SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 4 | November 2019

(Continued on outside back cover)

Science Diplomacy Review

SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 4 | November 2019

SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 4 | November 2019

EDITORIAL

The Science Diplomacy Review's November issue marks one year of its publication as a peer reviewed international journal specialising in diverse perspectives related to Science Diplomacy. We are greatly encouraged by the enthusiastic response from our readers and the growing interest amid researchers and practitioners for contributing to the journal.

In continuation of our efforts towards sharing experiences, instances and best practices in science diplomacy, this issue contains a number of interesting papers. The first paper by Jyoti Sharma and Sanjeev Kumar Varshney highlights the significance of mega science projects for India and other developing countries, through examples such as the International Nuclear Fusion Research and Engineering (ITER). It asserts the need for multilateral scientific cooperation, across socio-economic, geographical and cultural diversities, in order to address issues of common interests.

The paper on the role of Science, Technology and Innovation Diplomacy in Biotechnology by Douglas Nascimento Santana explores the diplomatic challenges and opportunities, in the wake of recent scientific advances such as precision genome editing using CRISPR technology. It highlights how global collaborations are setting the foundation of biotechnology-led interventions in defence and security. In another paper by David Abiamofo, India- Suriname relations have been examined in the context of promoting cooperation to achieve the SDGs, including health, water and sanitation, education, energy and agriculture. The paper proposes that through bilateral and multilateral relations, STI can be leveraged for sustainable development.

In the Perspectives section, the paper by Amit Kumar delves into the importance of S&T Diasporas in strengthening the home country's STI ecosystem. Specific modalities of engagement are outlined for this purpose. This is an area of considerable interest to all countries, as increasing mobility of STEM professionals and globalisation of STI have led to inter-woven complexities of Brain Drain, Brain Gain and Brain Circulation.

The book review section includes a review of a three volume book series based on the conference proceedings on 'Science and Technology Diplomacy: A Focus on the Americas with Lessons for the World', organised at the University of Arizona in Tucson in February 2017. It aims to bring the idea of technology transfer and capacity building to the forefront, particularly in context of developing countries. The series presents a comprehensive documentation to delve deeper into S&T diplomacy, for researchers, policy makers, science diplomats, technocrats, bureaucrats and students.

The report review of '*Synthetic Biology and its Potential Implications for Biotrade and Access and Benefit-Sharing*' published by UNCTAD, captures the underlying policy implications for genetic resources. The review signals moves towards taking common positions on investment and R&D in Synthetic Biology. Besides these insightful papers, the News Update section showcases recent developments in S & T, Science Policy and Science Diplomacy, both at national and international levels.

SDR hopes to attract a wide range of contributions from the field of Science Diplomacy across the globe, including stakeholders. We look forward to valuable suggestions from our readers.

ARTICLE

Mega Science and International Relations: A Case of 'International Nuclear Fusion Research and Engineering (ITER)'

Jyoti Sharma*
Sanjeev Kumar Varshney**

Jyoti Sharma

Sanjeev Kumar Varshney

Science by its nature facilitates diplomacy because it strengthens political relationships, embodies powerful ideals, and creates opportunities for all. The global mega projects, based on science and technology, embrace global cooperation, accountability, meritocracy and broad as well as democratic participation. Mega projects are able to bridge deep political and religious divides for addressing both domestic and the increasingly transnational problems confronting humanity in the 21st century. There is a growing recognition that science and technology will increasingly drive the successful economies of the present era.

India's Participation in Mega Science

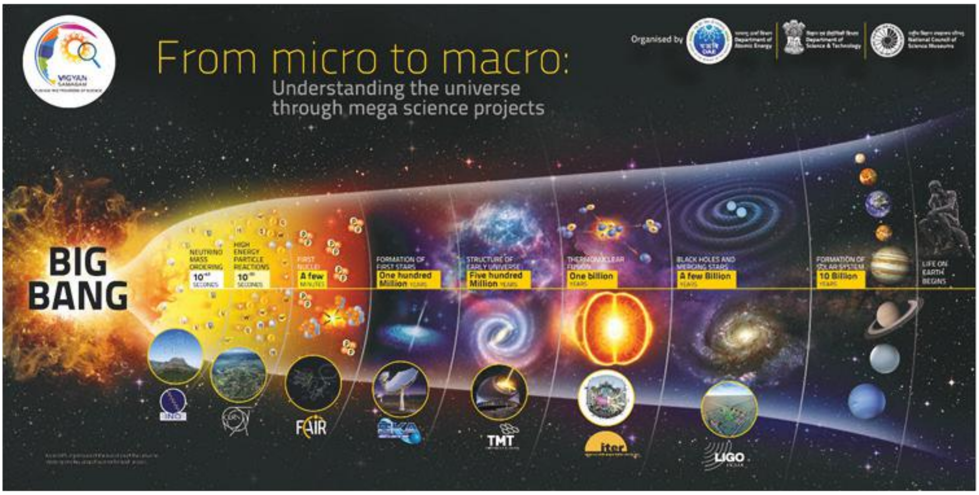
Innovative research in nearly all scientific fields requires large and complex infrastructure, cutting-edge technologies and long-term projects. Major collaborative efforts, often international in scope, are thus becoming a common means to reduce costs, share risk, and augment scientific expertise. The growing importance of global scientific engagement usually emphasises its components of synergy, science diplomacy, and beneficial impacts on economies.

The Indian government is committed to facilitating Indian scientists, providing them an opportunity to lead at the global level and supporting academic-

---

Senior Scientist*, Head & Advisor**, International Bilateral Cooperation Division (IBCD), Department of Science and Technology, Ministry of Science and Technology, Govt. of India.

Figure 1: India's Participation In Mega Science



Source: Vigyan Samagam, 2019.

industry partnerships for development of cutting-edge indigenous technologies through participation in mega projects. The Science, Technology and Innovation (STI) 2013 policy of India, released by DST also advocates India's participation in mega-science projects (DST, 2013). Active participation and billion-dollar investments in mega science projects, i.e. European Organisation for Nuclear Research (CERN), Facility for Antiproton and Ion Research (FAIR), India-based Neutrino Observatory (INO), International Thermonuclear Experimental Reactor (ITER), Laser Interferometer Gravitational-Wave Observatory (LIGO), Square Kilometre Array (SKA) and Thirty Meter Telescope depict India's vision and understanding that any single country is not able to fund, execute and bear the risk of the uncertain outcome of these mega projects (Sharma & Varshney, 2019).

ITER: A Good Example of 'Technology Diplomacy'

All mega projects addressing the grand challenges in science and technology are inherently international in scope and collaborative by necessity. In a complex multi-polar world, relations are more challenging, the threats perhaps greater, and the need for engagement more paramount. ITER (ITER was originally an acronym for International Thermonuclear Experimental Reactor) is a good example of technology diplomacy, starting in 1985 for promoting the use of nuclear fusion for the peaceful use of energy and overcome the political tensions during the cold world war. The United States and the Soviet Union used science diplomacy as a tool to maintain communications and avoid misunderstanding during the height of the cold war. The ITER Project, an international fusion research and development collaboration, is a product of the thaw in superpower relations between Soviet President Mikhail Gorbachev and U.S. President Ronald Reagan (Fedoroff, 2008). President Ronald Reagan sent the following message to Congress on March 22, 1982 (Harding, Khanna & Orbach, 2012): "*It is becoming increasingly important that we all reach beyond our borders to form partnerships in research enterprises. There are areas of science, such as high energy physics and fusion research, where the cost of the next generation of facilities will be so high that international collaboration among… nations may become a necessity. We welcome opportunities to explore with other nations the sharing of the high costs of modern scientific facilities*".

On 19 November 1985, the Soviet leader shared his thought about an ambitious programme of research and experimentation on a subject on which scientists of his country had been devoting much attention for years with his counterpart. Immediately following the standoff over nuclear disarmament at the Reykjavik Summit in October 1986, the ITER proposal for the peaceful use of nuclear energy was made and joined by the United States, the European Union and Japan to the Soviet Union in the following year (Harding, Khanna & Orbach, 2012). Later, China, India and South Korea joined this adventure. A long journey of its conceptualisation, negotiations and establishment of the ITER organisation makes an interesting case study in the intersection of science and diplomacy for large-scale, capital-intensive international projects.

The journey between the conceptualisation of this idea to the final signing of the ITER Agreement in November 2006 has gone through many legal and political challenges confronted by the participating countries. There were a number of difficult negotiations on design, financial obligations, construction sites, the provision of privileges and immunities and a form of agreement and organisation that would allow partners with diverse political and legal systems to work together on a mega-science experiment. The significant uncertain cost of ITER, multiple currencies of the participating countries and a long time of its construction and operation make funding commitment of all parties is one of the key legal and political issues. However, it was

Figure 2: ITER Site in France

Source: ITER, 2019a

necessary that each party have a high level of confidence that each of the other parties would remain committed financially. A series of negotiations were also held for withdrawal and dispute settlement provisions. Except for the EU (host party) that was pushed for clear, legally binding funding commitments, others were flexible and different on almost all points, with each party interested in formulations that were most acceptable and familiar to its domestic system. Finally, on 17 November 2010, the foundation stone of the experimental reactor was laid in France on the Cadarache site (Ruffini, 2017).

Scientific Dimensions of ITER

Fusion Experiment

In the tremendous heat and gravity at the core of the stellar bodies, hydrogen nuclei collide, fuse into heavier helium atoms and release tremendous amounts of energy in the process. At extreme temperatures, electrons are separated from nuclei and gas becomes a plasma that is the fourth state of matter. Three conditions must be fulfilled to achieve fusion in a laboratory: very high temperature of the order of 150,000,000° (150 million) Celsius; enough plasma particle density (to increase the likelihood that collisions do occur); and sufficient confinement time (to hold the plasma, which has a propensity to expand, within a defined volume) (ITER, 2019b).

Twentieth-century fusion science identified the most efficient fusion reaction in the laboratory setting to be the reaction between two hydrogen isotopes, deuterium (D) and tritium (T). The DT fusion reaction produces the highest energy gain at the "lowest" temperatures. The plasma particles are heated that is, sped up by different types of auxiliary heating methods. The fusion between deuterium and tritium (DT) nuclei produces one helium nucleus, one neutron, and a great amount of energy (ITER, 2019b).

The advantages of fusion reaction are release of abundant energy, sustainability, no carbon-di-oxide (major by-product is helium: an inert, non-toxic gas), no long-lived radioactive waste (could be recycled or reused within 100 years), limited risk of proliferation (exploited to make nuclear weapons), no risk of meltdown (the plasma cools within seconds and the reaction stops) and appropriate cost. The power output of the kind of fusion reactor that is envisaged for the second half of this century will be similar to that of a fission reactor, (i.e. between 1 and 1.7 gigawatts). The average cost per kilowatt of electricity is also expected to be similar or slightly more expensive at the beginning when the technology is new and less expensive as economies of scale bring the costs down.

In terms of sheer scale, the energy potential of the fusion reaction is superior to all other energy sources that we know on earth. Fusing atoms in a controlled way releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil or gas and four times more than nuclear fission. In ITER, fusion will be achieved in a Tokamak device that uses magnetic fields to contain and control the hot plasma.

Tokamak

The term "tokamak" comes to us from a Russian acronym that stands for "toroidal chamber with magnetic coils." First developed by Soviet research in the late 1960s, the tokamak has been adopted around the world as the most promising configuration of magnetic fusion devices.

The heart of a tokamak is a doughnut-shaped vacuum. Inside, under the influence of extreme heat and pressure, gaseous hydrogen fuel becomes a plasma—the very environment in which hydrogen atom can be brought to fuse and yield energy. The charged particles of the plasma can be shaped and controlled by the massive magnetic coils placed around the vessel; physicists use this important property to confine the hot plasma away from the vessel walls.

The helium nucleus carries an electric charge which will be subject to magnetic fields of the tokamak and remain confined within the plasma, contributing to its continued heating. However, approximately 80 per cent of the energy produced is carried away from the plasma by the neutron which has no electrical charge and is, therefore, unaffected by magnetic fields. The neutrons will be absorbed by the surrounding walls of the tokamak, where their kinetic energy will be transferred to the walls as heat. Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators.

ITER Experiments: An Overview

ITER will be the first fusion device to test the integrated technologies, materials, and physics regimes necessary for the commercial production of fusion-based electricity. ITER will not produce electricity, but it will resolve critical scientific and technical issues in order to take fusion to the point where industrial applications can be designed. By producing 500 MW of fusion power from 50 MW of power injected in the systems that heat the plasma—a "gain factor" of 10. ITER will be the world's largest tokamak—twice the size of the largest machine currently in operation, (the Joint European Torus in the UK) (ITER, 2019b). This unique experimental machine has been designed to:

- ITER is designed to produce a ten-fold return on energy (Q=10), or 500 MW of fusion power from 50 MW of input heating power.
- Demonstrate the integrated operation of technologies for a fusion power plant
- Achieve a deuterium-tritium plasma in which the reaction is sustained through internal heating
- Test tritium breeding: The world supply of tritium (used with deuterium to fuel the fusion reaction) is not sufficient to cover the needs of future power plants. ITER will provide a unique opportunity to test mock-up in-vessel tritium breeding blankets in a real fusion environment.
- Demonstrate the safety characteristics of a fusion device.

