a shared knowledge platform and science-policy networks between South and North. Also, underlining the role of science diplomacy, the report strongly emphasises on sustainability science in tackling trade-offs and contested issues for achieving the goals. Therefore, it urges governments to institutionalise science-policy-society alliances for building context-specific pathways. It also suggests enabling co-creation of citizen science and testing of transformational ideas and building knowledge societies in low- and middle-income countries. It calls for support towards higher and gender-inclusive enrolment in science, technology, engineering and mathematics (STEM) programmes for building human capabilities.

In the last chapter of the report, it made several recommendations and called for action across various entry points indicated by it earlier for achieving the goals of the Agenda 2030. The report focuses on collaborating both national and international entities for synthesising knowledge and sharing best practices for implementation of SDGs through continuous research, development, deployment, and diffusion of changes. S&T emerges as an important instrument in leveraging sustainability targets. Therefore, the report gives adequate attention to science both for evolving pathways to transformations as well as applying STI for realising the aims of Agenda 2030. It also recommends strengthening science-policy interface. The report realises the critical role of context-specific transformations both through collaboration between various stakeholders within the country and international collaborations/global partnerships while engaging with various interconnected goals and their underlying systems. The report clearly shows that sufficient knowledge is available for initiating these transformations if the gaps between what we know and what is being done are addressed. The report provides a strong foundation for scientists working on future editions of several scientific contributions aiming towards achieving sustainable development. It consistently emphasises on concerted efforts towards a just and equitable human well-being with the objective of 'leaving no one behind'. It also stresses at bridging the S&T divide between the developed and developing countries. However, for achieving the SDGs by 2030, developing countries must strengthen their scientific community and scientific institutions and direct their S&T capability towards evolving context-specific pathways for science-centric transformations. Through multilateral collaborations between North-South and South-South, developing countries need to engage with specific S&T needs and align their STI policies towards attaining the SDGs.

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Science Diplomacy

New Science, Technology & Innovation Policy Draft

India plans to unveil a new National Science, Technology and Innovation (STI) Policy, which will replace the existing policy enacted in 2013. The new policy document will be forward-looking and have both a vision document as well as an action plan on the fundamental research required in crucial areas such as space, health, atomic physics, and biotechnology. The Department of Science & Technology has been entrusted with the task of drafting the new policy and the department will soon initiate stakeholder interaction. Prof. K. Vijay Raghavan, the Principal Scientific Advisor to Government of India, noted that the drafting process will take into account the fact that private investments in R&D are very low and that it is important to make India an attractive destination for companies to invest. Also, restoring the 200 per cent income tax deduction for in-house R&D spend, which was reduced to 150 per cent from April 1, 2017, could be one way to encourage investment in the area. In this regard, the stakeholder consultation process will be at four levels: the first level would involve the scientific community and industry representatives for undertaking people-centric scientific break-through and innovation. The second level would involve consultations with state governments for forging effective partnerships and to work on a policy for developing world-class products. The third level involves consultations with various government ministries and departments such as railways, shipping, and water resources to understand their science and technology-related needs. And at the fourth level would be horizontal focusing on the requirements of basic research in fundamental areas such as condensed matter physics, solid-state physics, material research, etc.

Source: https://www.thehindubusinessline.com/economy/policy/new-policy-on-science-technology-innovation-being-framed-by-centre/article30585104.ece.

India announces National Mission on Quantum Technologies

The government in its budget 2020 announced a National Mission on Quantum Technologies & Applications (NM-QTA) with a total budget outlay of Rs 8000 Crore for five years. The mission will be implemented by the Department of Science & Technology (DST). Under this mission, the several next-generation transformative technologies such as quantum computers and computing, quantum communication, quantum key distribution, encryption, cryptanalysis, quantum devices, quantum sensing, quantum materials, quantum clock, etc will receive a major push. In particular, the mission will focus on fundamental science, translation, technology development, human and infrastructural resource generation, innovation and start-ups to address issues concerning national priorities. The mission draws upon the existing deep strengths within academic institutes across India to support interdisciplinary research projects in key verticals involving quantum technology, while simultaneously developing key foundational strengths in important core areas. Also, it will be able to address the ever-increasing technological requirements of the society, and take into account the international technology trends and road maps of leading countries for the development of next-generation technologies. The mission will help prepare skilled manpower, boost translational research and also encourage entrepreneurship and start-up ecosystem development. By promoting advanced research in quantum science and technology, technology development and higher education in science, technology and engineering disciplines India can be brought at par with other advanced countries and can derive several direct and indirect benefits.

