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Science and Technology Dimensions of Indian Foreign Policy

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Science is the basic knowledge of nature and Technology is the practical application of that knowledge. This is sometimes not so clear. For example, we knew that penicillin works against bacteria, but not why. At each level of understanding, new science opens up, and there is new technology to be applied. Another concept is Governance. The goal of governance in any country is firstly national security and, secondly, a better quality of life for its people. Science and Technology have a very strong impact not only on society but also on the international system. There are many examples of this, such as mobile phones and smart phones. In the international system, countries which discover and use new science and technology gain an advantage - both economic and military. Because of this, all governments must deal with science and technology in an appropriate manner, and respond to new developments in both.

Science research has moved away from small laboratories and individual researchers - such as Madame Curie who worked alone in a garage sized lab processing one ton of pitchblende and extracting radium. Today, scientific research is a much larger scale operation, involving large budgets, and many researchers and facilities which might be spread across several countries. A good example is the Manhattan Project in the USA, which developed the first nuclear bomb. Governments have been funding Science and Technology research, and building large facilities for this purpose. They have put in place policies designed to stimulate and support scientific research. Science and Technology can also have disruptive effects - for instance, it can change the

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balance of power among States as well as increase inequality within them. Persons who can take advantage of Science and Technology will prosper, while those who cannot will be left behind.

In the pursuit of economic and military power, countries may try to control the knowledge of science and technology and prevent it from going to rivals. The USA and its allies set up the COCOM[1] during the Cold War to prevent technology leakage to the Soviet bloc. Various technology control regimes have come into being,[2] and there is a system of intellectual property rights which also controls access to technology; it also enables profits to be made from access to technology. There are cases of technology denial to certain countries, and India itself has been a victim of the denial of nuclear technology.[3] In response, countries which are denied access to technology will seek to develop it indigenously, or acquire it by open or covert means. Today, the main issue between the USA and China is about the illegal and clandestine acquisition of technology. The denial of nuclear technology resulted in countries such as India, Iran, and North Korea, making indigenous efforts to acquire this technology, or to acquire it clandestinely, as in the case of Pakistan. As new technology comes into the world, policymakers and civil society will continue to face such challenges.

Science Diplomacy and its Challenges

Science diplomacy is a term which was coined about 10 years ago. It is analogous to economic diplomacy, cultural diplomacy, or sports diplomacy. There have been efforts to define this concept - for example, by the Royal Society of the UK, and the AAAS in the USA[4]. One popular way of looking at science diplomacy is to regard it as composed of three components: science in diplomacy, diplomacy for science, and science for diplomacy. Science in diplomacy means the scientific inputs going into diplomacy and foreign policy making. Diplomacy for science means making use of diplomacy to gain benefits in science and technology - bilaterally, multilaterally as well as globally. Science for diplomacy means using collaborations in science and technology to bring together countries which have differences. Another way of looking at science diplomacy is based on intentions - advocacy, promotion, and influence. Yet another approach is based on geographical scope - domestic, trans-border, and global. A good working definition for most purposes would be the full integration of science and technology into the diplomatic and foreign policy framework of a country.

This concept recognises that science and technology are becoming increasingly important in international relations, and also in determining global competitiveness wherein the role of knowledge based industries is becoming increasingly critical.

The first aspect is science in diplomacy. Increasingly, global challenges such as weapons of mass destruction, climate change, cyber security, human health, energy and environment, outer space, etc., all require scientific inputs in order to understand and deal with them. These challenges are trans-border, and require the application of Science and Technology in order to resolve them, in addition to normal diplomatic efforts. This requires that science and technology experts must have a good dialogue with policymakers so that the latter are well informed about the scientific aspects of the global challenges, and the former also appreciate the diplomatic challenges involved. Many advanced countries have long recognised this, and have integrated science and technology experts into their policymaking bodies. The challenge is that policymakers must understand the basic science underlying global challenges, and the scientific community must be able to explain, in plain and simple terms, the scientific issues involved. Therefore, close co-ordination between the scientific community and policymakers is extremely important. Developing countries in particular face severe challenges in this respect, and often their delegations are not well prepared at international negotiating tables. This results in the advanced countries sometimes pushing their interests, while developing countries are not prepared to defend their interests.

There has been a steady increase in science and technology issues, on which international consultations have become more and more necessary. Similarly, increased inter-actions have been noticed on specific issues. (See Table 1). Besides, the older topics such as Chemical and Nuclear weapons, relatively newer subjects such as biotechnology, cyber security, outer space, energy, and climate change, etc., have become important in international negotiations. As technology advances, it may become necessary to review and revise older international agreements related to nuclear weapons, biological weapons,[5] etc., and devise new agreements and frameworks in areas such as internet governance, cyber security, etc. Past experience indicates that governments often react late to the emergence of new technologies, and usually only after some negative or harmful effects begin to appear - for example, on employment, environment, etc. This can happen long after the technology and knowledge of the scientists in the laboratory has emerged into the world.

Table 1: S & T Areas of Importance in Foreign Policy

S & T areas	Issues involved
• Nuclear technology • Aerospace technology • Chemical technology • ICT, including cyber security, AI • Biotechnology • Nanotechnology • Climate change and energy • Ocean science & technology • Human Health • Technology diffusion, IPRs	• Military power and balance • Economic competitiveness and development. • Harmful impact management and control • Positive cooperation and building relations • Technology control and regulation • Access to technology

Diplomacy for science is quite similar in many respects to economic diplomacy, which seeks to expand exports and increase inward investment. Diplomacy for science seeks to acquire the knowledge of science and technology to strengthen the national economy and capacity, and to participate more effectively in international discussions where science and technology are involved. External collaboration in science and technology (especially with advanced countries), and engaging in large international scientific projects, therefore, becomes important. The more advanced developing countries can use their knowledge of science and technology and their capacity to support other developing countries and, in general, to achieve the sustainable development goals.