The ITER Project: Structure and Status

Thousands of engineers and scientists have contributed to the design of an international joint experiment of ITER since its inception in 1985. The initial design of ITER was a circular cross-section for magnetic confinement which was changed to a 'D' shaped cross-section that leads to more stable operation. This change escalates the cost significantly and forced the United States to discontinue its involvement in ITER (Harding, Khanna, & Orbach, 2012).

After significant domestic development towards burning plasma experiments, Securing America's Future Energy Act of 2001 and Snowmass workshop, held in the summer of 2002, encouraged the United States to re-join this international effort in 2003. China and South Korea also expressed their interest to join ITER in the same year, followed by India at the end of 2005, bringing the total number of ITER members to seven.). Taken together, the ITER Members represent three continents, over 40 languages, half of the world's population and 85 per cent of global gross domestic product. The ITER Members (China, European Union, India, Japan, Korea, Russia and the United States) are now engaged in a 35-year collaboration to build and operate the ITER experimental device and together bring fusion to the point where a demonstration fusion reactor can be designed.

The ITER Organization has also concluded non-Member technical cooperation agreements with Australia (through the Australian Nuclear Science and Technology Organisation, ANSTO, in 2016) and Kazakhstan (through Kazakhstan's National Nuclear Centre in 2017); a Memorandum of Understanding with Canada agreeing to explore the possibility of future cooperation and a Cooperation Agreement with the Thailand Institute of Nuclear Technology (2018); as well as over 60 Cooperation Agreements with international organisations, national laboratories, universities and schools.

The work of the ITER Organisation is supervised by its governing body, the ITER Council. The ITER Council is responsible by following the ITER Agreement, for the promotion and overall direction of the ITER Organisation. The ITER Council comprises representatives of the seven Members. The Chair and Vice-Chair of the Council are elected from amongst its members. Meetings are held at least twice a year; a press release is issued after each meeting. Each Member has created a Domestic Agency to fulfil its procurement responsibilities to ITER. Communication between the ITER Organization Central Team and the Domestic Agencies is facilitated by state-of-the-art collaborative CAD design tools, integrated project teams for specific components or projects, and video conferencing. The working language for the project is English (ITER, 2019a).

Construction Site

Three potential sites were proposed at the initial proposal: in France, Spain, and Japan. Later, it was reduced to two possible sites after the European Union chose the French site (Cadarache) over the Spanish site. In a meeting hosted by Energy Secretary Spencer Abraham in December 2003 to take a collective decision on the ITER site, Russia, China, and the EU supported the Cadarache, France site, while the United States, South Korea, and Japan supported the Rokkasho-mura, Japan site. This was resolved through Broader Approach agreement. Under this agreement, Japan agreed to withdraw its bid to host ITER, and the EU agreed to procure a certain amount of ITER materials through Japan, support additional Japanese staff at ITER, and the nomination of a qualified Japanese candidate to be the first ITER Director-General (Harding, Khanna, & Orbach, 2012).

Finally, the on-site construction of the scientific facility began in 2010 at Cadarache, France. The fabrication of large-scale mock-ups and components is underway in the factories of the seven

ITER Members. The shipment of the first completed components began in 2014 and will continue into the 2020s. Machine assembly will begin as soon as the giant Tokamak Complex is ready for occupation. First Plasma is planned for December 2025.

The Cadarache research centre (CEA) played an instrumental part in supporting site studies and in rallying local political players for welcoming ITER to France. Thirty-nine buildings and technical areas will house the ITER Tokamak and its plant systems. The Tokamak Building, the heart of the facility, is a seven-story structure in reinforced concrete that will sit 13 metres below the platform level and 60 metres above. Pre-assembly of Tokamak components will take place in the adjacent Assembly Hall. Other auxiliary buildings in the vicinity of the Tokamak Building will include cooling towers, electrical installations, a control room, facilities for the management of waste, and the cryogenics plant that will provide liquid helium to cool the ITER magnets. Over the next years each building, as it becomes ready for occupation, will be handed over to the ITER Organization for the start of assembly works (ITER, 2019a).

The successful integration and assembly of over one million components (ten million parts) built in the ITER Members' factories around the world and delivered to the ITER site constitute a tremendous logistics and engineering challenge. An assembly workforce of approximately 2,000 people will be needed at the height of assembly activities. France has provided the site for the project and carried out preparatory works including clearing and levelling, fencing, and networks for water and electricity. It created an international school for the families of

Main Components of ITER

Tokamak	World's largest tokamak with a plasma radius (R) of 6.2 m and a plasma volume of 840 m^3, weight 23000 tonnes.
Magnets	Ten thousand tonnes of magnets, with a combined stored magnetic energy of 51 Gigajoules (GJ)
Vacuum Vessels	with an interior volume of 1,400 m^3, 19.4 metres across (outer diameter), 11.4 metres high, and weigh approximately 5,200 tonnes. with the installation of the blanket and the divertor, the vacuum vessel will weigh 8,500 tonnes.
440 blanket modules	Will cover the inner walls of the vacuum vessel, protect the steel structure and the superconducting toroidal field magnets from the heat and high-energy neutrons produced by the fusion reactions. Each blanket module measures 1 x 1.5 metres and weighs up to 4.6 tonnes
Divertor	Situated at the bottom of the vacuum vessel, the divertor extracts heat and ash produced by the fusion reaction
Cryostat	the largest stainless-steel high-vacuum pressure chamber ever built (16,000 m^3), weighs 3,850 tonnes—provides the high vacuum, ultra-cool environment for the ITER vacuum vessel and the superconducting magnets.

Source: Authors' compilation.

ITER employees, adapted the roads along the ITER Itinerary for the transport of ITER components and contributed (with the European Domestic Agency) to building the ITER Headquarters. At the end of the ITER experimental phase, France will have the responsibility for the dismantling and decommissioning of the site.

Cost Assessment

As signatories to the ITER Agreement, concluded in 2006, the seven Members will share the cost of project construction, operation and decommissioning. They'll also share the experimental results and any intellectual property generated by the operation phase. Europe is responsible for the largest portion of construction costs (45.6 per cent); the remainder is shared equally by China, India, Japan, Korea, Russia and the US (9.1 per cent each). The lion's share (90 per cent) of contributions will be delivered "in-kind." That means that in the place of cash, the Members will deliver components and buildings directly to the ITER Organization. For the operation phase, the sharing of cost amongst the Members will be as follows: Europe 34 per cent, Japan and the United States 13 per cent, and China, India, Korea, and Russia 10 per cent (ITER, 2019a).

India's Engagement in ITER

India formally joined the ITER Project in 2005 and the ITER Agreement between the partners was signed in 2006. ITER-India is the Indian domestic agency, a specially empowered project of the Institute for Plasma Research (IPR), an aided organization under the Department of Atomic Energy. ITER-India is responsible for the delivery of the following ITER packages: Cryostat, In-wall Shielding, Cooling Water System, Cryogenic System, Ion-Cyclotron RF Heating System, Electron Cyclotron RF Heating System, Diagnostic Neutral Beam System, Power Supplies and some Diagnostics. Additionally, related R&D and experimental activities are being carried out at the ITER-India laboratory in Gandhinagar, Gujarat. ITER-India carries out other common activities in support of

Timeline for ITER Project

2005: Decision to site the project in France
2006: Signature of the ITER Agreement
2007: Formal creation of the ITER Organization
2007-2009: Land clearing and levelling
2010-2014: Ground support structure and seismic foundations for the Tokamak
2012: Nuclear licensing milestone: ITER becomes a Basic Nuclear Installation under French law
2014-2021: Construction of the Tokamak Building
2010-2021: Construction of the ITER plant and auxiliary buildings for First Plasma
2008-2021: Manufacturing of principal First Plasma components
2015-2023: Largest components are transported along the ITER Itinerary
2020-2025: Main assembly phase I
2022: Torus completion
2024: Cryostat closure
2024-2025: Integrated commissioning phase (commissioning by system starts several years earlier)
Dec 2025: **First Plasma**
2026: Begin installation of in-vessel components
2035: **Deuterium-Tritium Operation begins**

Source: *Authors' compilation.*

In-Kind Contribution Package

Cryostat:
30 m high and 30 m diameter Outer vacuum shell of ITER

Cryolines and cryo distribution system: 4 km cryolines, 7 km warm lines and 7 cryodistribution boxes for ITER cryo-plants of capacities 75 kW at 4.5K, 1 MW at 80K & their supply

In wall shielding: ~80 % volume between the two shells of vacuum vessel is filled with borated steel (SS304B4, SS304B7) and ferritic steel for neutron shielding and reducing toroidal field ripple. Requires ~9000 blocks from 70,000 precision cut plates.

ITER – Cooling water and Heat Rejection System:
10 cells of Cooling Tower: Avg. 510 MW: Highest heat rejection capacity – Peak ~ 1.2 GW
14 Plate type Heat Exchanger: 70 MW each: Possibly at the highest range of design
6 Air cooled Chillers: 450 kW each: First, with requirement of seismic qualification for nuclear site

ICRF source system:
9 RF sources: 2.5 MW at VSWR 2.0/35-65MHz/CW OR 3.0 MW at VSWR 1.5/40-55MHz/CW

Diagnostic neutral beam system: Detect He ash during D-T phase of ITER plasma and plasma diagnostics using 100 keV 20 A H neutral beam @ 20.7 m from the ion source. This requires extracting and accelerating 100 keV 60 A H- beam from the ion source at an extracted current density of 35 mA/cm2

Power supplies for DNB, ICRF and ECRF systems:
DNB: 10 kV, 140 A Extraction PS
90 kV, 70 A Acceleration PS
ICRH Driver Stage: 8-18 kV, 250 kW, End stage: 27 kV, 2.8 MW
ECRH: 55 kV, 5.5 MW

ECRH:
2 gyrotron sources: 1 MW power output at 170 GHz for 3600s pulse length

Diagnostics: Essential to monitor plasma impurities and emission. Ports are needed to house the Diagnostic systems in position and act as shielding from neutrons.

- X-Ray Crystal Spectroscopy (XRCS): Set of spectrometers ((X-ray crystals, Detectors, Vacuum chamber)
- Electron Cyclotron Emission (ECE): Set of Michelson Interferometers & Radiometers, Polarization splitter unit, Transmission lines
- CXRS: Optical Fibers, Detectors, Visible Spectrometers, Opto-mechanical components like filters, mounts, I&C

Special material development
CuCrZr with % compositions controlled to Cr: 0.6 – 0.8%; Zr : 0.07% to 0.15% ; Cd : 0.01%; Co : 0.05% ; total impurities not to exceed 0.1%

Source: *ITER, 2019c.*

the in-kind deliveries and other related commitments to the ITER Organisations which include project coordination, project management, quality control, assurance and quality audit (ITER, 2019c).

India is one of the seven major partners of ITER that indicates India's presence in cutting edge science and technology at the global level. One of the biggest benefits for India is 'know-how' and Intellectual Property Rights (IPR) from ITER experiments which are 90 percent by giving 10 percent only. This can be used in existing power plants to enhance their capabilities. The other benefits are the establishment of new high-end technologies in Indian industries through ITER experiments. Now Indian industries and research institutions are involved in the manufacturing of those technologies which were not available in India before ITER. The 1,250-tonne cryostat base, the first two sections of which have been constructed by conglomerate Larsen & Toubro (L&T), is India's one of the most important contributions in ITER. Apart from technology development, our scientific community is getting an opportunity to interact and work with the best brains of other parts of the world.

Training and Capacity Building

The ITER International School aims to prepare young scientists and engineers for working in the field of nuclear fusion and in research applications associated with the ITER Project. The adoption of a "school" format was a consequence of the need to prepare future scientists and engineers on a range of different subjects and to provide them with a wide overview of the interdisciplinary skills required by ITER.

Till date, a total ten ITER schools have been conducted on a variety of subjects: turbulent transport in fusion plasmas (Aix-en-Provence, France, 2007), magnetic confinement (Fukuoka, Japan, 2008); plasma-surface interactions (Aix-en-Provence, France, 2009); magneto-hydro-dynamics and plasma control (Austin, Texas (US), 2010); energetic particles (Aix-en-Provence, 2011); radio-frequency heating (Ahmedabad, India, 2012); high performance computing in fusion science (Aix-en-Provence, France, 2014); transport and pedestal physics in tokamaks (Hefei, China, 2016); physics of disruptions and control (Aix-en-Provence, France, 2017); and the physics and technology of power flux handling (Daejeon, Korea, 2019) (ITER Newsline, 2019).

