SCIENCE DIPLOMACY REVIEW

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EDITORIAL

This third issue of *Science Diplomacy Review (SDR)* comes out at a time when the global community is set to review progress towards achieving the SDGs 2030 and give it a stronger thrust. The recent HLPF meetings in New York and the 2019 SD Report have highlighted the slow progress towards achieving the SDGs. Science Diplomacy may be able to play a critical role by bringing to bear science, technology and innovation to tackle the challenges posed by the SDGs 2030, while also providing objective evidence based analysis of the challenges. The Bonn UNFCCC meetings have ended on a discordant note on tackling climate change, with some countries refusing to welcome the IPCC report on 1.5 degree limits. These developments have attracted increasing public concern and activism. Science Diplomacy can help to bridge the divides among countries on climate change. The fossil fuels based industry needs to transition away from energy production which contributes towards global warming, towards feeding the chemical industry. International scientific collaboration in alternative uses of fossil fuels could be of help.

This issue presents an interesting range of articles. Lisette Pérez Ojeda (Cuba) presents an article on the evolution of common regulatory framework for medicines and devices in Latin America and the Caribbean region. Such a harmonized framework offers a win-win opportunity for the participating countries. Interestingly in this particular case the six countries include the USA and Cuba, which have serious political differences, but the regulatory and technical agencies seem to work well together. This is an interesting example of "science for diplomacy" at work. Mostafa Safdari Ranjbar and Mahdi Elyasi (Iran) present an interesting analytical article on Iran's Science Diplomacy. It proposes a comprehensive model of science diplomacy based on its four dimensions and related questions — actors (who?), aims (why?), aspects(what?), and actions(how?), setting out a different analytical framework to the classic three pillared one evolved by the Royal Society and the AAAS (2010).

The Perspective section discusses global governance of emerging biotechnologies and role of science diplomacy, in the light of an array of ethical and global issues, emerging from technological breakthroughs. A book review on The Collaborative Era in Science: Governing the Network (by Professor Caroline Wagner), reflects on governance of global knowledge networks, which hold relevance for scientific collaborations in the global South. The review of summary for policymakers of the Global Assessment Report 2019 released on 6 May 2019 after the meeting of the 132 member Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), brings out the growing threats of extinction of species in number and diversity. We conclude the issue with some highlights from the fortnightly Science Diplomacy Alerts.

This issue also marks the completion of one year of the RIS work programme on Science Diplomacy, supported by Department of S&T, Government of India. The programme, inter alia, has published a number of case studies on Science Diplomacy, issued fortnightly email alerts, organized meetings and consultations, and also conducted some training activities in science diplomacy. We propose to take these further in the year ahead with a range of activities, publications and closer engagement with Indian diaspora, particularly the scientists and technocrats.

ARTICLE

Science Diplomacy for Strengthening Medicine Regulatory Systems in The Americas: Emerging Regional Experience

Lisette Pérez Ojeda*

LISETTE PÉREZ OJEDA

Introduction

Science diplomacy is the use of scientific collaborations among nations to address common problems facing 21st century humanity and in building constructive international partnerships (Fedoroff, 2009).This applies also in the field of health regulations and regulatory science. Good Health and Well Being is Goal 3 of the Sustainable Development Goals. Its aim is to achieve universal health coverage and provide access to safe and affordable medicines and vaccines to all (United Nations, 2015a). Supporting research and development for vaccines is an essential part of this process as well (United Nations, 2015b). Regulatory systems play a key role in assuring quality, safety and efficacy of medical products. An effective regulatory system is an essential component of the health system, and it contributes to desired public health outcomes and innovation. National Regulatory Authorities (NRAs) are government entities responsible for ensuring safety, efficacy and quality of medicines; and they play a vital role in the health- care system by providing regulatory oversight of all medical products.

Since many decades, a growing number of networks and initiatives have been developed to strengthen medicines regulatory systems. The region of the Americas has developed an initiative to strengthen

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health regulatory systems through an evaluation- and- certification process that allows appointment of Regional Reference Regulatory Authorities of medicines and biological products (NRArs). NRArs work jointly through cooperation mechanism on capacity- building in other countries of the region; allowing them to strengthen their regulatory systems and act as a group with consensual positions in different international forums (Ojeda, 2016).

Strengthening Regulatory Systems in the Americas

National Regulatory Authorities play a vital role in the health- care system by providing regulatory oversight of all medical products such as medicines, vaccines, blood products, traditional or herbal medicines and medical devices. They perform their mandate based on a legal framework along with a set of recommended regulatory functions that span the medical product life-cycle, including clinical trial oversight, marketing authorization and registration, licensing and inspection of premises, market surveillance and enforcement activities when required.

The Americas is a region of deep asymmetries where inequalities to access have persisted in poor and vulnerable populations, and there still exists fragmentation and segmentation in the system, which should guarantee access to health technologies. In the case of national regulatory authorities, large difference in structure and autonomy of the regulatory bodies, financing systems and their regulatory capacity are abridged to ensure effective compliance with their functions (Ojeda, 2016). In the last two decades, a group of global and regional initiatives have been developed for strengthening NRAs' capacities, based on the population's right to access to quality medicines commensurate with science and technology advances. One of the initiatives is the evaluation and certification of the Regional Reference Regulatory Authorities' process in the Americas.

In 2006, a group of five regulatory authorities from Latin America (Argentina, Brazil, Chile, Cuba and Mexico) had met in Oaxaca, Mexico, with a proposal to build a common agenda to consolidate mutual trust in regulatory matters for the economic well-being and public health of inhabitants of the region.[1] That led to the proposal of an NRA evaluation process as the regional mechanism of certification of drugs regulatory authorities, focusing on evaluation of their performance in fulfillment of their functions, and also for serving as the capacity- building mechanism in the regulation of medicinal products' field. The evaluation process concludes with the rating of the authority assessed, according to its results in one of the four levels. A Regional Reference Authority reaches level IV—this describes an authority that is competent and efficient in fulfilling functions recommended by PAHO/WHO to ensure efficacy, safety and quality of medicines. The Pan American Health Organization (PAHO) acts as the facilitator of the process leading to evaluation and giving certification to the Regional Reference Regulatory Authority for medicinal products and biologists to those very NRAs which reach level IV.

To- date, 8 National Regulatory Authorities have been recognized by PAHO/WHO as National Regulatory Authorities of Regional Reference—

Argentina's National Administration of Drugs, Food and Medical Technology (ANMAT);Brazil's National Health Surveillance Agency (ANVISA);the Center for State Control of Drug and Medical Devices of Cuba (CECMED);the National Institute of Food and Drug Monitory of Colombia (INVIMA);the Federal Commission for Protection against Sanitary Risks of the United Mexican States (COFEPRlS);Canada's Health Canada, US Food and Drug Administration and Chile's Institute of Public Health (PAHOc, 2018)

A significant milestone was the discussion of this initiative at the 50th PAHO Directing Council meeting, in September 2010, and the approval of Resolution CD50. R9: "Strengthening National Regulatory Authorities for Medicines and Biologicals". In this resolution, PAHO Member States were urged to strengthen and evaluate their regulatory capabilities with respect to the functions characteristic of the regulatory and oversight agency for medicines and biologicals through examination of the performance of their essential functions; to use the results of the qualification activity and the designation of the regulatory authorities of regional reference to strengthen their performance in terms of steering role of the health authority; and to support national regulatory authorities so that they can benefit from the processes and information from the national regulatory authorities of reference (PAHO, 2010)

The regional reference authorities work as a network; which together with PAHO are committed to support efforts to strengthen other regulatory agencies, based on their own experience by promoting exchange and cooperation among countries and by actively participating in regulatory harmonization efforts within the framework of the Pan American Network for Drug Regulatory Harmonization (PANDRH). Considering this, they develop a wide range of cooperation activities for capacity -building in other NRAs. From 2010 till-date, more than 30 courses have been carried out in different countries of the region along with bilateral consultancies and internships in the ARNr[2]. They also lead different regional projects on pharmaceutical regulation approved by PANDRH (PAHO, 2016).

These reference authorities are also working in building trust among themselves while sharing information on their best practices and in exchanging technical information to achieve mutual recognition of their regulatory decisions to speed-up drugs' approval processes allowing their better access. Regulatory collaboration through inter-agency work and data-sharing help to strengthen the regulatory capacity of all partners by promoting sustainable exchange of technical knowledge. Some bilateral agreements have been established to highlight inspection of final report exchange, considering large number of pharmaceutical companies, and the cost of *in situ* inspections, to establish mutual recognition of Good Manufacturing Practices Compliance.

Regional Reference Authorities in Multilateral Forums

In 2011, a group of ARNr was created—this group carries out two annual meetings; in the first semester it reviews the results of the work of the previous year and defines strategies and working plan for the new year[3] and in the second semester, a meeting with PAHO is held to evaluate progress of their joint work to strengthen regulatory systems in the region. The following section highlights the regional level initiatives:

The Regional Working Group on Medical Device Regulation: Established during the "1st Regional Meeting of the Regulatory Authorities for the Strengthening of Regulatory Capacity on Medical Devices in the Americas Region" held in La Habana, Cuba. It currently comprises16 NRAs; countries joined the Working Group voluntarily with the commitment to advance towards strengthening the Regulatory Capacity on Medical Devices through Regional exchange of information, joint projects, and training strategies towards the harmonization of regulatory requirements. This group is led by CECMED, the Cuban NRA (PAHO, 2018b):

Specialist from regional reference authorities are a collection of experts in NRA acting as PAHO advisory experts of the system for evaluation of national reference regulatory authorities; 26 ARNs have so far been evaluated.

Center for the State Control of Drugs and Medical Devices (CECMED) is working with PAHO and the Ministry of Health to strengthen the Nicaraguan National Regulatory Authority of Drugs as part of the technology transfer project for production of biologicals and immuno-biologicals between the governments of Russia and Nicaragua (PAHO,2018a)

The regional reference NRA group is coordinated by one of its members for a period of two years. In the meetings different international forums and meetings that take place during the year, most current topics and initiatives, criteria, concerns and position are discussed. After the discussion process they try to adopt joint position responding to regional concerns.