Source: https://dst.gov.in/budget-2020-announces-rs-8000-cr-national-mission-quantum-technologies-applications.

Research and Development

Development of Indigenous Graphene Supercapacitor for Energy Storage

Energy requirements are central to modern civilisation. The research in material science for more than a decade has presented numerous alternate sources of energy. The scientists and technologists have made efforts towards synthesising materials that can be developed and used in electronics and automobiles. Dr. Nirmalya Ballav led a team of researchers at the Indian Institute of Science Education and Research (IISER) and CSIR-National Chemical Laboratory at Pune, to develop a cost-effective method for chemical reduction of graphene oxide. This new way of reducing graphene oxide led to the formation of self-healed, ambient and stable graphene oxide (rGO). The cost of production of one gram of rGO is estimated to be less than INR 700, which is substantially low when compared with the cost of commercial rGO developed by reputed international chemical companies. Graphene is a promising electrode material for high-performance supercapacitors. IISER generated low-cost functionalised graphene for the development of graphene-based supercapacitors. It will be fabricated for energy storage by SPEL Technologies, Pune. The project of 'High-Performance Graphene-Based Supercapacitor' is funded and supported by the Technology Mission Division (Energy & Water), under Materials for Energy Storage Programme by the Department of Science and Technology (DST). The DST is supporting research on energy materials through a Materials for Energy Conservation and Storage Platform (MECSP) which supports research and development for the entire spectrum of energy conservation and storage technologies from early-stage research to technology breakthroughs in materials, systems, and scalable technologies to maximise resource use efficiency.

Source: https://dst.gov.in/iiser-spel-pune-jointly-develop-indigenous-graphene-supercapacitor

CSIR-NCL produces Silver Nanowires through inexpensive technology

The importance of nanowires has grown manifolds, particularly for the development of several nano-electronic devices including conductor inks. These inks are used in electronic circuit manufacturing and production of touchscreen and infrared screens. They are suitable for printed and flexible electronics. A team of researchers at the CSIR-National Chemical Laboratory (NCL), Pune has developed a low-cost technology for manufacturing silver nanowires with precision, which can be used in nano-electronic devices in the future. For the continuous manufacture of these silver nanowires, the Council of Scientific and Industrial Research (CSIR) has launched the pilot plant at NCL campus, which can produce 500 grams a day and is scalable to desired production rates. According to researchers at Chemical Engineering and Process Development Division, NCL, the method of synthesis was already known but developing nanowires that could compete globally was possible only through application of different controlled parameters in the laboratory. Patents have been filed to protect the technology and product has been tested for various applications. The technology development was carried out under the Advanced Manufacturing Technologies (AMT) initiative by the Department of Science and Technology (DST). The silver nanowires produced through this technology at the CSIR lab costs twelve times cheaper than global rates which varies between 18,000-43,000 INR per gram according to its size. The technology developed can help in manufacturing wide range wires on a large scale which has a huge demand in the global market as a result of its diverse applications.

Source: https://www.csir.res.in/slider/inexpensive-technology-production-silver-nanowires-csir-ncl.

India's first underwater drone, EyeROV TUNA

In 2018, the Ministry of Defence launched the Defence Excellence (iDEX) programme to support and hand-hold start-ups and individual innovators in the country. The programme so far has successfully been able to generate innovations from the private industry. A Kochi-based startup, EyeROV Technologies Pvt. Ltd. demonstrated India's first remotely operated commercial under-water robotic drone known as EyeROV TUNA, which received support under the iDEX. The company developed a miniature version of highly sophisticated and bulkier equipment to inspect the ship hull. The idea got selected for the incubator programme with BPCL and Kerala Startup Mission Idea Grant Scheme. They agreed to provide initial funding to the company. The first order was received from the Naval Physical and Oceanographic lab under DRDO. EyeROV has focused on the capabilities of TUNA and developed the EyeROV TUNA. It is a light rover which can take real-time HD video images up to a depth of 50 meters for specialised inspection of critical infrastructures like dams, bridges primarily rail bridges and other water retaining structures. The newly developed underwater drone can also be useful for oil and gas sector. It can play a key role in energy and transport sector and help in establishing India along the lines of other developed countries. The startup has successfully completed various projects which include BPCL's oil pipeline bridge and surveying dams for the Kerala State Electricity Board.