The 11th ITER International School will be held from July 20 to July 24, 2020 at Aix-Marseille University, France. The subject of this year's school is: "The Impact and Consequences of Energetic Particles on Fusion Plasmas". As the start of ITER operations approaches, it is timely to address this multidisciplinary topic that includes plasma self-heating by fusion-born alpha-particles, the influence of energetic particles on stability, diagnosing energetic particle transport and loss, and understanding runaway electrons (ITER Newsline, 2019).

Conclusion

The challenges are huge and there is still a long way to go using science diplomacy. Participants in international project negotiations should expect that there will be significant cultural and other divides. However, ITER is an excellent example where science diplomacy was used in parallel to economy diplomacy within countries that have differences together. Strong political will, trust, flexible international agreements and commitments are the key to carrying such mega projects. Science and Technology is the hope of Sustainable Development Goals (SDGs) and international scientific cooperation is the new endeavour to achieve them. All parties should maintain a flexible spirit and political goodwill when difficulties and mistrust arise and promote it rather than place obstacles in its way.

ITER is an ambitious programme which demonstrates that diplomacy can be a catalyst for technological development. This is a global platform to facilitate the cooperation of the global scientific community and industries while developing commercial performance. This is the creation of a high-level pool of international technical expertise and inspiration for diplomats and policymakers. The upcoming $25 billion plasma-based fusion reactor ITER, in which India is a partner, is hope for the source of tremendous, carbon-free and safe energy for the world.

Reference

Claessens, M. 2020. Beyond Technology Diplomacy. In *ITER: The Giant Fusion Reactor* (pp. 199-209). Copernicus: Cham.

DST. 2013. "Science, Technology and Innovation Policy-2013". Accessed on November 2, 2019 from http://www.dst.gov.in/sites/default/files/STI%20Policy%202013-English.pdf.

Fedoroff, N.V. 2008. "Making Science Diplomacy More Effective**.** US Department of State"**.** Accessed on November 25, 2019 from https://2001-2009.state.gov/g/stas/2008/105286.htm

Harding, T. K., Khanna, M. J., & Orbach, R. L. 2012. "International fusion energy cooperation: ITER as a case study in science and diplomacy". *Science and Diplomacy*, *9*.

ITER, 2019a. "ITER in France". Accessed on November 17, 2019 from https://www.iter.org/org/ITERinFrance

ITER. 2019b. "ITER: The Way to New Energy". Accessed on November 9, 2019 from https://www.iter.org/

ITER. 2019c. "ITER: India". Accessed on November 8, 2019 from https://www.iter-india.org/indias-contribution-iter

ITER Newsline. 2019. '11th ITER International School announced'. Accessed on December 1, 2019 from https://www.iter.org/newsline/-/3349

Ruffini, P. B. 2017. "What Is Science Diplomacy?". *Science and Diplomacy*; pp. 11-26

Sharma, J., & Varshney, S. 2019. Science Diplomacy and Cooperation in Science and Technology in India. *Science Diplomacy Review*, pp. Vol. 1(2)

Sharma, J., & Varshney, S. K. 2019. "Vigyan Samagam: Showcasing India's Participation in Mega Science Projects". *Science Reporter*

Vigyan Samagam. 2019. "Vigyan Samagam". Accessed on November 23, 2019 from *https://w*ww.vigyansamagam.in/

ARTICLE

Biotechnology and STI Diplomacy

Douglas Nascimento Santana[*]

Douglas Nascimento Santana

Introduction

The convergence of methods for producing scientific knowledge and creating new technologies is increasing among the fields of chemistry and biology, resulting in a newly shaped biotechnology. It is now possible to produce chemicals by using living beings, as well as to synthesize biological molecules through chemical processes (Tucker, 2010). The technical developments that has allowed the approach of these two sciences is manifold: metabolic engineering; enzymatic engineering (biocatalysis); biopharming; traditional DNA-recombinant technology; Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) technology; DNA synthesis and semi-automatized peptide synthesis; "omics" technologies, such as genomics, transcriptomics, epigenomics, immunology, proteomics, metabolomics, and others (Khosla, 2014; Ibrahim, Pasic & Yousef, 2016.).

This technological convergence between chemistry and biology that underpins the current state of the art of biotechnology expands the range of products, services and solutions in the areas of health, agriculture and the environment, fostering economic development and improvements in the living standards of populations. An illustrative example of how these technological convergences can spillover economic and social benefits is the development of molecules similar to the poliovirus through the genetic manipulation of the tobacco plant aiming at manufacturing vaccines at a lower cost (Marsian et al. 2017).

However, it might not be neglected as nuclear and ballistic missile technologies, biotechnology breakthroughs pose the risk of dual use, and must remain

---

[*] Career Diplomat, Brazilian Ministry of Foreign Affairs.

under severe scrutiny of international rules of the current systems of non-proliferation of weapons of mass destruction. The difficulty in discerning the nature (whether chemical or biological) of these new agents sparks doubts about what is the appropriate institutional framework of surveillance for each case, whether the Chemical Weapons Convention (CWC) system or the Biological Weapons Convention (BWC) system (Trapp, 2014).

This paper argues that some parameters for regulating innovations in the field of biotechnology can start at the agenda of Science, Technology and Innovation (STI) Diplomacy towards the agenda of Defense Diplomacy. Surveillance considering exclusively security preoccupations can restrict access to essential technologies for various sectors of the economy, especially in developing countries, with no guarantees of additional security gains. At first, this paper will briefly present the *rationale* that has restricted the use by states of technological developments in chemistry and biology for non-peaceful purposes, in order to try to correctly evaluate risks, without alarms or negligence. Later, it will be presented how diplomats that work with STI Diplomacy can contribute to future biotechnology development by prioritising principles and alternatives that are commonly neglected in the political discussions focused on minimising risks of misuses of new technologies.

New Advancements and Traditional Practices

During World War I, the use of toxic gases resulting in a high number of deaths demonstrated a`destructive potential that would bring chemical and biological weapons to be categorized as weapons of mass destruction. In the period between the First and Second World War, recognizing the terror that this threat caused and the need to extend humanitarian protection in armed conflicts, states acceded to the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, the Geneva Protocol of 1925 (Guillemin, 2005).

Although it expressly prohibited the use of chemical and biological weapons, this convention was silent on the possibility of developing or acquiring them, so that some of its signatories, particularly the large industrial nations, set up robust government programmes for the production of these "higher forms of killing "(Paxman and Harris, 2011). Taking into consideration the technical feasibility of producing these armaments, why were chemical and biological weapons not widely used in World War II and subsequent inter-state wars? This question is important because it allows us to understand the rationality underlying the current reluctance to the use of these weapons by states.

Since the middle of the twentieth century, the development of large arsenals of chemical and biological weapons by major military powers, the inability of a state to defend itself against all the multiple types of toxins and pathogenic gases that can be produced by the enemy, and the permanent threat of retaliation with the same types of weapons inhibited - and have inhibited - the so-called first strike. There are also technical limitations on the handling of these weapons in real combat situations. The impossibility of determining the necessary dose of the toxic agent to be sprayed and the difficulty to predict the wind flows that would spill over them would attribute an inconceivable logistical uncertainty to the military planning of a possible attack (Guillemin, 2005).

In addition to the imbalances among nations in their capacities to develop such weapons and the technical limitations mentioned above, the massive expression of public opinion, especially in democratic regimes, against attacks with lethal poisons had curbed belligerent impulses (Paxman & Harris, 2011). Thus, it can be said that the decision on the use of chemical and biological weapons in inter-state wars is now, on the one side, between the certainty of violating international law and unacceptable behaviour in terms of international public opinion and, on the other side, doubts about military success of the attack and the type of retaliation to be suffered. As a result, the decision not to use these weapons has been found to be the best option.

The mastering of nuclear technology, whose use as a weapon of mass destruction would be more effective and with more predictable results, has definitively discouraged the use of chemical and biological weapons. As a consequence, throughout the second half of the twentieth century, military powers gradually abandoned their offensive programmes of chemical and biological technologies and promoted a deepening of norms and institutions that guarantee their use only for peaceful purposes (Guillemin, 2005).

We argue that there is no reason to believe that the *rationale* underlying the future application by states of new technological developments in biology and chemistry is different from this historically settled *rationale*. Case-specific control measures against dissident groups can be an appropriate alternative instead of comprehensive interventions against nations, even when the formers are well-conducted under the rules of the Chapter VII of the United Nations Charter (Sossai, 2010).

STI Diplomacy: Alternative Pathways

STI Diplomacy has been increasingly recognised as an important instrument for stabilising relations between countries and reducing risks of direct conflicts. The technical knowledge and the apolitical language of science are capable of bringing erstwhile political enemies to the table of negotiation to help solving transnational problems, such as the natural resources quarrels involving Middle East nations or the aerospace dispute between the United States and the Soviet Union during the Cold War.

Despite this potential to help freezing warm international themes, STI Diplomacy is still far from the High Politics discussion, in the classical words of Joseph Nyer, such as that of mitigating the risks of the dual use of biotechnologies breakthroughs. Notwithstanding, this paper argues that a pro-active diplomatic stance towards pushing STI Diplomacy into major security issues could help tackling some problems of the future biotechnology agenda.

The first contribution that Science Diplomacy could provide to biotechnology would be to help deepening the institutionalisation of the regime of non-proliferation of weapons of mass destruction by strengthening the importance of scientific knowledge in the decision-making process of these systems. In order to improve the surveillance measures of the CWC and BWC, diplomats that work with science, technology and innovation shall make the necessary efforts to guarantee that technical reports of specialists that systematically analyze the production of organic molecules by biological processes and the chemical synthesis of natural toxins could prevail over the subjective opinions of diplomats that work in the political area of their chancellery.

The normative and institutional system of CWC, which includes the Organization for the Prohibition of Chemical Weapons (OPCW), is considered exemplary in the area of disarmament and non-proliferation. It has succeeded in almost completely destroying the chemical weapons stockpiles of its 190 member states without creating additional obstacles to the technical and scientific progress of the chemical industry, which is aligned with the interests of developing countries (OPCW, 2008; OPCW, 2019b).

As BWC lacks a formal verification system, the burden of avoiding the production of lethal chemical agents by biotechnology and of monitoring chemical processes capable of synthesizing biological toxins would come under the CWC. This convention specifically provides for the types of industrial plants to be inspected by the OPCW. The current OPCW routines (products listed in Schedules I, II and III and OPCW inspections - production facilities of other chemicals), however, do not cover verification of the development and production of these compounds (OPCW, 2019a; Tucker, 2010).

Given the need to create combined methods of verification within the BWC, including a declaration of activities by states, continuous monitoring and inspection of suspected plants, it is essential to guide the decision-making process by reliable scientific information (OPBW, 2019; Goldblat, 1997). At the BWC Review Conferences, the apolitical language of science may be crucial in avoiding the intensification of the already existing rivalries between Western Countries (WEOG) and the Non-Aligned Movement Countries (NAM) regarding a protocol for strengthening the institutional framework of the convention with verification mechanisms[1] (Trapp, 2014).

The second contribution of STI Diplomacy is to help in modelling the future agenda of biotechnology which could be related to the management of risks arising from the sharing of technical data via specialized journals or through access to large online databases by high-level laboratories and research centers. The publication of research results is fundamental for the maintenance of the peer-review process that has gradually improved the science since its origin. Considering the multiple potential applications of the recent advances in biotechnology, ensuring the peaceful use of information becomes part of the work of each researcher and each knowledge-producing institution. Updating the existing codes of conduct for the publication of scientific information is a crucial step to guarantee an appropriate flow of knowledge. For this objective, it would be important that STI diplomats could consider the building or revision of these codes of conduct not a matter of private institutions relations but a part of their work to push forward national interests in many innovative areas, such as biotechnology. In this regard, they could lead the process of negotiating broad international agreements on scientific information sharing, a commonly neglected issue in political discussions between diplomats about non-proliferation.

Furthermore, it is important that these codes could be guided by the premise that vital information for the synthesis, replication and inoculation of new agents must be kept confidential. Due to the operational nature of this information, this reservation does not compromise the evaluation of the testability and falsifiability of theories and conclusions which derive from the original studies. An analogous system of selective information disclosure has been practiced in the field of quantum physics since the mid-twentieth century, with full success in preventing the proliferation of the capacity to produce nuclear artifacts by non-state agents (Miller & Sagan, 2009).