These actions are of particular importance during the international consultation process on the strengthening of the regulatory systems developed by WHO since October 2014 aimed at reaching a Global Benchmarking Tool (GBT) for evaluation of national regulatory system of medical products. The World Health Organization began assessing regulatory systems in 1997 using a set of indicators, designed to evaluate regulatory programmes for vaccines. Since that time, a number of tools and revisions were introduced. In 2014, work started on the development of a unified tool for evaluation of medicines and vaccines regulatory programmes following a mapping of existing tools in use within and external to WHO (WHO, 2018). For this, tools already applied by the organization, the tool used by the Pan American Health Organization for the evaluation and designation of Regional Reference Authorities, the standards established by the ISO standards, among others, were taken into account. The final objective was to have only one tool that replaces all tools previously used by WHO, representing the first truly 'global' tool for benchmarking regulatory systems.

Recently, WHO has published a new document (Revision VI) that has taken into consideration inputs received from two international consultations with Member States in 2015, a public consultation in early 2018 and a series of meetings involving experts from regulatory authorities from different parts of the world. The work of the Americas region, (represented by PAHO), was significant, particularly as the region that already had a tool and an evaluation process with 8 years of experience. This last document contains a large part of recommendations and criteria, made by the NRAs and has incorporated indicators and measures criteria of the evaluation tool used in the process developed in the Americas. The document would be used to evaluate and publicly designate WHO-listed authorities (WLAs), which have objectively been documented to perform at high maturity levels in 2019.

Conclusion

The process of evaluation and certification of Regional Reference National Regulatory Authorities in the Americas completes 9 years of establishment in 2019. During these years, the initiative has succeeded in building capacities in the drug regulatory agency in the region strengthening their medicines regulatory systems,. An example is the process of strengthening the Nicaraguan National Drug Regulatory Authority as part of the technology transfer project for the production of biological and inmuno-biologicals, implemented by the governments of Russia and Nicaragua and the process of development of regional ecosystems, to evaluate the regulatory capacity on medical devices.

The joint work of the regional reference authorities can be an example of the real implementation of science diplomacy based on the international collaboration of the authorities involved; showing their engagement in value- based international partnerships. This alliance adds values to national medicines programmes and other Ministries of Health missions. The development of joint capacity-building programmes enables taking advantage of the strengths of each member of the group of authorities for the benefit of their regional counterparts while sharing responsibilities and expenditures with maximized results to assure safety, efficacy and quality of medicines. Effective regulatory systems are an essential component of health systems and contribute to desired public health outcomes.

Endnotes

1 The meeting reports and commitment of the meetings between the regulatory authorities are not always public domain, they are working documents between them. For further information are available presentation of Dr Jose Pena Ruz p.e https://www.redeami.net/docs/docs/encuentros/ix_encuentro/7.1-Proceso_evaluacion_OPS-Jose_Pena.pdf

2 Capacity building activities could be found on each National Regulatory web site.

3 Press release and information on Regional Reference NRA annual meeting are available on the RNA websites that have hosted the meetings like CECMED, ANMAT, COFREPRIS, INVIMA, HEALTH CANADA AND CHILE ISP.

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ARTICLE

Science Diplomacy in Iran: Strategies and Policy Alternatives in the Making

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MAHDI ELYASI

Introduction

Science, technology and international affairs are acknowledged to be pervasively influencing one another. It goes without notice that globalisation has enhanced and considerably extended the importance of science and technology (S&T) in international relations (IR) beyond their traditional domains. National policy-making, for instance, can no longer ignore S&T developments and activities abroad, especially of rival countries. S&T issues underpin many concurrent global challenges and scientific collaboration clearly bears upon the social capital and trust-building needed to nourish civil relations between different and adversarial countries or cultures (Flink and Schreiterer, 2010).

'Science Diplomacy' is a relatively new term, and it reflects the fusion of two previously distinct elements: science and diplomacy. Science is an evidence-based form of knowledge acquisition, and Diplomacy is a non-violent approach to the management of international relations; characterized by dialogue, negotiation and compromise. Science diplomacy, therefore, is the process by which states represent themselves and their interests in the international arena in the areas of knowledge acquired by scientific method. It is increasingly critical in addressing many of the urgent challenges, such as management

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of global commons, faltering public health systems, and threat of collapsing ecosystems (Turekian *et al.,* 2014).

Direct relationship of science diplomacy with national interests and objectives distinguishes it from other forms of international scientific co-operations, which are sometimes oriented commercially and often are without direct state participation. Thus, in a way, international science cooperation and science diplomacy are overlapping endeavours— they are related, yet analytically separate. International science cooperation is mainly concerned with the advancement of scientific discovery; while the central purpose of science diplomacy is often to use science to promote a state's foreign policy goals or inter-state interests. In other words, international science cooperation tends to be driven by individuals and groups, and science diplomacy, while may be derived from the efforts of individuals, often involves a state-led initiative in the area of scientific collaboration (Turekian *et al.,* 2014).

Governments are well aware that S&T cuts -across national politics and can be engaged to tackle and hopefully solve global problems. However, the degree to which their international S&T policy is guided by one or the other strand of reasoning, by offensive or defensive objectives or by a blend of all these varies considerably. Also, a great variety of approaches, in goals and in means, suggest it to be futile to look for a one-size-fits-all model to deal with international S&T and science diplomacy. Instead, different institutional settings and political trajectories, interests and governance modes entail different approaches, which are still difficult to separate clearly (Flink and Schreiterer, 2010).

In spite of the widespread popularity of science and technology diplomacy in recent years, it seems that there is no common understanding of this interdisciplinary concept. Naturally, understanding a concept and its constituent dimensions is essential for conducting research, developing theories and making decisions and policies (Norouzi *et al.,* 2018). There is not plenty of literature on science diplomacy, and also it is relatively difficult to find some earlier works proposing a holistic view of science diplomacy. Some of them had focused on goals and objectives (Nye, 1990; Flink and Schreiterer, 2010), while others had highlighted initiatives and activities (Leach, 2015; Gluckman *et al.,* 2017).

This paper aims at proposing a comprehensive model about science diplomacy consisting of four key components — aspects, aims, actions and actors— through review of current literature and body of knowledge of science diplomacy. These components refer to what, why, how and who regarding science diplomacy. And then this paper intends to shed light on Iran's science diplomacy regarding these four components. The remainder of the paper is organized as follows— in section 2 the proposed model introduced and explained; section 3 gives some evidences and examples about Iran's science diplomacy, and section 4 includes summary and concluding remarks.

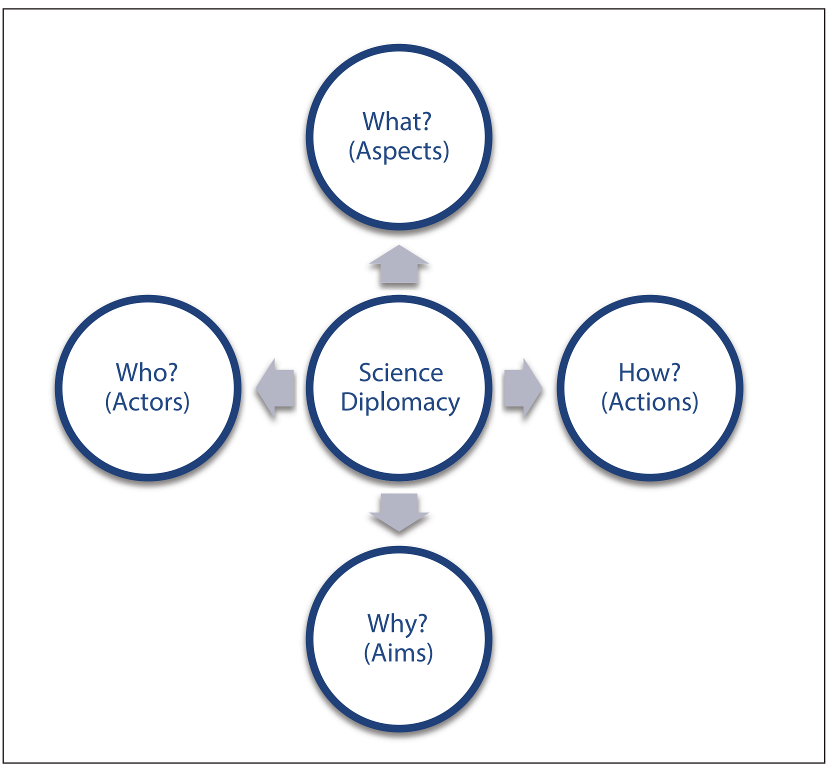
Ideas and Concepts in Science Diplomacy

There are two shortcomings in science diplomacy literature. First, since science diplomacy body of knowledge is very thin, there are few previous studies as articles and books in this area in comparison to other areas, such as science, technology and innovation policy (STIP). Second, most of the existing works have mostly focused on some components of science diplomacy like science diplomacy goals and objectives (Nye, 1990; Flink and Schreiterer, 2010) or initiatives and activities (Leach, 2015; Gluckman *et al.*, 2017) and none have developed and proposed a comprehensive model. To address these shortcomings, this paper proposes a big picture or holistic view of science diplomacy consisting of all four components through review of the current literature and body of knowledge of science diplomacy. The four components refer to four questions what, why, how and who regarding science diplomacy. The proposed model for science diplomacy is presented in Figure 1. By applying this model one can analyze and investigate science diplomacy in individual countries, and can have some comparative case studies about experiences of different countries. Through this model one would be able to identify deficiencies and weaknesses of science diplomacy in different countries and would be able to propose some policies, programmes and initiatives for strengthening each country's science diplomacy. The components of the model are introduced in the subsequent sections.

Features

Science diplomacy consists of three aspects – diplomacy for science, science in diplomacy and science for diplomacy (Turekian *et al.*, 2014).