Source: https://www.eyerov.com/eyerov-tuna/.

Call for Contribution

Science Diplomacy Review (SDR), a multidisciplinary, peer-reviewed journal, aims to capture developments, updates and events on science diplomacy. We invite contributions from interested readers on issues related to Science Diplomacy, in theory and practice. Reviews of latest publications – research articles, essays, books, monographs, reports - are also welcome. The contributions can be sent to Managing Editor, Forum for Indian Science Diplomacy Review, Research and Information System for Developing Countries (RIS), Core 4B 4th Floor, India Habitat Centre, Lodhi Road, New Delhi 110003, India (Email: b.balakrishnan@ris.org.in; Tel. +91-11-24682177-80; Fax: +91-11-24682173/74).

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G20: Call for Papers

G20 is gaining importance as a global platform for articulation of economic, social and development issues, opportunities, concerns and challenges that the world is confronting now. Over the years, G20 has witnessed a significant broadening of its agenda into several facets of development. India is going to assume G20 presidency in 2022 which would be important not only for the country but also for other developing countries for meeting the Sustainable Development Goals and achieving an inclusive society. India can leverage this opportunity to help identify G20 the suitable priority areas of development and contribute to its rise as an effective global platform.

In that spirit, Research and Information System for Developing Countries (RIS), a leading policy research institution based in New Delhi, has launched a publication called G20 Digest to generate informed debate and promote research and dissemination on G20 and related issues. This bi-monthly publication covers short articles of 3000 to 4000 words covering policy perspectives, reflections on past and current commitments and proposals on various topics and sectors of interest to G20 countries and its possible ramifications on world economy along with interviews of important personalities and news commentaries.

The Digest offers promising opportunities for academics, policy makers, diplomats and young scholars for greater outreach to the readers through different international networks that RIS and peer institutions in other G20 countries have developed over the years. The interested authors may find more information about the Digest and submission guidelines on the web link: **http://www.ris.org.in/journals-n-newsletters/G20-Digest.**

Guidelines for Authors

1. Submissions should contain institutional affiliation and contact details of author(s), including email address, contact number, etc. Manuscripts should be prepared in MS-Word version, using double spacing. The text of manuscripts, particularly full length articles and essays may range between 4,000- 4,500 words. Whereas, book reviews/event report shall range between 1,000-15,00 words.

2. In-text referencing should be embedded in the anthropological style, for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote). Footnotes are required, as per the discussions in the paper/article.

3. Use's' in '-ise' '-isation' words; e.g., 'civilise', 'organisation'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'. Use figures (rather than word) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old, etc.). In general descriptions, numbers below 10 should be spelt out in words. Use fuller forms for numbers and dates— for example 1980-88, pp. 200-202 and pp. 178-84. Specific dates should be cited in the form June 2, 2004. Decades and centuries may be spelt out, for example 'the eighties', 'the twentieth century', etc.

Referencing Style: References cited in the manuscript and prepared as per the ***Harvard style*** of referencing and to be appended at the end of the manuscript. They must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

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About FISD

As part of its ongoing research studies on Science &Technology and Innovation (STI), RIS together with the National Institute of Advanced Studies (NIAS), Bengaluru has endeavoured a major project for Science Diplomacy this year, supported by the Department of Science and Technology. The programme was launched on 7 May 2018 at New Delhi. The Forum for Indian Science Diplomacy (FISD), under the RIS–NIAS Science Diplomacy Programme, envisages harnessing science diplomacy in areas of critical importance for national development and S&T cooperation.

The key objective of the FISD is to realise the potential of Science Diplomacy by various means, including Capacity building in science diplomacy, developing networks and Science diplomacy for strategic thinking. It aims for leveraging the strengths and expertise of Indian Diaspora working in the field of S&T to help the nation meet its agenda in some select S&T sectors.

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Core IV-B, Fourth Floor, India Habitat Centre
Lodhi Road, New Delhi-110 003, India.
Ph. 91-11-24682177-80 Fax: 91-11-24682173-74-75
Email: dgoffice@ris.org.in Website: www.ris.org.in

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