A final contribution of STI diplomats to the peaceful use of biotechnological innovations is to support the construction of an international framework for technology control that encompasses computer systems, robotics and nanotechnology which are applied in the field of biotechnology. The convergence between scientific disciplines is even more evident here. To biology and chemistry, it is possible to add computing, robotics and nanotechnology to forge a complex of scientific knowledge production that uses the most advanced equipment and research inputs (Van Hecke et al., 2002). The large number of international producers and suppliers of these inputs sparks the alternative of implementing technology control through a broad and unified international register that associates technological capacity with security risks. A similar risk-scaling system has long been used to manage the availability and commercialisation of equipment that uses enriched uranium (Miller & Sagan, 2009).

Future Biotechnology Agenda

Technology, as an instrument of the practical application of scientific knowledge, cannot be aprioristically defined as beneficial or harmful to the population that develops it. The uses of technology are socially defined, in accordance with moral, ethical, religious and cultural values as well as philosophical conceptions ((Balakrishnan, 2017; National Research Council, 2006). After the atrocities practiced with chemical weapons by both contending sides during World War I, a consensus was generated in international society, which remains strong and intense, that whatever technology could be developed, it should never be used for the purpose of mass killing. Together, the CWC and BWC systems have offered a credible set of rules and institutions that have reinforced the peaceful use of chemical and biological breakthroughs for generations.

A new phenomenon has emerged in the last decade. The tendency to theoretical and empirical convergence between chemistry and biology is a hegemonic view in the specialised scientific environment, constituting the so-called Chemical Biology. It is also possible to add informatics, robotics and nanotechnology to this complex of disciplines (Khosla, 2014; Van Hecke et al., 2002). As a result, since the beginning of the 21st century, the international society has witnessed an exponential growth in the possibilities of biotechnology intervention in the reality of people. New drugs, prostheses, types of food, chemical and biological agricultural pesticides are traded and take part in the daily lives of families, companies and governments (National Research Council, 2006). Considering this, it would do no harm to think about reviewing and updating the normative framework of the system of non-proliferation of weapons of mass destruction in order to improve the surveillance over new biotechnologies.

Nevertheless, some principles must be kept in mind if the international community is to strengthen the CWC and BWC´s surveillance methods without undermining the economic and social potential of biotechnology breakthroughs. Comprehensive restrictive measures in the research, development and commercialisation stages of biotechnology can amplify barriers to the access of advanced equipment and research inputs, especially for developing countries that do not yet manufacture them, as well as to widen the technological gap between developed and developing countries. Furthermore, historical experience from the nuclear regime further demonstrates that comprehensive restrictions can have the collateral effect of posing barriers to access to technology for peaceful purposes (Miller & Sagan, 2009).

The aforementioned preoccupation is a hotspot at the STI Diplomacy agenda. However, STI Diplomacy has a minor role, if any, in the decision-making process of future changes in the non-proliferation regime. It is up to STI diplomats to demonstrate that an exclusive security perspective is limited in dealing with the innovations in the area of biotechnology. This battle must be fought inside chancelleries as much as in international fora. STI diplomats must engage in initiatives that present the potential of scientific knowledge to contribute to the technical underpinning of decisions in the non-proliferation regimes of chemical and biological weapons; that foster negotiations of international codes of conduct for the dissemination of scientific information; and that create an international framework for balanced and rational technology control of computer systems, robotics and nanotechnology applied in biotechnology experiments.

Conclusion

Minimising the risks of non-peaceful uses of new advances in biotechnology by collaboration coming from outside the area of defense and security can help balancing broader tensions in bilateral relations; open new institutional and personal channels of communication; and increase mutual trust among nations. These are possible positive externalities brought by STI Diplomacy, whose importance for international relations can no longer be neglected. These benefits have already emerged from negotiations involving, for example, climate change and pandemic control, so it is as possible as desirable that they could also emerge from the negotiations involving the future agenda of biotechnology.

Endnotes

[1] In the context of the Convention for the Prohibition of the Biological Weapons (BWC), the negotiations are polarized by a political division between two unofficial regional groups that act as voting blocs: 1) Western European and Others Group (WEOG), composed by European countries, Canada, Australia, New Zealand, Turkey and Israel as members, and the United States as observer; 2) the Non-Aligned Movement (NAM), composed since 1961 by a variety

of countries, such as Colombia, Cuba, Iran, India, Indonesia and other, that act against major blocs of power. For more information, see: United Nations Regional Groups of Member States (in: https://www.un.org/depts/DGACM/RegionalGroups.shtml) and Morphet, 2004

References

Balakrishnan, B. 2017. "Technology and International Relations". *Indian Council of World Affairs (ICWA)*.

Goldblat, J. 1997. The Biological Weapons Convention: An Overview. *International Review of the Red Cross Archive*, v. 37 (318), pp. 251-265.

Guillemin, J. 2005. *Biological Weapons: from the invention of state-sponsored programs to contemporary bioterrorism*. New York: Columbia University Press.

Ibrahim, R., Pasic, M., Yousef, GM. 2016. "Omics for personalized medicine: defining the current we swim in". *Expert Review of Molecular Diagnostics*, 16(7), Pp. 719-722.

Keohane, R. O. and Joseph S. N. 1977. Power and interdependence.

Khosla, C. 2014. The Convergence of Chemistry & Human Biology. *Daedalus,* v. 143 (4), Pp. 43-48.

Morphet, S. 2004. Multilateralism and the Non-Aligned Movement: what is the Global South doing and where is it going?. *Global Governance*, v. 10 (4), Pp. 517-537.

Marisain, J. et al. 2017. Plant-made polio type 3 stabilized VLPs—a candidate synthetic polio vaccine. *Nature Communications*, v. 8(1), p. 245.

Miller, S. E. and Sagan, S. D. 2009. Nuclear power without nuclear proliferation?. *Daedalus*, v. 138 (4), Pp. 7-18.

National Research Council. 2006. *Globalization, biosecurity, and the future of the life sciences*. Washington, DC: National Academies Press.

OPBW. 2019a. "Summary report of the ad hoc Group of Governmental Experts to Identify and Examine Potential Verification Measures from a scientific and technical standpoint. Accessed on January 7, 2019, from http://www.opbw.org/verex/docs/final_dec/verex%20final%20declaration.pdf

OPCW. 2019b. Convergence of Chemistry and Biology: Report of the Scientific Advisory Board's Temporary Working Group. Accessed on January 7, 2019, from https://www.opcw.org/fileadmin/OPCW/SAB/en/TWG_Scientific_Advsiory_Group_Final_Report.pdf

OPCW. 2019c. Genesis and Historical Development. Accessed on January 7, 2019, from https://www.opcw.org/chemical-weapons-convention/genesis-and-historical-development..

OPCW. 2008. Report of the Scientific Advisory Board on Developments in Science and Technology. Note by the Director-General.

Paxman., J. and Harris, R. 2011. *A higher form of killing*. Random House.

Sossai, M. 2010. Drugs as weapons: disarmament treaties facing the advances in biochemistry and non-lethal weapons technology. *Journal of Conflict & Security Law*, v. 15 (1), Pp. 5-24.

Trapp, R. 2014. Convergence at the Intersection of Chemistry and Biology—Implications for the Regimes Prohibiting Chemical and Biological Weapons. Biochemical Security 2030. *Policy Paper Series, no. 6*

Tucker, J. B. 2010. The convergence of biology and chemistry: Implications for arms control verification. *Bulletin of the Atomic Scientists*, v. 6(66), Pp. 56-66.

Van Hecke, G. R. *et al*. 2002. An integration of chemistry, biology, and physics: the interdisciplinary laboratory. *J. Chem. Educ*, v. 79 (7), p. 837.

ARTICLE

Suriname-India Cooperation in Rural Development: A Science Diplomacy Perspective

David Abiamofo*

DAVID ABIAMOFO

Suriname and India Bilateral Relations: An Overview

The Republic of Suriname, located in South America, was, until 1975, part of the Kingdom of the Netherlands, and prior to that a Dutch colony. Suriname is one of the most ethnically diverse countries in the world. Dutch is the official language. Suriname and India started their bilateral ties in 1975, the year Suriname gained its independence. Both states are represented at the highest diplomatic level in each other capital. The most important activities within the bilateral relations of Suriname and India in the past 16 months are:

Suriname became a member of the International Solar Alliance (ISA) in February 2018. ISA aims to make 'scaling up' a reality in the deployment of solar energy in the 121 countries with strong sunshine situated between the Tropics of Cancer and Capricorn. These countries represent 73 per cent of the world's population.

The Honourable President of India Shri Ram Nath Kovind and First Lady Smt. Savita Kovind paid a visit to Suriname in June 2018. According to the Embassy of India in Paramaribo (Suriname's capital), a total of five MoU's were signed in the areas of Centre for IT Excellence, cooperation between the electoral authorities, National Archives, cooperation between diplomatic institutes and remunerative employment of dependents of the diplomatic personnel of the two countries. In addition two Letters of Credit were signed and previous to that India had provided four credit lines, worth US$ 57 million, to Suriname (Embassy of India - Suriname, 2019)

---

* Lecturer, University of Suriname, Suriname.

Under the Indian Technical & Economic Cooperation Programme (ITEC) the slots reserved for Suriname are 50 during the year 2018 - 2019.

An Agreement to set up a Joint Commission (JC) was signed in 1992 and six JC meetings have been held so far. Other areas of (continuous) cooperation are: economy, education and culture.

Culture has a special place in the bilateral relations between Suriname and India. The main reason is the fact that approximately 30 per cent of the Surinamese population is of Indian descent (Censusstatistieken 2012; ABS, 2019). The Indian Cultural Centre in Suriname (ICCR) was opened in 1978 and it actively pursues soft-power diplomacy initiatives and the whole gamut of ICCR's outreach including, Hindi language, Kathak, Yoga and classical music. India provides yearly grants for promotion of Hindi in Suriname.

India and Suriname are lookalikes in many areas. Apart from the scales there are many similarities. In this paper the focus is on the existence of relatively poor rural communities scattered over different parts of the country. Their livelihoods need sustainable improvement in several areas. In this paper the disadvantages in the areas of health, water and sanitation, energy, education, and agriculture will be touched upon.

Rural communities in Suriname and India

Suriname

Rural communities are found in villages along rivers in the tropical Amazon rainforest of Suriname. Unlike in the urban area in the coastal zone, many rural areas lack basic resources necessary for a sustainable livelihood. The rural areas are being inhabited by different indigenous Amerindian tribes and different Maroon groups. The Maroons are descendants of enslaved Africans who escaped slavery and established sustainable self-ruled communities in the Surinamese rainforest.

Although 95 per cent of the overall population is obtaining their drinking water from improved sources, large disparities remain between the urban coastal (98.6 per cent), rural coastal (95.9 per cent) and rural interior populations (70.7 per cent). Of great concern is that less than 10 per cent of households using an unimproved drinking water source use an appropriate method of treatment, meaning that the vast majority of those households are at risk from water-borne diseases. While 91 per cent of the overall population has access to improved sanitation facilities the disparity between urban, rural coastal and rural interior areas is even more striking. In the urban coastal area, 98 per cent of households have improved facilities, and as compared to rural coastal areas where 94 per cent of households have such facilities. However in rural interior households, just 42 per cent of households have access to improved sanitation. Open defecation is still the main practice of nearly half of all households (49.1 per cent) in the rural interior (UNICEF 2014).

This means that in the rural interior, one third of households don't have access to safe drinking water, and fewer than half of all households has access to improved sanitation. According to its multi-year development plan (2017-2021), the main goal of the government of Suriname is to develop rural areas sustainably whereby the quality of life of those living in these areas would be substantially improved (Government of Suriname, 2017).

India

India has the largest population of poor people (Hegde, 2019) but community development has assumed high priority by the government. The initial programmes aimed at upliftment of the rural poor covered agriculture, animal husbandry, infrastructure, health, education and housing. Though 30 per cent of rural population still lives in a chronic condition of poverty, in the last three decades some improvement in the number has been seen because of anti-poverty schemes and migration from rural to urban areas. The government of India nowadays has more progressive schemes, including the Mahatma Gandhi National Rural Employment Guarantee Scheme, and the National Social Assistance Programme. According to the Global Multidimensional Poverty Index 2018 (a joint work of OPHI and UNDP), between 2005-2006 and 2015-2016 the incidence of multidimensional poverty in India almost halved, climbing down to 27.5 per cent from 54.7 per cent (OPHI, 2018). The World Bank reported in 2016 that 80 per cent of India's poor lived in rural areas (World Bank, 2018).

Apart from poverty, other major issues in India's rural areas include: poor sanitation, illiteracy, poor access to healthcare, environmental issues, etc

According to World Bank, India is the world's seventh largest economy and among the fastest growing large ones, with average annual growth of about 7 per cent. Yet India is also home to the world's largest concentration of poverty, with more than 250 million people living below the poverty line of $1.90 a day (World Bank, 2018).