Figure 1: A holistic view of science diplomacy



Source: Authors' compilation.

1. Diplomacy for Science

This seeks to facilitate international scientific cooperation in top-down strategic priorities for research and bottom-up collaboration between individual scientists and researchers (The Royal Society, 2010)

2. Science in Diplomacy

Many of the major challenges facing states are of increasingly global in nature and scale and have science and technology in the fingerprint of their cause or cure. Science in diplomacy describes the role of science and technology in providing requisite advice to inform and support foreign policy objectives. The function of science in diplomacy should be to ensure effective uptake of high-quality scientific advice by policy-makers (National Research Council, 2002). It is a must for diplomats and foreign affairs policy-makers to know about key trends in some areas such as nuclear energy, new and renewable energy, climate change, ICT revolution, nanotechnology, biotechnology, industry 4.0 and etc.

3. Science for Diplomacy

This is the use of science to help build and improve international relations, especially where there may be strain or tension in the official relationship. Science for diplomacy draws primarily on the 'soft power' of science: its attractiveness and influence both as the national asset and as the universal activity that transcends national or partisan interests. Perhaps the real promise of science for diplomacy, however, lies in its ability to develop stronger links between countries where political environment is tense and official relationships are strained or constricted (Lord and Turekin, 2007).

Objectives

Various aims for science diplomacy can be defined from different perspectives. And activities under them have been divided into two levels — national level and international level.

1. National level

Access to researchers, research findings and research facilities, natural resources and capital is one of the national-level aims of science diplomacy. And here the thrust is to improve national innovation capacity and competitiveness by way of benchmarking international R&D trends and policies; spotting new technologies, scientific discoveries and research potentials; seizing new markets, knowledge and key technologies; and attracting foreign talents and investments. Also, promotion of a country's achievements in R&D is another national-level aim. As part of a nation's global marketing efforts, SD and collaboration in S&T are geared to attract the world's best students, researchers and companies. Making them interested in its R&D may help raise country's academic capacities, reputation and performance, may stir innovations or enhance its innovative capacities, and may lay the ground for sustainable international partnerships of mutual benefit (Flink and Schreiterer, 2010).

2. International level

Apart from strengthening a nation's knowledge and innovation base, international scientific cooperation comes to be seen as an effective agent in managing conflicts, improving global understanding, laying the ground for mutual respect and contributing to capacity-building in deprived world regions. All in all, it has become subject to policy initiatives around the world, though its scope and objectives, instruments and intensity differ widely (Flink and Schreiterer, 2010). The ongoing de-nationalization of scientific research (Wagner and Leydesdorff, 2005), economic globalization, and growing international competition on all markets for goods and services keep on extending the playing fields of international relations. Science and Technology have gained an important and ever-increasing role in the competitive quarrel for market shares, power and influence (Skolnikoff, 1993; Wagner, 2002).

The more a nation's prosperity and economic success hinges on its ability to tap into global resources and to attract talent, capital, support and admiration, the more it is advisable to look for strategies to use its R&D assets most effectively to secure competitive advantages. At the same time, global phenomena such as climate change, infectious diseases, famines, migration, nuclear non-proliferation or terrorism call for international collaboration in S&T to tackle, or at least to ease the many multi-faceted problems raised or entailed by them (Flink and Schreiterer, 2010).

Access-driven initiatives also carry opportunities for value-driven or merely instrumental activities to ease tensions among states, build trust, and manage or prevent conflicts which may or may not be made explicit goals. Furthermore, access is crucial for extremely expensive 'big science' projects, which no country can afford to run alone, such as the International Thermonuclear Experimental Reactor or the International Space Station. Often, even if not always, collaborative projects and programmes of such a size are pitched under multilateral international S&T umbrella agreements (ISTA) (Flink and Schreiterer, 2010).

Practices

In general, science diplomacy actions are designed to meet some local needs, to address cross-border interests and to solve certain global challenges.

1. Practices designed to directly advance national needs

Science diplomacy can be enlisted to meet a range of national domestic needs— from exercising soft power to serving economic interests to promoting innovation (Gluckman *et al.*, 2017).

- **Exercising soft power:** The concept of "science for diplomacy" emerged originally to describe the aspiration of larger countries to project their culture and influence beyond their boundaries. More recently, smaller countries have discovered the value of science in asserting themselves on a global stage and increasing their relevance to international policy discussions.
- **National security and emergency response:** National security needs are dominated by science on many levels. Establishing and maintaining the confidence needed for many arms-control treaties depends on scientific verification.
- **Economic dimensions:** In the twenty-first century, trade and diplomacy are intimately linked and, in many countries, organizationally linked within the same ministry. Correspondingly, trade in advanced technologies and in technology-based services is on the rise. Given the global value- chain encompassing intellectual property, data and manufacturing, multiple countries are often involved in developing a single product. In

turn, innovative countries seek out one another to achieve synergy toward optimizing such products. At the same time, countries look for advantages regarding the sale and the protection of products with a high intellectual component. Thus, recent trade negotiations have been heavily invested in debate and negotiation about intellectual property, copyright, software, and advanced biology. Scientific inputs into such negotiations are critical to protect national positions.

2. Practices designed to address cross-border interests

In addition to engaging in the actions described above, a country can serve its national interests by using science to address specific bilateral or cross-boundary issues. One obvious case involves the management of ecosystems and resources that span jurisdictional borders. Clearly, matters relating to trans-border shared resources such as gas fields, fish stocks, rivers and watersheds all have large scientific components, meaning that diplomatic efforts without adequate science can be ill-directed (Gluckman *et al.,* 2017).

3. Practices designed primarily to meet global needs and challenges

In expanding the scope beyond national interests, one encounters problems truly global such as climate change, ozone depletion, global biodiversity and marine pollution. On these topics, there is often greater focus on the perceived immediate interest versus longer-term implications, which expand beyond traditional political timescales (Gluckman *et al.,* 2017). Some examples of science diplomacy actions at different levels are presented in Table 1.

In addition, several science diplomacy actions are proposed regarding three main aspects of science diplomacy (Diplomacy for Science, Science in Diplomacy and Science for Diplomacy) (See, Table 2).

Table 1: Science Diplomacy: National and Beyond

	Actions
National needs	• Influence, soft power and reputation: bilateral relations; projections and development assistance • Security: crisis, emergencies, disasters and threats • Economic: trade, innovation, standards and definitions • National needs and capabilities: technical capabilities, access to know-how and development of domestic STI
Common interests across national boundaries	• Trans-boundary and regional issues • Standards and definitions • Shared technical services • Crisis and disaster management • Social licensing for new technologies • Big science
Global interests	• Shared challenges across borders • Ungoverned spaces, global commons.

Source: Gluckman et al., 2017

Governments and Institutions

To be successful in doing SD by any measure, a country has to be very clear about both its overall strategy and who should be in charge to carry it out. Often potential partners abroad do not know what is being offered to them and whom they can turn to with questions, project proposals or grant applications. Regardless of which goals come first, which strategy looks most promising, and up to which department or agency it is to carry them out, 'leadership' becomes crucial in what has become a global war for talents and opportunities. Many of the obvious shortcomings, ambiguities, and inefficiencies in the ways to do science diplomacy can be associated with a lack of leadership; starting at the level of agenda-setting up to the 'machinery of government'. Yet this does not mean that any compelling SD has to start with convening top-ranking committees to elaborate strategic guidelines that then need to be pushed down the throats of the executive branch for successful delivery.

Table 2: Different Dimensions of Science Diplomacy

Aspects/ Actions	Professional Science Communication	Popularization of Science	Science Communication Policy
Diplomacy for Science	Researchers communicating to establish large-scale international cooperation in science	Public relations and journalism activities raising awareness of outcomes of large-scale international projects	National attempts to give researchers skills in organizational communication, negotiation and intellectual property issues
Science in Diplomacy	Initiatives by research bodies to communicate the potential of research to solve policy problems, to open dialogue, and give advice about the regulation of science and technology	Targeting policy-makers as a key audience for research results and outcomes	National attempts to encourage researchers to communicate with policy- makers and embed research in governmental processes
Science for Diplomacy	Researchers communicate with collaborators across national divides despite restrictions	Popularization encouraging high level of general scientific literacy, awareness, and dialogue about science and technology	National encouragement and support for international research through communication skills, cultural programmes, and language programmes to increase capacity for international collaboration as well as to facilitate international dialogue about contested science and technology.

Source: Leach, 2015

Rather, the challenge lies in an effective, recurrent and sustainable combination of bottom-up interest aggregation with strategic decision-making (Flink and Schreiterer, 2010). Nowadays plenty of actors including governmental actors (e.g. Ministries of Science and Technology, Ministries of Foreign Affairs, Universities and GRIs) and non-governmental actors (e.g. Think -Tanks, Private research institutes, and companies) are active in science and technology diplomacy activities in terms of policy-making, planning and implementing research and development and international collaborations). In Table 3, diverse range of actors and different activities related to science diplomacy are presented.

Iran's Science Diplomacy

This section gives some information and evidence about Iran's science diplomacy in terms of aspects, aims, actions and actors.

1. Aspects and Actions

In Table 4 some activities are presented in terms of diplomacy for science, science for diplomacy and science in diplomacy.

2. Aims

The general aim of Iran's science diplomacy is to create co-operation between diplomacy and science and technology through the expansion of interactions among governments, institutions and specialists, and to use diplomacy capacities to develop country's science, technology and innovation, and mutually use the country's scientific and technological capacities and capabilities to advance foreign policy goals. Also, Iran's science diplomacy seeks some international aims including use of scientific and technological capabilities to advance political goals and use diplomatic capacities to advance scientific and technological goals to facilitate bilateral or multilateral relations between countries for meeting interests of the countries involved and to solve international challenges.

Table 3: Institutions and Activities in Science Diplomacy

Actors / Activities	Ministries of Science and Technology	Ministries of Foreign Affairs	Governmental Research Institutes (GRIs)	Univ-ersities	Think Thanks	Private research institutes	Companies
Policy-making	*	*					
Planning	*	*					
Policy analysis					*		
Research & Development			*	*		*	*
International collaborations			*	*		*	*

Source: Authors' compilation.

Moreover, Iran's science diplomacy at the national-level aims at maintaining and enhancing the country's scientific and technological assets while trying to influence decision-making levels of other countries to strengthen national authority and increase international influence by combining scientific and technological capacities and diplomatic capabilities (Figure 2).

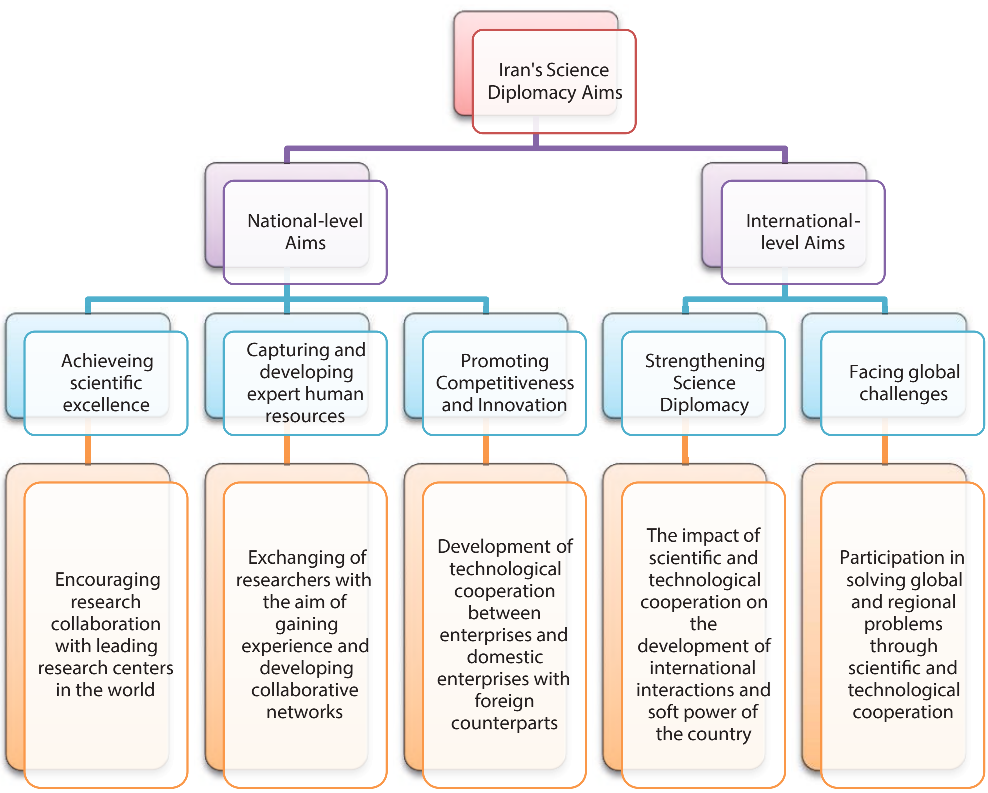
3. Actors

Iran's science diplomacy actors can be divided into following three levels, as given bellow:

- **High-level performers:** Vice Presidency for Science & Technology, Ministry of Foreign Affairs, Ministry of Science, Research and Technology.
- **Intermediate actors:** Center for Innovation and Technology Cooperation, Center for International Scientific Cooperation, Center for International Scientific Studies and Collaboration, Iranian Research Organization for Science and Technology, Institute for Political and International Studies, Students Affairs Organization, universities, other ministries
- **Actors at lower levels:** Scientific Associations, School of International Relations, Technology-based Firms and Companies and non-state actors.

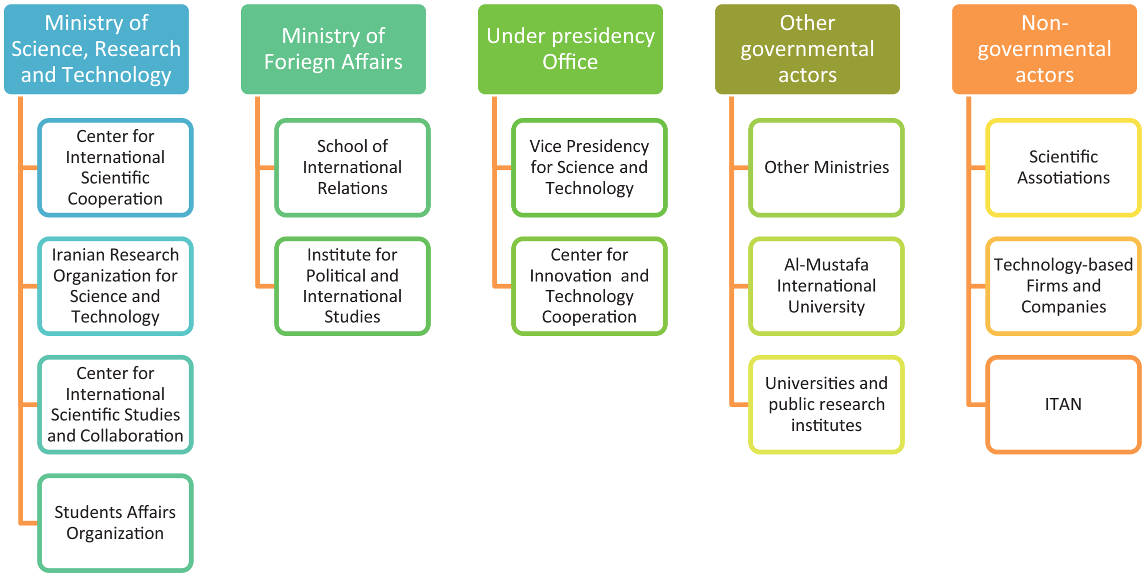
In addition, figure 3 enlists different actors of Iran's science diplomacy.

Figure 2: Iran's Science Diplomacy: Tasks and Objectives



Source: Authors' compilation.

Figure 3: Departments and Institutions in Science Diplomacy



Source: Authors' compilation.

Some of the significant characteristics of these actors are as follow:

- A large share of the science diplomacy actors in Iran is related to the Ministry of Science, Research and Technology (MSRT). Also, the variety of actions taken by the Ministry of Science, Research and Technology in the field of science diplomacy are so high that it covers all three aspects of science diplomacy.
- The Ministry of Foreign Affairs actions are limited to science in diplomacy, and merely the empowerment of

Table 4: Science Diplomacy in Practice

Features	Initiatives
Diplomacy for Science	• Follow -up of international cooperation projects for the development of education (inviting foreign professors to teach in the country) and an international cooperation plan for the development of applied research (conducting bilateral or multilateral research) • Membership in international assemblies (e.g. CERN) • To Identify overseas elites and to facilitate their cooperation with Iranian researchers • To Identify internal capabilities and to introduce these capabilities and opportunities to international scientific assemblies • To facilitate studying abroad for Iranian researchers and students

Table 4 continued...

Table 4 continued...

Features	Initiatives
Science for diplomacy	• To expand the Persian language in international scientific society • International collaborations (human resource exchanges), holding workshops and regional/international conferences, supporting conferences and workshops) • To attract, train and send people to different countries • Networking with other scientific centres, concluding scientific agreements • To attract foreign professors, researchers and students • Training and introduction of science and technology affiliates • Supporting and holding international conferences and workshops (e.g. Inotex, participation in the meeting of ministers of science in non-aligned countries, etc.) • Conducting consultative studies on other countries, providing technology donations to host delegations • To hold and support global, regional and Islamic events • Educational interactions and human resource exchanges • Networking among people
Science in diplomacy	• Networking, membership, and communications with international professional organizations • Conducting study and research activities • To provide human resources empowerment services at the state department • Education (Faculty of International Relations), providing advice on required political issues (Bureau of Political and International Studies of the Ministry of Foreign Affairs) • To educate and to introduce science and technology affiliates, conduct advisory studies on other countries • Bilateral cooperation (design and creation of the High Commission for Technology Cooperation) with Russia, China Silk Road Science • To facilitate interaction with China, joint programmes with countries such as Indonesia, Singapore, etc.), • To facilitate communication mechanisms among key actors (State, Financial, and ...)

Source: Authors' compilation.

human resources. Although these dimensions are very important for the nature of Ministry of Foreign Affairs as the main actor in the field of science and technology diplomacy; it has not taken other actions on other issues, except for certain issues (such as nuclear negotiations).

- The Vice Presidency of Science and Technology has been pursuing

Table 5: The Relationship between Four Key Components of Science Diplomacy

Aims / Aspects	Science in Diplomacy	Science for Diplomacy	Diplomacy for Science
National	Actors / Actions	Actors / Actions	Actors / Actions
International	Actors / Actions	Actors / Actions	Actors / Actions

Source: Authors' compilation.

diplomacy in two aspects of science for diplomacy and science in diplomacy, but it can be said that, these actions should be expanded to a greater degree in diplomacy for science and science in diplomacy.

Conclusion

Science Diplomacy has been identified as a potential tool to strengthen or improve relations among nations, in addressing global issues and in the exchange of resources where Science, Technology and Innovation (STI) has been identified as an engine of social and economic progress and also as a driver of globalization. Science diplomacy also strengthens principles of science and makes it more transparent and powerful (Sharma and Varshney, 2019).

Science diplomacy should be a serious part of every nation's tool kit; whether the country is large or small, developing or wealthy. But it cannot be instituted capriciously. Science diplomacy requires a structure that must encompass not only the promotion of international science, as covered by many science agencies, but also explicit attention to issues at the national, regional, and global levels. Technical ministries and foreign ministries thus have compelling reasons to work more closely, and with greater coordination, and must recognize the need for specific expertise for the good of the planet and the reduction of transnational conflict (Gluckman et al., 2017).