Science diplomacy and Sustainable development

The practice of science diplomacy could be dated back until the early days of diplomacy. According to Linkov et al. (2014) the idea of science diplomacy is itself not new, with the literature pointing out that the US was among the first to make use of a science attaché, having representation in Germany as early as 1898 (Linkov et al. 2014, as cited by Masters 2016). This practice could be defined as the use of scientific collaborations among international communities to address common scientific challenges and to build constructive global partnerships and cooperation (Saxena, 2017).

Science diplomacy is not only conducted at the level of states. With a growing divide between the "haves" and "have nots", and the prominence given to the role of science, technology and innovation in addressing issues of human security, non-state actors, including civil society, the private sector, academia and research organisations, have been drawn into international debates and scientific collaboration. In the case of India and Suriname, science could be used to bring together expertise in promoting research and the use of innovation for the benefit of rural communities in both nations. This leads to sustainable development. For countries to achieve sustainable development they need to engage in partnerships to develop best policies and practices. Sustainable development diplomacy needs deeper participation of all relevant stakeholders and could, therefore, be defined as the engagement of diplomatic and civil society to collaborate on addressing and tackling challenges that avert the creation or preservation of sustainable livelihoods.

Scope of Cooperation

The areas of cooperation are selected based on mutuality. Both countries have the same problems in their rural areas. It will be necessary for both governments to share knowledge, experiences, and technology, by also engaging NGOs, the private sector, scientists and (all layers of) the rural communities. The current global industrial revolution has an exponential pace of technological change, building on new (mostly) digital technologies and transforms, practices and systems. The both countries could engage in Sustainable Development Diplomacy and Science Diplomacy to deploy science and technology to enhance livelihoods and thereby guarantee sustainable rural development. Some possible areas of cooperation are discussed in more detail below.

Health

Although rural communities often have access to local healthcare facilities, there are other factors that contribute to how they can access healthcare. Some factors include cost of insurance and specialist services, transport to and from required services, time and confidence in the quality of services. A coordinated approach to healthcare that incorporates technology such as artificial intelligence is an ideal goal for rural communities; for example technologies that can help doctors provide effective video consultation to patients in rural areas. India and Suriname can pair to tackle healthcare challenges in their rural areas. For example Suriname is very well known in the Americas for successfully combating malaria within its borders. According to the World Health Organization (WHO), in 2018, only 30 indigenous malaria cases were reported in the interior of Suriname (WHO, 2019). Compared to the 1712 cases in 2010 this is significantly a lesser amount.

On the other hand malaria is (according to the World Malaria Report 2017) a main threat for India's health system. In the year 2016, more than half of the population (698 million) was at risk. According to this report, India accounted for 6 per cent of all malaria cases in the world, 6 per cent of the deaths, and 51 per cent of the global *plasmodium vivax* cases. The report estimates the total cases in India stood at 1.31 million and deaths at 23,990. The biggest burden of malaria in India is borne by the most backward, poor and remote parts of the country, with between 90 to 95 per cent of the cases reported from rural areas (WHO, 2017).

Water and Sanitation

Access to clean water and proper sanitation are basic human rights and are critical sustainable development challenges. The causes are in most cases are polluting industries, agriculture, households and energy generation. In the rural interior of Suriname, fewer than 15 per cent of households have safe drinking water piped into their households or yards and fewer than half have any improved water source on their premises (UNICEF, 2015). Most villages in the rural interior are built on river systems, and for generations people have used the river for all of their needs, while open defecation is still a common practice. Rural India faces the same problems regarding access to safe water and proper sanitation.

Education

The mission for ensuring quality of education and promoting lifelong learning depends on a range of prerequisites including, primarily spirit for knowledge, relevant as well as futuristic curriculum, and well-trained teachers. As all these feed each other, they need to be realised in an integrated and holistic way. According to UNICEF, in Suriname, 97 per cent of the children are enrolled in primary education, but serious disparities exist between the coastal and rural schools and those in the interior (UNICEF, 2017). Far less children in the interior enroll in the primary school system and pre-schools too are scattered. Other bottlenecks of the education system in those rural areas are the widespread use of local languages instead of the Dutch (the instruction language), the poor facilities, lack of electricity and the absence of qualified teachers. UNICEF (2017) reported that 30 per cent of the teachers in the interior were not qualified to teach, and in public primary schools 5 per cent of them had not completed primary education themselves. Both countries could engage in a sustainable cooperation with mutual benefit by sharing knowledge and experience. They face the same challenges and technical cooperation in the fields of the development of new curriculum and the use of ICT (the introduction of distance learning concepts, for example) could play a vital role in improving education in rural areas.

Energy

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential. Focusing on universal access to energy, increased energy efficiency and the increased use of renewable energy through new economic and job opportunities is crucial to creating more sustainable and inclusive communities and resilience to environmental issues like climate change. Sustainable energy is a boost for economic growth and is essential for creating sustainable livelihoods. Furthermore, access to energy creates health benefits and enables people to study or start a business. India and Suriname could pair in the development and use of renewable energy. Scientists agree on the fact that energy from renewable resources as wind, water, solar and biomass is clean. All of these sources are available in both countries.

Agriculture

According to the FAO, achieving food security would require an integrated approach that addresses all forms of malnutrition, the productivity and incomes of small-scale food producers, resilience of food systems and the sustainable use of biodiversity and genetic resources (FAO, 2019). Again both governments could work together with scientists, local farmers and multilateral organisations to guarantee food security, nutrition and sustainable agricultural practices for the rural communities. Because of, among others causes, the use of old technology (if technology is being used at all) the communities stick with low-productivity agriculture.

Barefoot College: A Successful Model

The success of the barefoot model in India is widely recognised. Barefoot College demonstrates that illiteracy does not have to be a barrier to poor communities developing themselves and that the most sophisticated technologies can be disseminated by poor rural men and women who can barely read and write. As such, thousands of people are trained each year to be teachers, doctors, midwives, dentists, health workers, solar engineers, water drillers and testers, hand pump mechanics, architects, artisans, designers, masons, communicators, computer programmers, and accountants (Schwab Foundation for Social Entrepreneurship, 2019).

The Barefoot College connects rural communities to solar, water, education, professions and advocacy to help communities and individuals take control of their lives and the wellbeing of their communities. In 2016 two Surinamese women completed the International Solar Training Programme of Barefoot College. Currently these two women are skilled enough to share their knowledge and experiences with other local communities in remote villages in the interior of Suriname.

This training programme began in 2008 and is being supported by the ITEC Programme. According to Barefoot this six-month programme, conducted twice a year, is a collaborative effort of Barefoot College, ITEC and the respective Governments and NGOs (ground partners) of the participating countries. Trainees are often illiterate or semi-literate grandmothers who maintain strong roots in their rural villages and play a major role in community development, and bringing sustainable electricity to remote, inaccessible villages. Solar electrification reduces CO2 emissions, slow the negative impacts of deforestation and decrease air pollution from burning firewood and kerosene.

Recommendations

Based on the findings of this preliminary study, this paper concludes with the following recommendations:

- Whereas India has developed a policy on Science Diplomacy, Suriname still needs to engage all stakeholders and develop an inclusive policy on this subject. The multi-year development does not mention Science Diplomacy and technological cooperation is ad hoc. The Ministry of Foreign Affairs is yet to install a Science Diplomacy division.
- Both nations clearly need to do better in engaging with non-state actors who can play a vital role in both Sustainable Development Diplomacy and Science Diplomacy. Improving livelihoods of rural communities requires a broad level of cooperation including (all levels of) government, rural communities, universities and scientists, civil society and private sector.
- Engagement with all layers of the rural communities (including women and youth) in developing this policy is pivotal to ensure sustainability. Both countries can do better in engaging the communities in policy development and priority setting.
- Both nations can do a better job in sharing knowledge, technology and success stories. Improving livelihoods of rural communities has been on the agenda of both states for decades and it is plausible that successful mechanisms or models in different areas have been developed in the course of the years and that those could be shared.
- In many developing states, there are constraints on capacity. This also limits the options for international engagements. Suriname and India

have the structure and infrastructure to enhance their partnership. Apart from the presence in both capitals, the Joint Commission is a suitable environment to further engage in this regard. The frequency and output of the Joint Commission meetings need to be increased accordingly.

References

ABS. 2019. "Algemeen Bureau voor de Statistiek". Retrieved on January 09, 2019 from https://statistics-suriname.org/nl/

Amazon Conservation Team. 2015. "Barefoot". Retrieved on January 11, 2019 from http://www.act-suriname.org/barefoot/

Barefoot College. 2019. "At Barefoot, we harness the power of the sun". Retrieved on January 11, 2019 from https://www.barefootcollege.org/solution/solar/

Contemporary History, 41(1); pp:169-186

Embassy of India, Suriname. 2019. "Advisory". Retrieved on January 10, 2019 from https://www.indembassysuriname.gov.in/pages.php?id=98

FAO. 2019. "Sustainable Development Goals: End hunger, achieve food security and improved nutrition and promote sustainable agriculture". Retrieved on January 19, 2019 from http://www.fao.org/sustainable-development-goals/goals/goal-2/en/

Hegde, N. 2019. "Community Development in India: An Overview". Retrieved on January 11, 2019 from http://baif.org.in/doc/scientific_papers_sustainable_rural_devt/Community%20Devt %20 in%20India.doc

Kaur, R. 2013. "Causes of rural poverty and Anti-poverty schemes in India". Retrieved on January 10, 2019 from https://www.mapsofindia.com/my-india/society/causes-of-rural-poverty-and-anti-poverty-schemes

Masters, L. 2016. South Africa's two track approach to science diplomacy. *Journal for Contemporary History*, 41(1), pp.169-186.

Oxford Poverty and Human Development Initiative. 2018. "Global Multidimensional Poverty Index 2018: The Most Detailed Picture To Date of the World's Poorest People", University of Oxford:UK

Panigrahi, H S., and Kumar, R. 2018. "Relook at Education for realizing SDG 4". India CSR Network. Retrieved on January 10, 2019 from http://indiacsr.in/relook-education-realizing-sdg-4/

Saxena, S.K. 2017. "Role of Science in Export Trade". Paper presented at RIS, New Delhi, India

Schwab Foundation for Social Entrepreneurship. 2019. "Social Entrepreneur: Sanjit (Bunker) Roy". Retrieved on January 1, 2019 from https://www.schwabfound.org/awardees/sanjit-bunker-roy

Suriname Planning Bureau Foundation. 2017. "201-2021 Policy Development Plan" Retrieved on January 17, 2019 from http://www.planningofficesuriname.com/wpcontent/uploads/2018/02/2017-2021-DEVELOPMENT-PLAN.pdf

Tasneem, G. 2018. "How can technology benefit healthcare in rural communities". Orion Health blog. Retrieved on January 10, 2019 from https://orionhealth.com/ca/knowledge-hub/blogs/how-can-technology-benefit-healthcare-in-rural-communities/

UNICEF. 2014. "Increasing access to water, sanitation and hygiene in Suriname's rural interior: An Appreciative Inquiry". Retrieved on January 11, 2019 from https://www.unicef.org/evaldatabase/files/Rural_WASH_progr_eval_Surinam_2010-14_-_Unicef_29.01.15.pdf

UNICEF. 2017. "UNICEF Annual Report 2017 Guyana and Suriname". Retrieved on October 02, 2019 from https://www.unicef.org/about/annualreport/files/Guyana_and_Suriname_2017_COAR.PDF

United Nations. 2019. "Goal 7-Affordable and Clean Energy". Retrieved on January 14, 2019 from https://www.un.org/sustainabledevelopment/energy

WHO. 2017. "World Malaria Report-2017". Retrieved on January 10, 2019 from http://www.who.int/malaria/publications/world-malaria-report-2017/en/

WHO. 2019. "The E-2020 Initiative of 21 Malaria-Eliminating Countries: 2019 Progress Report". Retrieved on October 03, 2019 from https://apps.who.int/iris/bitstream/handle/10665/325304/WHO-CDS-GMP-2019.07-eng.pdf?ua=1

World Bank. 2018. World Bank Research Digest, Vol. 12(2). World Bank: Washington, DC. Retrieved on January 13, 2019 from https://openknowledge.worldbank.org/handle/10986/31553 License: CC BY 3.0 IGO

PERSPECTIVE

Leveraging Scientific Diaspora to Strengthen National STI Ecosystem

Amit Kumar*

AMIT KUMAR

The word '*diaspora*' is derived from the Greek word '*diaspeirein*', which means "to scatter, spread about." Diaspora has been defined in various different ways. According to Barre *et al* (2003) 'diaspora' means a '*self-organised group of expatriates*' and 'scientific diaspora' refers to '*all self-organised communities of expatriate scientists and engineers working to develop their home country or region, mainly in science, technology and higher education*'.