In the current paper to enhance our understanding of science diplomacy, a comprehensive model has been proposed that consists of four main components of science diplomacy— aspects, aims, actions, and actors. The relationships among these four are illustrated in Table 5.

The proposed model was employed to shed some light on Iran's science diplomacy. Some key findings regarding Iran's science diplomacy are as follow:

The role of governmental actors in the field of science and technology diplomacy is a significant one; as many actions are also carried out by these actors. In Iran, non-governmental and academic actors (universities, associations, and think- tanks) mainly carry out purely technological and non-political activities, and their potential capacity in the field of science and technology diplomacy has not become the actual capacity. In other words, both scientific and political activities are mostly carried out by governmental actors.

It seems that the actions of each group of actors are largely parallel to other actors, and there is a lack of inter-organizational mechanisms that help integrate and coordinate these actions to cover all three dimensions of science diplomacy.

In the structure of Iran's science and technology diplomacy, there is no specific organization for planning and setting short and long-term targets in this field (similar to the CSTI in Japan). So, various actors, based on their interests, benefits and organizational goals are working on this topic.

Due to the lack of purpose and division of labor in this area, actors do not know their role and do not create the required capacities and capabilities to play the role in their specific positions. The scene of science and technology diplomacy, without a coordinator organization, results in different actors working individually and thus outputs are not tangible and inclusive. In addition, the resources and mechanisms for funding such activities are not enough and proper.

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PERSPECTIVE

Global Governance of Emerging Biotechnologies and Role of Science Diplomacy

K. Ravi Srinivas*

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In the early 1970s concern was expressed over threats and impacts of advances in biology, particularly on the impacts of genetic engineering, and Issues related to biosafety and regulations were discussed. As genetic engineering was getting established as a novel technology that had huge potential to benefit and harm, scientists themselves were concerned about biosafety and issues arising out of recombinant DNA research. So in the Asimolar Conference, convened by scientists themselves a Declaration was adopted and scientists decided that they would adopt self-regulation as at that time there was no national level legislation/regulation in the USA. The rules adopted by the scientists laid the foundation stone for modern biotechnology regulation. Over the next few years, it became clear that fears were exaggerated and recombinant DNA research was crucial in biotechnology research.

Today about four decades and a half have passed. Still the Asimolar conference is regarded as a pioneering conference, not just for the technical issues discussed there, but also for the decision to adopt self-regulation and minimize potential risk. Scientists thus responded to public concerns and concerns within the scientific community. What was novel once often turns out be routine and an ordinary matter over a period of time. The same has happened to the techniques and technologies discussed in Asimolar Conference, as recombinant DNA research soon

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became a routine affair in biotechnology. It became clear that fears were exaggerated and technology resulted in applications, many of which were not envisaged then. A criticism of the Conference was that it ignored ethical, legal and social impacts (ELSI) of the technology and focused solely on technical issues and concern for environment and health. Yet the key lessons from Asimolar were that developing consensus was critical and prudent action in light of uncertainty was important.[1]

Today, we have technologies/ applications such as synthetic biology that confer to scientists far more power than genetic engineering or recombinant DNA technologies did.[2] But they have such a wide-ranging impact that discussion on ethical, legal and social implications are part of the debate among scientists, National Academies of Science and regulators. In case of human genome project, a specific percentage of money as allocated for ELSI research and governments and scientists made efforts to reach out to the public and allay their fears as well as to learn from the public about their concerns, values, fears and expectations. But governing human genome mapping was relatively easier as the number of countries was limited and they had come to an understanding among themselves. So, except for a few issues like intellectual property rights and data management models, human genome mapping did not emerge as a challenge for governance at the international level. At the national level, countries had revised their regulations based on regulation of biotechnology/genetic engineering. In case of human reproductive cloning while there was a UN declaration on banning human reproductive cloning, progress could not be made on a binding international treaty on human reproductive cloning. Although efforts were made to build a consensus and move towards a binding treaty it did not go beyond a point, because consensus did not emerge. Thus while. In 2005, the United Nations adopted Declaration on Human Cloning, a binding treaty is nowhere is sight. Still it is suggested that a global governance framework may still be possible.

Synthetic biology is not governed by any international treaty or convention. In the last few years it has been discussed in Convention on Biological Diversity and many studies have been done. The forthcoming COP-MOP to be held next year in Kun Ming, China is likely to make some progress on this. But given its implications for biosafety and biosecurity, whether the Convention on Biological Diversity (CBD) is the right forum is a question. At the same time as it has ramifications for other sectors ranging from health to agriculture, its governance at the global level raises new challenges. These range from whether the precautionary principle is the right principle to govern synthetic biology to whether products of synthetic biology are treated as Genetically Modified Organisms (GMO) / Living Modified Organisms (LMO) or their equivalent. In December 2017 the ad-hoc technical experts group created by Parties to the Convention on Biological Diversity, decided that organisms developed or being developed under current methods of synthetic biology, including the ones containing gene drives will fall under the category of LMOs. LMOs are regulated under Cartagena Protocol on Biosafety (CPB). CPB has been ratified by most countries in the world and has 171 Parties to it. CPB has an elaborate mechanism to handle LMOs and invokes the Precautionary Principle. So negotiating further under CBD/CPB seems to be a better option but some of the countries that are innovators in Synthetic Biology and Gene Drives are not Parties to CBD or CPB. For example, USA is not a Party to CBD while Australia, and, Canada are not parties to CPB. Noting that broader shifts in global biodiversity governance are happening, Rabitz points out that a broader package deal with specific provisions on Gene Drive Organisms (GDO) can be arrived at the forth coming COP-MOP (Rabitz, 2019; P.9).

But in the case of Synthetic Biology there is a strong and growing Do It Yourself Biology (DIY Bio) movement that has become global and the DIY Bio community is also an important contributor in terms of innovation and events like iGEM incentivize students to work on Synthetic Biology. This diffusion of technology among those who do not work under the typical biosafety regulatory regime and the diversity in their uses and applications is a challenge to governing Synthetic Biology. Most of the DIY Bio groups are aware of biosafety concerns and adopt safety procedures and take precautionary measures. How to regulate and govern DIY Bio is a key issue because DIY Bio promotes citizen science and enables better understanding of science and hence has to be supported but as it raises questions on biosecurity, biosafety and bioterrorism, it cannot be left entirely to DIY Bio groups. Will self-regulation combined with monitoring by a government agency is enough or should this also be regulated as a regular scientific activity?

Genome Editing is a novel technology that has emerged since 2012 or so, and is revolutionizing the way scientists handle and manipulate genomes. While human genome mapping enabled scientists to explore and understand the genome better, Genome Editing, offers them tools and protocols to edit the Genome, or, 'to rewrite the genetic code'.

There are some common features among Synthetic Biology, Genome Editing, Gene Drives and GM Mosquitoes from a governance perspective:

- There is no clarity on applicability of any convention/treaty for their governance globally
- Although nations have been trying to develop frameworks and regulatory norms, there are many unresolved issues ranging from categorization/classification to identifying appropriate governance principles. For example should Gene Drives be classified as LMOs? Should Genome Edited Crops be treated as similar to crops bred in traditional plant breeding programs or as GMOs for regulatory purposes.
- Are principles like precautionary principle adequate to develop regulatory regimes
- Traditional risk assessments may not be sufficient to fully understand the long terms environmental impacts of these
- Given the gaps in knowledge about impacts, issues on impact assessment methodologies, there are uncertainties on assessing their impacts
- They raise concerns about biosafety and biosecurity and some of these are new and arise out of their unique and novel features, and, this includes concerns about DIY bio.[3]
- Given the wide-ranging applications in different sectors, is it possible to develop coherent governance frameworks, which

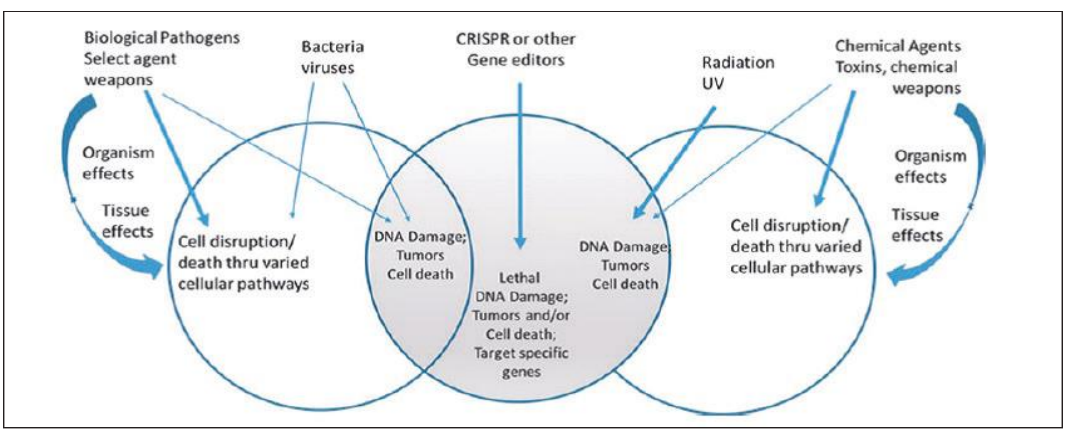
can adapt in tune with technological developments.