Since last several decades, emigration of highly skilled professionals from the global South to the global North has contributed significantly to the S&T-driven innovation and economic progress in the developed countries (Saxenian, 1999a; Burns, 2013). However, increasingly the scientific diasporas are been seen as agents of development in their country of origin (Tejada, 2012). Barre et al (2003) and Tejada and Bolay (2010) have argued that the increasing relevance and use of knowledge-based activities in the development process within the country of origin has open up many possibilities of engaging the scientific diaspora to leverage their expertise and support.

Barre et al (2003) stated that the '*scientific diaspora option*' should be increasingly considered to harness the available potential of such a highly-skilled section for national development and in order to take this up, the home country should '*publicly state the principle that S&T diasporas are actors in co-development in the scientific and technical arenas, and declare the principle of an official policy of support for S&T diasporas*'. This 'option' advocates for the implementation of strategies that guide the flow of technology, knowledge and other resources of emigrated scientists and skilled professionals for the purpose of catalysing the economic and social transformations in their countries of origin.

---

* Research Associate, RIS, New Delhi.

The UNESCO (2010) Science Report, referred to the seriousness of the exodus of human capital that some developing countries suffer. However, it also recognized the importance of diasporas *as a useful departure point for the design of policies for more effective technology transfer and knowledge spillovers*, either by return to the country of origin or through their participation '*from a distance*' (P.7).

Over a period of time, there has been a change in the focus from 'brain drain' prevention to the possibility of leveraging 'brain circulation' or 'brain gain' (Meyer and Charum, 1995; Meyer, 2001). Cohen (1997) and Sheffer (1986) have argued that the diasporas have the capacity to make valuable and creative contributions to the country of origin and to the country of destination at the same time. Barre et al. (2003) and Kuznetsov and Sabel (2006) stated that a certain groups of emigrant scientists, engineers and skilled professionals belonging to the scientific diasporas or knowledge diasporas, tend to organise themselves in order to create cooperation opportunities with the aim of impacting the socio-economic development of their countries of origin, particularly in areas related to science, technology and education.

Sharabati-Shahin (2009) put forth the perspective of 'brain exchange', whereby brain drain is compensated by corresponding brain gain. This is made possible through the exchange of scholars, researchers and scientists. Within this perspective, the emigrated intellectual, skilled and technological professionals would remain an invaluable resource for the development of their home country through the platforms of knowledge economy and via knowledge networks of global knowledge societies.

There are various modalities such as remittances, business investment and knowledge transfer mechanisms, through which the diaspora maintains its relationship with their country of origin (Lowell and Gerova, 2004). The advances in ICT coupled with better and cheaper air connectivity options, have provided the scientific diasporas the opportunity to become transnational citizens; thus allowing them to connect and contribute to the businesses and academic/research of their country of origin (Seguin *et al*, 2006; Meyer and Brown, 1999; Meyer *et al*., 1997).

Diaspora Knowledge Networks (DKNs) have emerged as a key tool to engage diaspora members in development of their home country. Meyer et al (1997) described the emergence of scientific Diaspora Knowledge Network; where they analysed the emergence of the Columbian *Red Caldas* network, which was established by the expatriate scientists to build the Columbian S&T community and link them to international S&T communities. Khadria (2003) has profiled major Indian diaspora networks in the USA such as American Association of Physicians of Indian Origin (AAPI), Enterprising Pharmaceutical Professionals from the Indian Subcontinent (EPPIC), Network of Indian Professionals (NetIP), Global Organization of People of Indian Origin (GOPIO), etc.

Seguin et al. (2006) argued that the countries with "*strong diaspora policies such as India and China, tended to have a greater number of self-identified diaspora networks focusing on knowledge transfer between their 'host county' and their country of origin*. (P. 83)".

Saxenian (2002) stated that in the 1990s, the US-educated Indian professionals, who had established two the Silicon

Valley's most vibrant associations, viz. The Indus Entrepreneur (TiE) and the Silicon Valley Indian Professional Association (SIPA) began to actively build bridges to India by opening local chapters of these associations in India. Such networking also played some part in India's emergence as a major exporter of software programming and development skills (Saxenian, 2002).

Various ways used by skilled diasporas in the transmission of knowledge include the following (Abdelgafar *et al.*, 2004; Lucas, 2001; Zhenzhen *et al.*, 2004; Kapur, 2001; Newland, 2004):

- organising joint annual conferences/ seminars with institutions from country of origin;
- providing consultative services to the government of home country;
- providing technology and technical know-how through license agreements;
- assuming top managerial positions in companies/institutions based in home country;
- providing mentorship to start-up companies at their country of origin;
- providing venture capital/angel investments; and
- helping the development of diaspora business networks.

Saxenian (1999b) in his seminal study highlighted the role of this transnational community in the successful development of Taiwan's IT sector during the 1980s and 1990s. He credited this development, to a large extent, on the Asian-American engineers who could built the strong social and economic linkages between Silicon Valley (USA) and Hsinchu Park (Taiwan), with the active support from the Taiwanese government.

Kapur (2001) elaborated upon the policies and strategies adopted by some select countries such as India, Republic of Korea, Taiwan, China and Mexico, to establish and promote diaspora linkage with the home country. Though the strategies vary across these countries, it clearly highlighted the critical role of government in this endeavour.

Khadria (2003) has very well documented many instances of specific contributions of the Indian diaspora in the field of S&T in India in the areas such as IT, biotechnology, chemical sciences, high energy physics, meteorological sciences, materials sciences, and medical science.

Successful presence of diaspora also helps in building the reputation of the country of origin and trust among the foreign companies; which often leads them to establish their R&D centres outside their country. Kapur (2001) argued that the companies like Yahoo, HP and GE, opened their R&D centres in India largely because of the confidence gained by the presence of many Indians working in their USA offices.

Pandey *et al* (2004), while elaborating the important role of the Indian diaspora in the development of IT industry in India in 1990s, argued that by 2000s, they began to play a vital role in further developing the IT and BPO industry in India, either by starting their own companies in India or by investing in many Indian companies.

Nanda and Khanna (2009) based on their found that that the local Indian entrepreneurs who had previously lived outside India relied more on diaspora networks for business leads, markets and funding especially when their companies were based outside the software hubs.

Pande (2014) has very well articulated the symbiotic relationship between the Indian diaspora and the Indian IT industry, where both have reinforced each other's growth over a period of time. The Indian Diaspora brought in the gains in terms of enhanced skills, capital (human, social and financial); inward remittances, FDI inflows, creation of networks/markets and a high reputation of India; which helped the Indian IT industry a lot in leaping forward at the global arena. At the same time, the emerging Indian IT industry provided for a strong incentive for the mobility of skilled professionals with the sense of an opportunity to engage with their motherland. This sort of mutual beneficial arrangement helped the growth of Indian IT industry to an extent. Twelve out of top twenty IT firms in India have expatriate Indians as founders, co-founders, CEOs or Managing Directors (Pande, 2014).

Many foreign-based venture capitalists of Indian-origin or VC firms with senior Indian-origin managing partner have been actively funding many Indian companies and technology start-ups (Pandey *et al*, 2004). Some of the prominent venture firms are, viz. Westbridge Capital, Norwest Venture Partners, Greylock Partners, Accel Partners, Mayfield Fund, Insight Venture Partners, and Menlo Ventures (Karnik, 2015).

According to the recently released International Migrant Stock 2019 dataset by the UNDESA (2019), India has been ranked as the leading country of origin of international migrants with 17.5 million strong diaspora. According to the Economic Survey 2018 (MoF, 2018), "*there are more than 100,000 people with PhDs, who were born in India but are now working outside India (more than 91,000 in the USA alone). From 2003 to 2013, while the number of scientists and engineers residing in the USA rose from 21.6 million to 29 million, the number of immigrant scientists and engineers rose from 3.4 million to 5.3 million. Of this, the number from India increased from just above half million in 2003 to 950,000 in 2013*" (P.129). There have been efforts made to leverage this huge resource of highly skilled human capital for the national social and economic development.

The Report of the High Level Committee on the Indian Diaspora (MEA, 2001) had acknowledged that the Scientists and Technologists of Indian Origin (STIOs) have earned a name for themselves in the cutting edge fields of S&T across the world and made several recommendations to create new avenues to engage STIOs to enhance India's excellence in S&T.

Various mechanisms and schemes have been launched toward this endeavour. Specific government policies such as the provision of dual citizenship, recognition of Persons of Indian Origin (PIO), organisation of annual Pravasi Bharatiya Divas, Ramanujan Fellowship Scheme (SERB, 2019a), Ramalingaswami Re-entry Fellowship (DBT, 2019) and VAJRA scheme (SERB, 2019b), have aided in knowledge and human capital transfer by providing avenues to qualified Indian researchers residing in foreign countries to work in Indian institutes/universities for short-term or long-term basis. The prospects of attractive academic/corporate jobs in India, have also served as a pull factor to bring back some of the scientific diaspora (Sabharwal and Varma, 2016).

According to Basu (2019), over 500 applications have been received under the VAJRA (Visiting Advanced Joint Research) Faculty Scheme since 2017. The programme emphasises on bringing Non-

Resident Indians (NRI), Persons of Indian Origin (PIO) and Overseas Citizen of India (OCI) to public-funded academic and research institutions of India to undertake high quality collaborative research and teaching. According to the scheme, VAJRA Faculty may also be involved in technology development, start-ups, etc. At least 75 per cent of the selected VAJRA faculty in the last academic year consisted of professors of Indian origin. This implies that there is a keen interest among the Indian scientific diaspora to contribute to the teaching and research in India.

Leveraging scientific diaspora is a vital component in the domain of science diplomacy (Royal Society, 2010). Apart from fostering academic/ research engagements and opportunities, there is need to establish more effective mechanisms and spaces for interactions between Indian academics, researchers, business leaders and start-ups from abroad and within the country to identify projects and processes that can further the interests of the communities and contribute to the social and economic development of the country. As part of its foreign policy, a sub-policy on science diplomacy incorporating the need to engage more with the scientific diaspora can be envisaged by the government to provide the necessary policy support and guidance.

References

Abdelgafar, B., Thorsteinsdottir, H., Quach, U., Singer, P.A. and A.S. Daar. 2004. "The emergence of Egyptian biotechnology from generics". *Nature Biotechnology*. Vol. 22, Suppl. DC25–DC30.

Barre, Remi, Valeria Hernandez, Jean-Baptiste Meyer and Dominique Vinck (Eds.). 2003. *Scientific Diasporas. How can Developing Countries Benefit from their Expatriate Scientists and Engineers?*. Institute de Recherche pour le Développement. IRD Editions. Paris.

Basu, Mohana. 2019. 'Modi Govt claims Good response from Foreign Faculty to its Advanced Joint Research Plan'. *The Print*. 24 September.

Burns, William J. 2013. "The Potential of Science Diasporas". *Science and Diplomacy*. Vol. 2. No. 4. AAAS.

Cohen, Robin .1997. *Global Diasporas: An Introduction*. UCL Press. London.

DBT. 2019. "Ramalingaswami Re-entry Fellowship". Accessed on September 22. 2019 from http://dbtindia.gov.in/schemes-programmes/building-capacities/building-critical-mass-science-leaders/ramalingaswami-re

Kapur, Devesh. 2001. "Diasporas and Technology Transfer". *Journal of Human Development*. Vol. 2. No.2.

Karnik, M. 2015. "Here are the best (sort of) Indian venture capitalists in the world". Accessed on November 12. 2019 from https://qz.com/india/370484/here-are-the-best-indian-sort-of-venture-capitalists-in-the-world/

Khadria, Binod. 2003. *"Case-study of the Indian Scientific Diaspora"*. In Barré, Remi *et al*. (Eds.). *Scientific Diasporas. How can Developing Countries Benefit from their Expatriate Scientists and Engineers?*. Institute de Recherche pour le Développement. IRD Editions. Paris.

Kuznetsov, Yevgeny and C. Sabel. 2006. "Global Mobility of Talent from a Perspective of New Industrial Policy: Open Migration Chains and Diaspora Networks," *WIDER Working Paper Series* 144, World Institute for Development Economic Research (UNU-WIDER).

Lowell, B.L. and G. Gerova. 2004. "Diasporas and Economic Development: State of Knowledge". *World Bank Publications*. 1-35.

Lucas, R.E.B. 2001. *Diaspora and Development: Highly Skilled Migrants from East Asia*. World Bank. Washington, DC.

MEA. 2001. *Executive Summary*. The Report of the High Level Committee on the Indian Diaspora. Ministry of External Affairs. Government of India.

Meyer, J.B. and Brown, M. 1999. *Scientific Diasporas: A New Approach to the Brain Drain*. UNESCO-ICSU. Budapest.

Meyer, J-B., B.D., Charum, J., Gaillard, J., Granes, J., Leon, J., Montenegro, A., Morales, A., Murcia, C., Narvaez Berthelemot, N., Parrado, L.S. and Schlemmer, B. 1997. "Turning Brain Drain into Brain Gain: the Colombian experience of the Diaspora Option". *Science, Technology and Society*. Vol. 2, pp.286–315.

Meyer, Jean-Baptiste .2001. "Network Approach versus Brain Drain: Lessons from the Diaspora"; *International Migration*. Vol. 39. No. 5. Blackwell. Oxford. pp. 91-110.

Meyer, Jean-Baptiste and Jorge Charum .1995. "Is the Brain Drain Exhausted? Paradigm Lost and New perspectives". *Cahiers des Sciences Humaines*. 31 (4). 1003-1017.

MoF. 2018. *Economic Survey 2017-18*. Volume 1. Ministry of Finance. Government of India.

Nanda, R. and T. Khanna. 2009. "Diasporas and Domestic Entrepreneurs: Evidence from the Indian Software Industry". *HBS Working Paper*. 08-003. Harvard Business School.

Newland, K. 2004. *Beyond Remittances: the Role of Diaspora in Poverty Reduction in their Countries of Origin*. Migration Policy Institute. Washington, DC.

Pande, Amba. 2014. "The Role of Indian Diaspora in the Development of the Indian IT Industry". *Diaspora Studies*. 7 (2). 121-129.

Pandey, A., Aggarwal, A., Devane, R., and Y. Kuznetsov. 2004. *India's Transformation to Knowledge-based Economy: Evolving Role of the Indian Diaspora*. Evalueserve.

Royal Society. 2010. *New frontiers in Science Diplomacy.*

Sabharwal, M. and R. Varma. 2016. "Return Migration to India: Decision-Making among the Academic Engineers and Scientists". *International Migration*. 54 (4).

Saxenian, A. 1999a. *Silicon Valley's New Immigrant Entrepreneurs*. Public Policy Institute of California.

Saxenian, A. 1999b. "The Silicon Valley-Hsinchu Connection: Technical Communities and Industrial Upgrading". *Industrial and Corporate Change*. 10 (4). 893-920.

Saxenian, A. 2002. "Transnational Communities and the Evolution of Global Production Networks: The Cases of Taiwan, China and India". *Industry and Innovation*. 9:3. 183-202.

Seguin, B., State, L., Singer, P.A. and A.S. Daar. 2006. "Scientific Diasporas as an Option for Brain Drain: Re-circulating Knowledge for Development". *Int. J. Biotechnology.* Vol. 8. Nos. 1/2. 78–90.

SERB. 2019a. "Ramanujan Fellowship". Accessed on November 22, 2019 from http://serb.gov.in/rnf.php

SERB. 2019b. "Visiting Advanced Joint Research Faculty Scheme (VAJRA)". Accessed on September 08, 2019 from https://www.serbonline.in/SERB/vajra

Sharabati-Shahin, Mervat Hatem .2009. *The Role of Diaspora Entrepreneur in the Advancement of Science and Technology: Knowledge Economy Perspective.* In Advances in Technology, Education and Development. Wim Kouwenhoven (Ed.) InTech.

Sheffer, Gabriel (Ed.) .1986. *Diasporas in International Relations*. St Martin's Press. New York.

Tejada, Gabriela and Bolay, Jean-Claude (Eds.) .2010. *Scientific Diasporas as Development Partner: Skilled migrants from Colombia, India and South Africa in Switzerland: Empirical Evidence and Policy Responses*. Peter Lang Publishers. Bern.

Tejada, Gabriela. 2012. "Mobility, Knowledge and Cooperation: Scientific Diasporas as Agents of Development". *Migration and Development*, Vol. 10. No. 18. 59-92.

UNDESA. 2019. *International Migrant Stock 2019.* Department of Economic and Social Affairs. Population Division. United Nations.

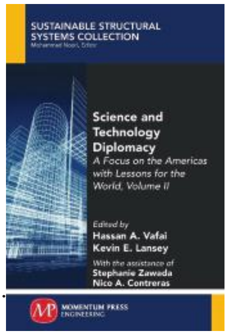
UNESCO .2010. *Science Report 2010*. UNESCO. Paris.

Zhenzhen, L., Jiuchun, Z., Ke, W., Thorsteinsdottir, H., Quach, U., Singer, P.A. and A.S. Daar. 2004. "Health biotechnology in China – reawakening of a giant". *Nature Biotechnology.* Vol. 22. DC13–DC18.

BOOK REVIEW

Science and Technology Diplomacy: A Focus on the Americas with Lessons for the World

Rajiv K. Mishra*



SUSTAINABLE STRUCTURAL
SYSTEMS COLLECTION
Mohammad Noori, Editor

Science and
Technology
Diplomacy
*A Focus on the Americas
with Lessons for the
World, Volume II*

Edited by
Hassan A. Vafai
Kevin E. Lansey
With the assistance of
Stephanie Zawada
Nico A. Contreras

MOMENTUM PRESS
ENGINEERING

This three volume book series is based on the conference proceedings on '*Science and Technology Diplomacy: A Focus on the Americas with Lessons for the World*', organised at University of Arizona. It is edited by Hassan A. Vafai, and Kevin E. Lansey, with the assistance of Stephaine Zawada and Nico A. Contreras. The context of organisation of the event in the University of Arizona was both in terms geographical and intellectual vantage point of connection with Latin America. Moreover, one of the key focuses of the conference was on science diplomacy on climate and water issues, for which University of Arizona has its global presence. The key discussion revolves around *"how and why scientific knowledge and policy is critical to effectively deal with the challenges and opportunities of the world"*. For this, the core of the discussion is the roles within science and technology diplomacy for addressing some pressing global issues. Some of the themes include nuclear energy, public health, sustainable development goals (SDGs), climate change and engineering sustainable solutions. Some of the eminent personalities of the field discussed the role of science diplomacy in addressing these issues. Beginning with Thomas Pickering's insights on science being the '*energizer of the world*', were the importance of science diplomacy and policy in dealing with Iran nuclear energy agreement initiated the chain of discussions. Being a former United States Ambassador to the United Nations, he was part of the Iran Nuclear Energy agreement diplomatic negotiations. His firsthand

---

* Researcher, Centre for Studies in Science Policy, School of Social Sciences, JNU, New Delhi

accounts of this crucial science based diplomatic negotiations were briefly reflected on the rapporteur scripts of his video presentation. Moreover, even though Pickering provided some insights on public health, Peter Agre's reflections on 'opportunity' through science diplomacy to solve global public health crises explicated the issue further, especially in war torn African regions. Certainly there is a need to understand the global and geographical context of solving larger problems as part of the sustainable development goals (SDGs). It is reflected in the presentations of David Pietz, E. William Colglazier and Nebojsa Nakincenovic on the role of science, technology and innovation diplomacy for achieving Sustainable Development Goals. To achieve them, the role played by international bodies like United Nations and governments, being crucial for internationalisation of science through events and forums on pressing concerns of climate change and sustainable future. In this regard, Lidia Brito Director of UNESCO Regional Office for Science for Latin America and Caribbean and Richard Roehrl's presentations showcased the importance of United Nations and sub-bodies. More specifically, the roles of UNESCO in internationalisation of science include creating forums of communications, and platforms for discussions on SDGs, environmental ecosystem and the approach on climate change. Part of which was a key approach on use of sustainable and people-environment centric engineering.

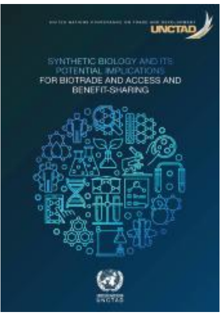
In this direction, people, politics and country specific science, technology and innovation policy and diplomacy approach from Latin American countries is shown. First being the case of Costa Rica's model of national planning for science and technology with R&D as the core of the economic growth. Costa Rica's story on building science capacity and its impact in science diplomacy connections with United States highlights the importance of policy and planning for science and technology for working sustainable solutions for future. Costa Rica is a unique country in the world which has abolished its standing army and has completely focused upon use of science and technology for national development. Furthermore, as part of this it has invested on R&D and channelised resources to engineer renewable solutions to climate change. With constant science communication and diplomacy with United States, it has created a special position for itself in the Latin American space. Contrary to this, the case of Mexico has the focus on the need for building science diplomacy capacity, impediments to R&D funding and slowly growing international collaborations in science and technology. More so, the role of politics, ideology and historical factors in building trust and partnership based science and technology collaborations was presented in the case of science diplomatic relations between United States and Cuba. Diplomatic relations between United States and Cuba began its rough patch from early 1960s. Having differing political ideologies, United States and Cuba did not share any diplomatic relations in the science until 1980 when Cuban Academy of Sciences revived its link with Smithsonian Institute through a memorandum of understanding. This further developed into North American-Cuban Scientific Exchange (NACSEX) developing throughout 1980s. Amidst the troubled past, the science diplomatic relations between these two countries grew stronger, and by late 2000s through a new relation on exchange of scientist and scholars was being facilitated. The volumes reflect on the importance of facilitating the connection and communication between scientist and scientific community around the world as an example from Americas; a case of building science diplomacy in a multi polar contemporary world, with conflicting ideologies of governance and development. This is reflected with presentations mentioning about pressing challenges of the world in terms of nuclear crisis and disarmament with the case of countries like Iran, North Korea and also about cold war tussles between United States and former Soviet Union.

This becomes more important as the subtitle focuses on the *lessons* for the world. Even though the presentations have highlighted historical context and evolution of science and technology diplomacy, clear assimilation and synthesis of these ideas have not been done by the authors. Moreover, cases from Latin America show examples of third world developing countries having the need and requirement of science and technology for economic growth and development. The discussions on scientific communication, exchange of scientific communities and building of regional networks of collaboration do provide nuances of science diplomacy, but aspects of technology transfer and capacity building of developing countries were not reflected in a broader manner.

The edited volume can have wider audience of readership, be it researchers, policy makers, science diplomats, technocrats, bureaucrats and students who might want to develop interest in science and technology diplomacy. Many of the Q&As after the presentations on science diplomacy asked about the point of entry to research and study science diplomacy. On which some eminent personalities of the field pointed on being good at the *science and technology* profession one is involved in, and then entering the field of science diplomacy, rather a very *science* centric approach. However, the point which is being missed in the replies and also by authors is to analyse from science and society perspective, an approach trying to understand science diplomacy with historical, social and cultural underpinnings; as Jeffrey Goldberg highlighted in his presentation with a note to engineering students on the importance of being good at the technical matter but more than that being good at *understanding* people.

REPORT

Synthetic Biology, Biotrade and Access and Benefit-Sharing



Krishna Ravi Srinivas*

K. RAVI SRINIVAS

The report from UNCTAD titled, 'Synthetic Biology and Its Potential Implications for Biotrade and Access and Benefit-Sharing'[1],deals with an issue that is important for developing nations and LDCs with rich genetic diversity and have implemented Access and Benefit Sharing (ABS) mechanisms. While Synthetic Biology or SynBio is an emerging technology, most of the genetic resources, particularly the plant biodiversity are considered as natural resources which have been modified, partially or otherwise by humans. Although ABS regimes are applicable for genetic resources covered by them, developments in Synthetic Biology have implications for all biodiversity, irrespective of ABS regulations.

Synthetic Biology has been defined as *"a further development and new dimension of modern biotechnology that combines science, technology and engineering to facilitate and accelerate the understanding, design, redesign, manufacture and/or modification of genetic materials, living organisms and biological systems"* by the Convention on Biodiversity in the 13th Conference of Parties. In the literature there are references to potential positive contributions of Synthetic Biology to sustainable development and also recognising the issues raised by a novel technology and on regulating it. The CBD's engagement with CBD started few years ago and an Adhoc Technical Experts Group was formed. Documents have been produced as part of the processes at CBD and greater clarity is expected to be available

---

* Consultant, RIS, New Delhi.

after the COP-MOP to be held in 2020. The implications of Synthetic Biology for conservation, sustainable use of biodiversity, particularly the ecosystems are being investigated. As Synthetic Biology in conjunction with Digital Sequence Information (DSI) can be used to develop novel organisms, the implications of this development are also examined in literature.