The good news is that different stakeholders are aware of these and are trying to understand the implications. Thus, whether it is National Academies of Sciences or WHO or professional bodies representing scientists or Parties to different Conventions/Treaties there are many initiatives on debating about governance issues and to develop a common understanding, if not a consensus. For example WHO has established a "expert advisory committee on Developing global standards for governance and oversight of Human Genome editing" and it has started functioning. Parties to The Biological and Toxin Weapons Convention (BTWC) are discussing the implications of advancements in science and technology, including genome editing for BWTC. A paper submitted by Switzerland states (BWTC, 2018):

> "CRISPR technology can reasonably be expected to surprise us with new twists and turns impossible to predict. This is likely also true for many other areas, including the above discussed nucleic acid origami, but also for synthetic biology or the neurosciences. In this context, it will be important to keep track of scientific and technological advances, and their potential bearings on the Convention. At the upcoming MX2, we should hold a technical discussion on genome editing technologies, and especially CRISPR technology, to then take the next step towards an assessment of their implications for the Convention by putting them into the broader context of the 'new era of biology'. In doing so, we should broaden our traditional focus of 'pathogens causing disease' to the wider prospects and implications that developments in the biosciences as a whole may have. Furthermore, technical discussions should also take into account any intangible aspects (e.g. 'tacit knowledge') of advances in science and technology, which may significantly shift initial perceptions about benefits and risks. All of this will allow for a holistic and more realistic understanding of the benefits and risks to the Convention"

The figure 1 illustrates some of the concerns on the potential of recent developments in science and technology.

Figure 1: Pathway Spectrum Across Potential Weapon Agents



Source: DiEuliis and Giordano, 2017

According to Diane DiEuliis and James Giordano (2017):

> "'Neurohacking' will increase, and biotechnology, such as CRISPR/Cas and novel gene editors, will provide tools to realize production of novel neuroagents with dual-use potential. Simple acknowledgment of these facts, however, is insufficient. It will be essential to pursue and obtain a deeper and fuller understanding of the ways that genetic pathways to human cognitive and behavioral modification can be engaged for dual and direct use as neuroweapons, to formulate policies based on this level of understanding, and to engage surveillance of the use of these technologies in various silos of development and application, so as to afford both preventive and more preparatory capabilities" (Pp. 300-301)

For obvious reasons, 'creating' babies through genome editing with enhanced traits or similar application have created a mixed feeling, from awe and wonder, to repulsion and shock. Even as nations struggle to regulate genome editing in health sector, the absence of international norms for governance can result in tricky situations and unanticipated turn of events. While giving an example of such a tricky situation, Dounda and Sternberg (2017), suggest that international governance is a better solution, by pointing out:

> "A cautionary tale on the risks of inaction can already be seen with a related assisted reproductive technology known as mitochondrial replacement therapy, which is being developed but is not yet clinically approved in the US. In a recent case, however, a New York physician exported genetically modified embryos to Mexico for implantation, specifically to evade US restrictions. Imagine the type of industry that might result if the intent were not to produce an embryo free of genetic disease, but an embryo with a genetic enhancement enabled by CRISPR. Robust international governance could discourage this kind of medical tourism, assure equal protection for the citizens of all nations, set international gene editing standards for scientists and companies, and help prevent trade disputes with gene-edited foods. The challenge is determining what mechanism of international convergence is actually possible, given the substantial legal differences that are already in place across the globe on issues like GMOs and genetic modification of human embryos."

Given the challenges in developing governance norms and principles for these emerging technologies is there a role for Science Diplomacy in helping countries to develop governance frameworks and arrive at commonly agreed principles, if not a consensus? The answer is YES. Science Diplomacy can play key role as 'Science for Diplomacy' and 'Diplomacy for Science' can play a vital role in bringing together scientists, regulators and policy makers by acting as interfaces and help in building bridges. It is not important that countries should start with a common understanding or with shared objectives. But through deliberations, countries can at least find out points they agree fully, points they totally disagree and points they agree and disagree with a give and take attitude. Science diplomacy can help countries in identifying these points and identify how their respective positions are shaped by these points.

For example with respect to human genome editing for reproductive purposes, countries can at least agree on what they want to prohibit at all costs and how they will ensure that, In arriving at such a common position, science diplomacy can play a vital role when scientists and diplomats work together towards this. While scientists can rely on positions taken by National Academies and ethical guidelines in vogue in the respective countries, diplomats can negotiate on developing flexible positions and norms that are beyond any bargain or compromise. Mutual interactions among them will enable a better understanding that can be used to arrive at a shared understanding for further deliberations. Through track II diplomacy, other stakeholders can contribute to further progress on developing such an understanding. On the other hand Science Diplomacy can be part of track II diplomacy although it may not be very visible.

If we conceptualize that Science Diplomacy is a broad activity that goes beyond closed doors of forums for negotiations, and, activities of scientists and diplomats, then we have to consider the role of, inter alia, non-state actors, and, civil society in activities related to developing norms for governance. Given the importance of public engagement and public participation, Science Diplomacy can facilitate that by engaging with other stakeholders directly or indirectly. For example while in many of the Conference of Parties and Meeting of Parties (COP-MOP) , civil society groups and others that are recognized, can participate as observers , their influence among the public and their role in shaping public opinion also has to be taken into account. Science Diplomacy can be useful in engaging with them as observers as well as interfaces between public on one hand, and, scientists and policy makers, on the other hand. Obviously the tasks are not easy and there are many challenges. Although there can be a consensus translating that into a binding agreement or treaty is not easy.

As these technologies have biosafety and biosecurity concerns, it is likely that Parties to BWTC will address those concerns as far as BWTC is concerned. Similarly some of the concerns relating to environmental impacts, long term impacts, and risk assessment can be addressed through deliberations by Parties of CBD/CPB, which might result in changes/additions/revisions in CBD/CPB. The WHO's expert advisory committee can develop guidelines to regulate genome editing for health/population related purposes. Dounda and Sternberg have identified some relevant initiatives in governance of genome editing. Thus there is scope for using health diplomacy, environmental diplomacy and perhaps innovation diplomacy in moving towards governance norms for these technologies.

But this will not happen on its own. Until countries realize that Science Diplomacy is essential to address tricky questions in international governance of these technologies and understand that some nudging including persuasion is required through Science Diplomacy and create forums and spaces for diplomats and scientists to interact and work together, Science Diplomacy will not have an effective role in this. As many of the Science Academies are active in addressing issues relating to governance, in each country, a small team from representatives of these Academies, negotiators can be formed to develop a coherent negotiating strategy across different forums, COP-MOPs etc.

One hopes that the countries will seize the opportunities for Science Diplomacy to play a positive role and give it the importance it deserves in this challenging task. Having said that, we should not expect that Science Diplomacy will be the saviour or a factor that could override all other factors in moving towards a consensus. Perhaps developments in this year and the next few years will indicate the directions in which the world is moving in governing these technologies.

Endnotes

1. For reasons of space, I will not go into questions like whether Asimolar conference is a relevant model today, and, can self-regulation be an effective solution. To more about this discussion, one may refer to: Paul Berg and Maxine Singer, The recombinant DNA controversy: Twenty years later, *Proc. Natl. Acad. Sci. USA* Vol. 92, pp. 9011-9013, September 1995; Jasanoff, S., Hurlbut, B., Saha, K., 2015. CRISPR Democracy: Gene Editing and the Need for Inclusive Deliberation, *Issues in Science and Technology*, VOL. XXXII, NO. 1; Hurlbut, B., 2015. Limits of Responsibility: Genome Editing, Asilomar, and the Politics of Deliberation, *Hastings Center Report* 45, no. 5: 11- 14.

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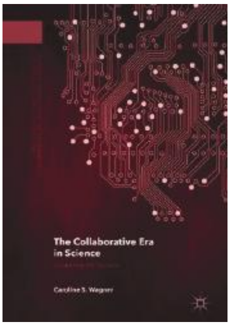
BOOK REVIEW



The Collaborative Era in Science: Governing the Network

Nimita Pandey*

NIMITA PANDEY

In recent years, Internationalisation of Science and Technology has become integral to discussions on sustainability, STI cooperation and socio-economic development, at national and global levels. With advent of digitalization and rapid shifts in technological paradigms, the knowledge systems have become more diverse and complex. Historically, science, technology and innovation have been championed by the developed countries, while the developing countries have sites of low-cost production. However, there are shifts in this trend and developing countries, like China, India, Indonesia and South Korea are contributing significantly through creation and commercialisation of innovative products, processes and services (UNCTAD, 2019). In this scenario, the significance of cross-border scientific collaborations has grown manifolds.

Globalisation of science and its relevance for science policy, diplomatic negotiations and sustainable development have been studied from different perspectives. Amid discussions around scientific progress and its relation with geopolitical agendas and economic outcomes, Professor Caroline Wagner's work titled, ***The Collaborative Era in Science: Governing the Network***, elaborates on the global network of science, which has emerged in the 21st century.

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The author, Professor Caroline Wagner[1], is an eminent academic working on collaborative aspects of science and technology and its relationship with policy, society, and innovation. Her research involves intersections of science and policy, showcasing the global-local exchange of knowledge between individuals, surpassing organizational, institutional and national boundaries. In one of her earlier books, *The New Invisible College: Science for Development (2008),* Prof. Wagner has discussed the influence of global knowledge networks, on science and technology advancements. However, the present book goes beyond to discuss knowledge network systems at three levels- individual, team, and nation, aligned with facets of network governance. She asserts the idea of *knowledge networks governance*, highlighting the role of regulations and norm setting, to oversee collaborations and knowledge exchange, with the aim to realise societal welfare and development.

As described in the book, networks are important for scientific and technological research and development, which has implications for policy making and advocacy. The author stated that, "[…] the spectacular growth of science and technology in networked form and its success in disseminating a way of conducting verifiable research and development characterizing the natural world", are factors leading to transformation in knowledge systems. With an array of insightful, concise and theoretically enriching narratives, this book analyses configurations of global knowledge systems – factors and processes – with significant focus on global networks of science.

The book views global network as a new form of organization of science. Each chapter relates to the globally distributed networks of science, providing a comprehensive view of the given subject. The first chapter describes the historical narrative of knowledge systems, and their characteristics. It highlights the interdisciplinary and multi-stakeholder aspects of science, operating at different spatial levels – national, regional and global- leading to the emergence of 'networked' science. The chapter weaves a narrative around scientific evolution, technological growth as well as innovation and illustrates two distinct yet adjoined elements – the scientist and the science (in written form) – elucidated through works of Latour (1987) and Derek DeSolla (1965), respectively. Subsequently, it discusses the systemic nature of science and the underlying complexities, which are not yet understood, in theory and practice. The second chapter describes the scale and scope of global science, through factual evidences. The growing trend of cross-border collaborations, leads to result a globalised and collective character of science; which is referred as the 'Collaborative Era' or the 'fourth age of research' (Adams, 2013). The author gives impetus to 'knowledge' as a public good and openness of knowledge systems for economic development.

Chapter three, Levels and Patterns of Communication in the Global Network, discusses communication dynamics within the global networks. While the chapter states that with growing quantum of information, the scientific fraternity is moving towards open sharing to make Knowledge accessible, leading to the idea of 'knowledge commons', it also highlights barriers and challenges for openness of science. Chapter four, It's who you Know (or could Know) that Counts, aims to explore networks, their typology and dynamism in science, scaling down to each node (participant) within the network. In doing so, the author assessed the motivations and incentives for people, institutions and nations, to be a part of the global network of science through examples of Human Genome Project, establishment of CNMS—the nano-scale science centers. She asserts, "The nature of the links among scientists—their connections and reasons for organizing into a groups, clusters, and networks—is established in science as it relates to two things: (1) the kinds of problems that are being studied and (2) the rules of affiliation" (P. 76).

Science is a social system – involving actors and agencies that are implicated in scientific discoveries, policies, social movements and culture (Latour, 1996). In this book, Wagner undertakes the Mertonian perspective in chapter five, the Global Network of Science Emerges, and presents that global exchange of knowledge and scientific networks are influenced by the socio-cultural, economic and political norms, across the globe. These norms differ across nations, technological trajectories and political regimes, and have a significant influence on the dynamics of global networks of science. These norms transform institutional architectures, policies, stakeholder participation and impact the Human-Technology relation. Cases of mega-projects like Large Hadron Collider, the Human Genome Project (HGP), the Hubble Space Telescope, and ITER (the international nuclear fusion project) are well articulated to strengthen these arguments. In chapter six, Openness in the Global Network, the author discussed team-level inter-dynamics, wherein individuals collaborate and form networks. The chapter illustrates concepts like Citizen Science, Intellectual Property Rights in Global Networks, Open Access and Open Sharing.

In chapter seven, Nations within the Global Network, the author elucidates on spatial scaling of global networks, from local to global. Reflections on patterns of global networks of collaboration build the foundation of this chapter, to draw inferences about changes in production, transfer and dissemination of knowledge. The recent increase in R&D investment and output in China showcases its openness towards international collaboration in Science and Technology. The author shares various examples to highlight a strong connection between Science and National identity. The concept of 'brain circulation' is mentioned to show that scientific prowess of nations is dependent on their integration in international networks. The next chapter, Local Innovation and the Global Network, relates to universal access of knowledge and the challenges. Regional knowledge ecosystems organically emerge amid conducive socio-economic, institutional and political settings, which are discussed by the author, referring to the concept of "THICK - technology, human resources, institutions, communications, and knowledge" (Farley et al, 2011). It has been observed in the developing as well as developed countries, where knowledge creation is regional embedded and nurtured. The mention of Uganda's ICT initiative for rural outreach highlights the social benefits that can be derived from global- local linkages. The final chapter, Governing Global Science, highlights the rules, norms and policies relevant for Mega Science projects, STI cooperation and science diplomacy.

While the book reflects on theories and concepts, drawing inferences from investment on R&D, publication data and R&D outputs, it is important to incorporate indicators like measurement related to public policy goals, sources of capital for innovation and others, to understand the globalizing nature of science and technology. Also, 'THICK' as an assessment tool, needs to be more contextual to examine the potential of different countries in the global North and South, A comparative study can be undertaken in future editions, to understand dynamics between countries in BRICS, ASEAN and other regional groupings. In my opinion, the governance of global networks is a critical topic to reflect in streamlining national priorities and social welfare from scientific collaborations, which also the overarching theme of the given book. It is a well-structured and comprehensive account of different inter-related concepts, to understand how globalization, mobility of science and scientists, scientific alliances impact the socio-economic, cultural and geopolitical contours of science, technology and innovation, at local to global levels.

Endnotes

1. For more details, visit the profile of Prof. Caroline Wagner at http://glenn.osu.edu/faculty/glenn-faculty/wagner/

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REPORT

IPBES Global Assessment Report 2019

Geetika Khanduja*

GEETIKA KHANDUJA

An important report was released recently on the side-lines of the 7th Session of the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) Plenary meet held in Paris, during 29th April to 4th May 2019. The event unveiled a Summary for Policymakers (SPM) of the *Global Assessment Report on Biodiversity and Ecosystem Services*, highlighting key takeaways, findings and policy alternatives. The public launch of SPM at the UN Educational, Scientific and Cultural Organisation (UNESCO) headquarters in Paris issued a clarion call on the lines of IPCC's (Intergovernmental Panel on Climate Change) climate report, published in 2018.

IPBES is an intergovernmental body established in 2012, consisting of 130 member states. It aims to strengthen science-policy interface for biodiversity and ecosystem services, for conservation and sustainable use of biodiversity, long-term human well-being and sustainable development. The organisation conducts assessment studies on specific themes and methodological issues at both, global as well as regional levels; provide policy support by identifying policy-relevant tools; is involved in knowledge creation and capacity building; and also has communications and outreach functions to its mandate in order to ensure effective and wide reach of its work.

International environment experts have lauded the report for its comprehensive coverage and fact-driven content. The report draws inspiration from the landmark

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Millennium Ecosystem Assessment of 2005, introducing innovative ways of evaluating evidence (UNEP 2019). It has been compiled by the 145 authors, from 50 different countries over the past three years, including systematic review of about 15000 scientific and government sources. The report provides an illustrative list of possible policy actions and pathways pointing towards an integrated approach in biodiversity conservation. Another unique and significant feature of the report is the inclusion of local and indigenous knowledge along with scientific studies. It covers some key issueslike vital contributions of nature to life and the scale of its loss; drivers of change and species decline; achieving sustainable development goals through transformative change across all dimensions spanning the economic, political, social and technological factors; and possible actions and policy pathways to achieve such a transformative change for sustainability, with supporting evidence and useful illustrations.

The SPM report begins with highlighting the contributions of Mother Nature to people, embodying all the biodiversity and ecosystem functions and services. It states that most of nature's contributions to people (NCP) are a direct combination of anthropogenic assets with the biophysical processes and ecological interactions only. The section also illustrates the directional trend across regions for a period of 50 years along with selected indicators for each of the NCPs. It also points towards the irreplaceability of some of the vital contributions of nature. The report further holds humanity responsible for the ongoing decline to the natural, terrestrial, freshwater and marine ecosystems; revealing that 75 per cent of the terrestrial environment been "severely altered" to date by human actions. The corresponding number for the marine environment stands at an equally alarming 66 per cent.

The decline has been a consequence of some direct and indirect drivers of change, as per the report. These drivers in descending order are 1) changes in land and sea use; 2) direct exploitation of organisms; 3) climate change; 4) pollution and 5) invasive alien species. Another astounding finding of the report is with regard to the global rate of extinction of species, including the current global extinction risk in different species groups. According to the report, up to 1 million species are presently threatened with extinction, many within decades. This calls for concerted global action to preserve endangered species through mutual cooperation and coming up with possible and workable frameworks for biodiversity conservation which each ratifying country has to adhere to.

Next, the report delves into the particular impact of each of the drivers of change and rate of their increase over a period of 50 years. Firstly, it notes the change in land and sea use, impacting the terrestrial, freshwater and marine ecosystems can be attributed to human activities of agriculture expansion, unprecedented urbanisation and over-exploitation of living organisms by way of hunting, fishing, logging etc. Secondly, the role of climate change on nature and human well being is brought out. The rise in sea-levels, increase in frequency and intensity of extreme weather events such as floods, droughts, heat and cold waves, and cyclones, are all result of climate change and have contributed to widespread impact in species distribution, population dynamics, community structure and ecosystem functioning. According to the report data, there has been a 100 per cent increase in annual greenhouse gas emissions since 1980, raising the average global temperature by at least 0.7 degrees since pre industrial times. Also, it points out that 8% of the total greenhouse gas emissions are from transport and food consumption related to tourism, with a 40 per cent rise in the carbon footprint of tourism from 2009 to 2013. The report also talks in particular detail about the ever-growing pollution as a significant driver of change. It states that marine pollution, in particular, has increased ten-fold since 1980, affecting numerous aquatic species and also having a profound impact on humans through the food chain. All these findings emphasise on the need for an urgent push towards following the targets set by the UNFCCC and other international conventions in order to combat climate change and fight global warming. The issue of pollution can also be tackled through green technology and capital transfer from technologically advanced nations of the world to developing nations and a global transition towards more eco-friendly methods of production and responsible consumption.

Further, the report talks about how the increase in population has positively affected global economic growth and international trade, also driving up demands for energy resources. It also points out towards the uneven distribution of resources and economic incentives across regions and different sections of human populations, thus leading to inequity and social conflicts. Also, these economic incentives are generally leading to environmental harm because of the unsustainable use of economic resources as well as over exploitative practices of the ecosystem services. The findings should be taken as wake up call for countries and communities to adopt sustainable ways of living for the conservation of the planet and the human race, alike.

The indigenous people and communities have been following such a lifestyle since ages but even their habitat is under threat due to the increased commercial activities in their areas, as pointed out by the report. These communities are facing growing resource extraction, commodity production, mining and travel and energy infrastructure which present a worrisome scenario. The harmful effects of such a commercial intervention into indigenous areas is threatening their subsistence agriculture practices, traditional livelihoods, hampering the transmission of indigenous and local knowledge and therefore in turn challenging their ability to sustainable resource and biodiversity management.

For restoration and conservation of nature, the report suggests the need for urgent and concerted efforts that foster a transformative change. This kind of transformative change can be brought about by committing to mutually supportive international goals and targets, supporting the indigenous people, local communities and their knowledge systems, adopting new frameworks for private sector investment and innovation, multi-sectoral planning and strategic policy-making, adopting all-inclusive and adaptive governance approaches and helping private as well as public sectors achieve sustainability at all levels-local, national and global. The role of enhanced and active international cooperation towards restoring nature to sustainability is also well highlighted in the report.