There are three major approaches in Synthetic Biology, viz. BioBrick engineering, Genome Engineering, and Metabolic Engineering. This report focuses on the latter two as they are more relevant for the study. In BioTrade and ABS access to, and use of and trade of natural products and/or natural resources is the core issue. But due to technological developments, substitutes can be developed for products derived from nature and this can be done in many ways. Synthetic Biology has taken this to the next level. In addition to this by combining developments in Synthetic Biology with tools in Artificial Intelligence and bioinformatics, processes for utilisation can be accelerated and new products that could compete with BioTrade products can be produced and developed. It is true that these developments may result in better and/or more utilisation of genetic resources, particularly in Synthetic Biology research and development. But these can result In reduced use of/ demand for ABS or BioTrade products if only DSI and DNA Synthesis are utilized. It is worth pointing out that in the debates on DSI a common concern is whether wider adoption of DSI will result in lesser demand for access to genetic resources or enable by passing, fully or partially, the ABS norms, if information can be successfully used to reduce use of genetic e-resources. The modern biosynthesis process is more effective in terms of time and cost when compared with traditional synthesis. Although chemically synthesised compounds that were produced were identical in terms of compound structure and chemical properties they were often labelled as or distinguished as 'artificial' or distinctly marked as 'Synthetic'. biosynthesis and chemical synthesis can be combined with and are not necessarily exclusive. But the issue of labelling in case of products from biosynthesis is more complex because whether they should be treated and regulated as Genetically Modified Organisms (GMOs) or not, is a key issue. Coupled with this is the issue of labelling. The regulatory norms are not uniform across countries. So are the labelling norms.

As this report points out citing the example of Stevia, the issues are not hypothetical but very real. For example, purified Stevia glycosides are used and classified, primarily as low-calorie, high intensity sweeteners. Many companies have developed Synthetic Biology pathways for producing steviol glycosides. The report states:

“Due to the ability of SynBio firms to market their stevia glycoside products as natural, “products containing such additives could be marketed in a way that consumers would think the product is sweetened from extracts of real stevia leaves” (P11).

It points out further that as of now stevia leaf is the main resource and their prices are lower than that of HFCS (High Fructose Corn Syrup) which is used as a sweetener, extensively in food products. More over their purity can be as much as

98 per cent and scale of production is not a limitation. But the report also points out that production of Synthetic Biology can be significant for farmers of sweet worm wood as the one developed using Synthetic Biology can result in reduction of market or elimination of natural product. In fact, while some compounds have been commercialized many are in different stages of development.

Another key issue is that of food labelling, and voluntary certification. The report points out that in European Union there is no harmonised definition for 'natural' in personal care and cosmetics industry. The arrival of Synthetic Biology products can exacerbate the confusion as whether they meet the 'truthfulness' criteria is not clear. Similarly, there are new issues on Non-GMO certification and voluntary certification. But the question is demand for and supply of how many ingredients will be impacted by developments in Synthetic Biology. It is huge according to one data base which lists about 350 compounds/ingredients (SYNBIOWATCH, 2019).

However, the catch is that this data base considers Synthetic Biology products as GM 2.0 and the UNCTAD report does not take this stand. This takes us to the key point in debates on Synthetic Biology. While NGOs like Friends of Earth and ETC Group argue that they should be treated like GMOs, the opinion is divided. Whether they have to be treated as a separate category and regulated so is an important question. Should they be regulated on the basis of product and not on the basis of process(es) of producing them? The opinion is divided because at the core of this debate is the product vs. process approach in regulation of GMOs. While the USA adopts the first approach, EU adopts the second approach. But irrespective of the approach adopted this has implication for labelling and trade. In case of Synthetic Biology there is no move for a global regulation as of now.

The UNCTAD report cautions about the impacts and has come up with recommendations as below:

Recommendations

- Provider countries may want to consider conducting socio-economic impact assessments for nationally important value chains when a synthetic biology alternative appears on the market in order to determine its potential impact on jobs and livelihoods.
- Where there is a significant risk to jobs and livelihoods, it may be appropriate for provider countries to assist producers to transition to different BioTrade value chains to prevent the impact on livelihoods and biodiversity that would result from a shift away from the existing value chain.
- Consider the need and potential implications of defining "natural product" or "goods and services derived from native biodiversity" in the context of BioTrade. This would be a challenging undertaking and it may be preferable to leave this to national decision makers and standard-setting bodies.
- Consider addressing how the BioTrade Principles and Criteria address specific types of technologies or products falling under the broad scope of synthetic biology. This may include the question of whether a broad approach is preferable, or whether a case-by-case approach based on sustainability criteria is appropriate.

- Consider whether a case-by-case approach to the use of products fabricated with genetically modified/ synthetic biology organisms in BioTrade products is appropriate where they are demonstrably more sustainable than their naturally derived counterparts (e.g. where there is a trade ban under CITES, listed on IUCN Red List).
- If a case-by-case approach is adopted, consider the development of a traceability mechanism for ingredients that are derived from CITES-listed species to prove that they have been fabricated using SynBio processes and not directly from these species." (P 29)

It can be inferred that these recommendations are pragmatic and as they neither take extreme positions on impacts, nor create an impression that Synthetic Biology products will create only adverse impact for BioTrade and ABS, they deserve serious consideration.

In the late 1980s and early to mid-1990s, Rural Fund Advancement International (RAFI, which renamed itself as ETC Group) published a series of studies that developments in biotechnology could harm interests of developing countries; products from biotechnology could become substitutes or displace natural products like vanilla, and, rubber. But nothing of that sort happened. Whether it will be different this time in the case of Synthetic Biology is yet to be known. But few points can be highlighted. One is that today, it is not just Synthetic Biology but its combination with bioinformatics, that can make a huge difference. Two, the developments on DSI have implications for not just ABS but also for sustainable use and conservation of plant genetic resources.

This issue of impacts of Synthetic Biology for BioTrade and ABS or impacts of DSI highlights how developments in S&T can have huge implications of sharing of natural resources particularly genetic resources. How countries that are providers of Genetic Resources should respond to these developments? Should they join hands and take a common position even as some among them are also investing in Synthetic Biology or at least doing R&D in Synthetic Biology? There are no easy answers but a thorough understanding of the issues and questions may help in developing responses without getting influenced by 'change is inevitable, adjust or perish' approach, or, by doomsday scenarios. This report will be very useful in understanding and responding to the issues and questions.

Endnote

[1] The Report can be accessed at https://unctad.org/en/PublicationsLibrary/ditctedinf2019d12_en.pdf.

Science Diplomacy

IAEA and FAO launch Plant Mutation Breeding Network

Genetic variation lays the foundation of evolution and breeding. Scientists have learned over the years, to create and utilise mutation, through different approaches and techniques. Realising the limitation of transgenic plant research, mutation breeding grown in a big way, as it does not pose any ethical concerns, related to human health and sustainability. Presently, different varieties of rice, wheat, cotton, sugarcane, potato, corn and soybean have been bred successfully by mutation breeding and are being used for human consumption in many countries. These exhibit superior yielding and abiotic stress tolerant traits, which are geographically relevant. The technique has exponential potential and can be harnessed through effective knowledge sharing and capacity building. However, mutation breeding has also some limitations, like beneficial mutant frequency is low and it is difficult to control the direction and nature of variation. Hence, improving the mutagenic effectiveness, rapid identification and screening of mutants and exploring the directed mutagenesis approaches are some of the important challenges in this area of research.

Keeping such aspects into consideration, the International Atomic Energy Agency (IAEA) and the Food and Agriculture Organization of the United Nations (FAO) have launched the Plant Mutation Breeding Network (MBN) which aims to improve efficiencies in crop mutation breeding across the region. In addition to strengthening their national capacities in plant mutation breeding and associated biotechnologies, participating governments are expected to exchange national germplasms. Presently, the constitution of MBN comprises of experts from Bangladesh, China, India, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam. The platform will facilitate multi-environment field trials in different countries to assess the productivity of crops and the suitable ecosystem for their cultivation. New speed breeding technologies are expected to be shared within the region through workshops, scientific visits, knowledge exchange platforms and fellowships. The network will be establishing platforms to enable the exchange of the technology and known genes of interest.

Source: https://www.iaea.org/newscenter/news/accelerating-growth-iaea-launches-plant-mutation-breeding-network-for-asia-and-the-pacific

Policy draft on Scientific Social Responsibility (SSR)

Science has brought in understanding of the natural and physical worlds, with limited recognition to the social impact it encapsulates. Realising this gap, the science-society connect has been advocated and realised through policy interventions at national, regional and global levels. In today's era, science and technology has deeply permeated across different facets of the society, Science, Technology and Innovation (STI) are at the forefront to cater to development priorities and societal good, particularly to solve problems related to healthcare, agriculture, energy and ecological environment. There is a realisation amid government authorities promoting S&T policy, that the gap between science-society shall be reduced by assessing the social value of scientific advancements, through implementing STI policies that are inclusive, demand-driven and have emanated from science-society linkages. Countries like the US, UK, Japan and China have adopted this model.

Taking forward the on-going efforts to bring science and society closer to each other, the Department of Science and Technology, Government of India, has released the policy draft on Scientific Social Responsibility (SSR). The policy proposes to enhance linkages between science and society, suggests a mechanism for access to scientific knowledge and proposes that scientists/knowledge workers commit to spend at least 10 days in SSR related activities. The draft also indicates the incentives that have to be provided and support that would be needed. The draft defines SSR as "the ethical obligation of knowledge workers in all fields of science and technology to voluntarily contribute their knowledge and resources to the widest spectrum of stakeholders in society, in a spirit of service and conscious reciprocity". The policy draft can be accessed at: https://dst.gov.in/sites/default/files/Final%20SSR%20Policy%20Draft_2019.09.09_0.pdf

Research and Development

IIT Madras Develops 'GraspMan' – A Robot-equivalent of Human Hand

Robotics and machine learning have opened up a different arena of technological innovations and scientific breakthroughs. With the advent of Artificial Intelligence (AI), the digital revolution has grown manifolds, drawing from the blend of computer science, cognitive psychology and engineering. Various countries are encouraging applications of AI and its deployment in across different sectors. However, challenges are arising in developing technological capabilities in this domain and harnessing them to achieve development priorities, through critical reflections on risks and regulations. In the Indian context, artificial intelligence regulation is at a nascent stage, whereas technological innovations are taking place in the public as well as private sectors. Moreover, the universities are also coming forward in developing technologies, which are cost effective and possess societal relevance.

One such endeavour is undertaken by the researchers at the Indian Institute of Technology, Madras (IIT-Madras); they have developed a robot with grasping and locomotion abilities like a human hand. The human hand robot can be used for industrial purposes and in search and rescue operations. The multimodal robotic system named 'GraspMan' comprises a pair of graspers (machine-equivalent of human hands) that enable it to conform to the geometry of an object being grasped. The motivation behind this research is to make a robot, with minimum design for specific tasks, capable of navigating and manipulating across different environments. The combination of locomotion and manipulation gives it the ability to hold an object and walk, armswinging like baboons (brachiation). In industrial use, it can climb on pipes, hold them and assemble. Besides, it can aid machines used in search-and-rescue operations and locomotory applications.

Source: https://www.thehindubusinessline.com/news/science/iit-madras-researchers-develop-industrial-and-field-robot-graspman/article29090999.ece

Technology developed to diagnose early spread of Cancer

A group of Pune-based scientists have developed a 'liquid biopsy' technology to detect early spread of cancer and claim it is the fastest in the world. The 'OncoDiscover' technology has been approved by the Central Drugs Standard Control Organisation, the national regulatory body for pharmaceuticals and medical devices. This technology is expected to revolutionise the early diagnosis and management of cancer patients in India, and has been launched by Actorius Innovations and Research, a Pune-based start-up. OncoDiscover is the first-of-its-kind to be licensed to manufacture for sale under the new Medical Device Guidelines, 2017, for early detection of metastasis in epithelial origin cancers. The start-up has been funded for high-risk innovations by the Biotechnology Industry Research Assistance Council, an industry support wing of the Department of Biotechnology. A team of scientists worked to crack the technological challenges in detecting circulating tumor cells (CTCs) from lung, breast, colorectal, head and neck cancers. While a similar CTC detection test approved by the US FDA costs USD 1,000 and is unaffordable for most Indians, OncoDiscover comes at a fraction of that cost. The test is now available in Pune at the OncoDiscover Liquid Biopsy Technology lab for cancer patients in India. The new technology has been patented internationally and validated via multiple clinical trials. To know more about the research in this regard, please visit https://ascopubs.org/doi/abs/10.1200/JCO.2019.37.15_suppl.e14516

Source: https://health.economictimes.indiatimes.com/news/diagnostics/pune-scientists-develop-tech-to-detect-early-spread-of-cancer/70739264

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).

For soft-copy of SDR, editorial information, contributions, feedback and comments, email: **science.diplomacy@ris.org.in** and **dgoffice@ris.org.in**

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.

Invitation to Join Mailing List

Interested readers, who wish to avail the soft-copy version of Science Diplomacy Review (SDR), may kindly send details, along with institutional affiliation to science.diplomacy@ris.org.in. Also specify if hard-copy is desired.

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.

Published by:

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

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

Follow us on:

www.facebook.com/risindia twitter @RIS_NewDelhi YouTube www.youtube.com/RISNewDelhi

CONTENTS *(continued from outside front cover)*

Forum for Indian
Science Diplomacy

Follow us on:

/FISD-Forum-for-Indian-Science-Diplomacy

@fisd19

/RISNewDelhi