The report also suggests policy actions and pathways, involving all the relevant stakeholders, viz, the international government organisations, governments, non-governmental organisations, citizen community groups, donor agencies, indigenous people and local communities, science and educational organisations and the private sector. It prescribes certain approaches for sustainability and corresponding policy actions that can supplement such an approach. Similarly, the ocean and marine systems can also be governed and managed in a sustainable manner by following relevant policy decisions. Energy and infrastructure projects that are based on a sustainability paradigm needs to be promoted through promoting innovative financing. The report calls for a redesign of government's incentive programmes and policies, favouring renewable and eco-friendly sources and practices and by supporting community-based management and decentralised sustainable energy production.

While the report has indicated several policy pathways leading towards a transformative change, it has left the details to achieve these pathways to the policymakers to decide for themselves depending on their respective social, economic and political realities. The macro-level conceptual frameworks provided might not be applicable to all the nations and communities alike due to differences in political systems, availability of economic resources and social fabric. The difference of geography, topography and cultural beliefs might also pose a challenge for application of a uniform environmental policy framework on a global level. Mention of some success stories, wherein the governance system has tried addressing the looming environmental crisis, would have been a useful exercise which could have been included in the report.

Still, the report launch is timed aptly amidst widespread concerns regarding biodiversity loss, climate change and global warming which the world environmentalist community is grappling with. The SPM to the report has pointed to the urgent need for concerted policy action and establishment of multi-disciplinary collaboration among decision makers and other concerned stakeholders at all levels for the conservation of biodiversity and global environment.The need of the hour is adoption of an integrated, adaptive, informed and inclusive governance approach across all levels in order to bring in a transformative change in the way environmental problems are being addressed. Implementation of existing environmental laws and formulation of new ones would not be successful until all the stakeholders come together at a multi sectoral level, in taking pre-emptive action and for better decision making keeping in mind the contemporary realities and contextual priorities.

Full Summary for Policymakers (SPM) of the Global Assessment Report can be retrieved from https://www.ipbes.net/sites/default/files/downloads/spm_unedited_advance_for_posting_htn.pdf

Science Diplomacy

Nine different Science & Technology missions under PM-STIAC

The Prime Minister's Science, Technology & Innovation Council (PM-STIAC) is the overarching body, aimed primarily to promote the implementation of synergy projects in various science and technology areas, comprehending challenges, formulating policy and strategic interventions in the STI domain as well as presenting a roadmap to the Prime Minister.

Recently, the Principal Scientific Advisor (PSA) to the Government of India- Prof. K. Vijay Raghavan shared details of the nine national missions guided by the PM-STIAC. The nine missions of national importance through the PM-STIAC, aim to understand and conserve our biodiversity and develop sustainable processes, leverage precision health for personal wellbeing, recover wealth from waste, develop and use artificial intelligence, quantum computing, connected mobility solutions and other technologies to address frontier scientific questions and our challenges, thereby enabling sustainable development for India and the planet. Each mission is to be led by a line ministry and will also engage international as well as national institutional partners, young scientists and industry.

Source: http://pibphoto.nic.in/documents/rlink/2019/mar/p20193601.pdf

Call for global moratorium on heritable genome editing

CRISPR experts from 7 different countries, including renowned experts like Emmanuel Charpentier, Eric Lander and Feng Zhang have called for a total ban on all clinical uses of human germline editing. The primary motivation behind such a call is the absence of any international framework on the issue of changing heritable DNA to make genetically modified children. It becomes highly important in the light of lack of national and global legislations as well as pending discussions on technical and medical issues having ethical and moral repercussions for the society. The call for the moratorium is however, only on clinical uses of the technique, sparing the research applications and also on temporary grounds, for a period of five years until an international framework on CRISPR editing is evolved. Also, the group advocates voluntary pledges by countries rather than an international treaty.

At present, around 30 countries have some type of direct or indirect legislations in place barring the clinical use of germline editing. The group has emphasised the need to hold international consultation, conduct a thorough transparent evaluation and achieve broad societal consensus about the application of genome editing technique, giving due importance to the opinion of all stakeholders involved on an issue which affects the entire species. The timing of this call is apt with some biologists like He Jiankui of China reportedly editing embryos to create at least two babies. Furthermore there exists lot of ethical issues that need to be debated properly and addressed before legalising the widespread clinical use of genome editing technique.

Source: https://www.nature.com/articles/d41586-019-00726-5

Research and Development

Breakthrough in advanced semiconductors technology at IISc Bangalore

Indian Institute of Sciences (IISc) Bangalore have developed India's first ever enhancement mode (e-mode) Gallium-Nitride Power Transistor in a major breakthrough research study marking India's strong presence in the niche field of semiconductors. Gallium Nitride (GaN) is being increasingly used as a semiconductor in making electronic components, though the technology is still evolving and silicon is still the most used semiconductor in the industry. GaN is a hard material and is better suited for high-power and high-frequency applications and also the energy loss is much less.

The interdisciplinary team at IISc have used the material and made a specific transistor called the High Electron Mobility Transistor (HEMT). These transistors made of gallium can operate at very high voltages, switch ON and OFF faster and occupy less space as compared to silicon-based transistors and hold potential of reducing the import costs and making India self-reliant in transistor technology. Operating at 600V, the HEMT technology-based transistor has better performance and power handling capacity than similar devices available in the market. The potential applications of the technology include electric vehicles, laptop chargers, military radars and cell phone base stations.

The institute has been involved in development of GaN semiconductor technology since 2009, supported by the Ministry of Defence (MoD), which was subsequently supported by the Ministry of Electronics and Information Technology (MeitY). This particular project is funded by the Advanced Manufacturing Technology (AMT) initiative of Department of Science and Technology (DST), Government of India, which is aimed at enabling the development of indigenous technologies vital to the country's economic and strategic growth.

Source: https://researchmatters.in/news/iisc-develops-india%E2%80%99s-first-e-mode-gallium-nitride-power-transistor

ICGEB discovers new method to increase ethanol production

The International Centre for Genetic Engineering and Biotechnology (ICGEB) Saccharomyces cerevisiae NGY10 that can produce 15.5% more alcohol upon fermentation of lignocellulose biomass (rice and wheat straw). India produces ethanol mostly using molasses, but in the wake of the country setting a target of blending petrol with 10% of biofuel by 2022, rice and wheat straw are also potential sources

The novel strain discovered by ICGEB, on the other hand overcomes challenges present with other currently available commercially used yeast strains. Firstly, NGY10 is thermotolerant, can continue to ferment the biomass even temperature increases to 40-degree C. Its performance is also not much affected from the three by-products (inhibitors) of the pre treatment process. Otherwise also it's functionally superior due to increased amount of ethanol production as compared to other yeast strains. However, the NGY10 was not able to ferment the pentose sugar (xylose and arabinose). Therefore, the researchers are thinking of genetically modifying the NGY10 strain so as to enable it to ferment the pentose sugar which may lead to an even further increase in ethanol production.

Source: https://www.icgeb.org/news/icgebs-novel-yeast-strain-increases-ethanol-production/

Technique to transform CO_2 into solid state

A team of researchers led by RMIT University in Melbourne, Australia have developed a new technique involving conversion of carbon dioxide gas into solid state and hence having potential applications in carbon sequestration. The study is part of a collaborative effort between Germany (University of Munster), the US (North Carolina State University), China (Nanjing University of Aeronautics and Astronautics) and Australia (UNSW, Monash University, University of Wollongong) , with the project being supported by the Australian Research Council Centre for Future Low-Energy Electronics Technologies (FLEET) and the ARC Centre of Excellence for Electromaterials Science (ACES).

For the purpose of converting CO2 into solid form, the researchers use a liquid metal catalyst with specific surface properties required for the process. It involves dissolving CO2 in an electrolyte liquid and also a small amount of the liquid metal. Upon passage of current through the electrolyte solution, the CO2 slowly converts into solid flakes of carbon which are naturally detached from the liquid metal surface. The carbonaceous solid thus formed can be used as an electrode or simply stored. Also, this solid carbon assumes properties of supercapacitor due to its ability to hold electrical charge and thus can be used for energy storage.

The research has shown the possibility of converting gas into solid at room temperature by the use of liquid metals as catalyst, unlike the previous processes wherein extremely high temperatures were a pre-condition for such a state conversion, thus making them industrially unviable. The study proposes an alternative and sustainable method of removal of the greenhouse gas from the atmosphere which is also efficient and scalable as per the claims of the research team.

Source: https://www.sciencedaily.com/releases/2019/02/190226112429.htm

Mobile app to monitor cardiac health developed for rural areas

In a collaborative study between Indian and Australian scientists, a new mobile based application has been developed for monitoring cardiac health of patients. The tool is targeted specifically towards the rural population which lack access to diagnostics

The app is in the form of a Clinical Decision Support System (CDSS) and can be installed on android enabled mobile phones. Through a system module, regular alerts can be sent to the health workers about high-risk individuals who need a follow up visit. Additionally, it has an interactive voice response system for the patients reminding them of their medication and follow up visits to the doctor.

The intervention has been rolled out in 18 primary health care centres, with trials taking place in states like Andhra Pradesh and Haryana, in order to test the strategy in different sets of population with PHCs having differing capacity levels. One of the other important features of the intervention is its utilisation of the already available ASHA workers network in the country, expanding their role beyond maternal and child health to non-communicable disease management and prevention. The digital health monitoring platform assumes vital significance in the wake of India having an alarming number of 140 million people diagnosed with high blood pressure, exposed to the risk of developing heart related ailments.

Source: https://vigyanprasar.gov.in/isw/New-mobile-app-may-help-in-addressing-heart-disease.html

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

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

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

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About FISD

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

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

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