Mega or large-scale international science projects are a good opportunity to participate in frontier scientific research at comparatively lower cost. Science research is increasingly becoming more expensive and beyond the means of individual countries, even for the large economies like the USA. International scientific collaboration is growing, and more and more projects are coming up in this sector. India has participated in projects such as CERN, ITER, Thirty metre telescope, square kilometre array, and LIGO. India missed the opportunity to participate in the Human Genome Project and the International Space Station. Now that India has given manned space exploration some priority, it is possible that it may participate in large-scale international projects involving manned space flights and space habitats.

Some international projects in which India has taken the initiative are the International Solar Alliance (ISA) launched in 2015 with France as the main partner, and the ICGEB which was launched in 1983 together with Italy. The NAM Centre for Science and Technology was set up in India in 1989. The ICGEB[6] was intended to help developing countries to gain access to the newly emerging field of genetic engineering and biotechnology, and to apply it to problems faced by them. The ISA is a global platform that seeks to bring together and mobilise technology and finance to implement solar energy projects in member states.

Large-scale international projects and activities in science and technology require detailed negotiations to reach agreement and for implementation. Diplomats and scientists need to work closely together in this process. Significant benefits can accrue through participation in such projects. For example, India's participation in CERN is on a win-win basis where India supplies components and equipment, the value of which then finances Indian researchers who work at CERN. As mankind goes deeper into the frontiers of science, the cost of doing research and setting up facilities will become higher. It may well be beyond the ability of a single country to finance this research. For example, the USA which had embarked on a large particle accelerator project in Texas had to abandon it because of the high costs, after which CERN became the leading laboratory in this field. Now, China is also trying to build a large accelerator by 2022, and it remains to be seen whether it will be able to build it. Therefore, in the future, one can expect more and more large scale international science projects which will be multinational in character.

Such large projects could be of two types: a single large facility like CERN; or a network of a large number of institutions dispersed around the world, as is the case with LIGO. Even in the case of CERN, the data generated from experiments is shared through a worldwide network (it was CERN that invented the World Wide Web) of collaborating institutions across the world who carry out analysis and research on the data. These trends are promising, and could offer good opportunities to institutions and universities across the world to participate in large scale international science projects, and collaborate with research groups.

Science and Technology for Development

Another important area of diplomacy for science is the focus on development, particularly sustainable development. Science and technology is critical for development. Development has to be seen in its widest context. The international community had agreed in 2015 upon a set of 17 Sustainable

Development Goals (SDGs) which all countries have undertaken to achieve by 2030. To support this effort, the UN and member states have established a Technology Facilitation Mechanism (TFM). This mechanism is intended to enable developing countries to access the technology which is required to achieve the SDGs. Given that the SDGs cover subjects that cut across several line Ministries and also the States of the union in India, NITI Aayog has been designated as the nodal coordinating agency for implementing the SDGs. It is very important for developing countries to share the technology which they have used or developed for achieving the SDGs. Therefore, South-South cooperation in this area is very important. Developing countries have come up with innovations which are very cost effective, and relevant to their needs. For example, a bicycle ambulance has been developed for rural areas to transport patients across rural roads. Such frugal innovation needs to be promoted and supported.

The SDGs were adopted in 2015, and every year, a Sustainable Development Report is published which ranks the performance of countries according to the SDG targets. Table 2 shows the performance and ranking of some countries in this respect. The top rank was secured by Denmark in 2019, while India's rank is 115. In Asia, Japan is ranked highest at 15. In South Asia, Maldives, Bhutan, and Sri Lanka have done quite well. In South Asia and in Sub-Saharan Africa, performance in achieving SDGs - especially in the larger countries - needs to be improved considerably.

Table 2. SDG Performance Index and Global Ranking, 2019

Country	**SDGP Index**	**Ranking**	**Country**	**SDGP Index**	**Ranking**
Denmark	85.2	1	Cuba	70.8	56
Sweden	85.0	2	Brazil	70.6	57
Finland	82.8	3	Iran	70.5	58
France	81.5	4	Mexico	68.5	78
Germany	81.1	6	Turkey	68.5	79
Norway	80.7	8	Bhutan	67.6	84
New Zealand	79.5	11	Egypt	66.2	92
UK	79.4	13	Sri Lanka	65.8	93
Japan	78.9	15	Saudi Arabia	64.8	98
RO Korea	78.3	18	Indonesia	64.2	102
Chile	75.6	31	Nepal	63.9	103
USA	74.5	35	Myanmar	62.2	110
China	73.2	39	South Africa	61.5	113

Thailand	73.0	40	India	61.1	115
Maldives	72.1	47	Bangladesh	60.9	116
Algeria	71.1	53	Pakistan	55.6	150
Vietnam	71.1	55	Afghanistan	49.6	153
Russia	70.9	55	Nigeria	46.4	159

In South Asia, Sub Saharan Africa, countries with large populations are at the bottom of the rankings. China has improved its ranking considerably.

Source: http://www.sdgindex.org

Science and Technology solutions developed in India for tackling development challenges can be very useful for other developing countries because the conditions in many developing countries are similar to that found in India. In fact, the development challenges which can be found anywhere are also present in India. Thus, India has a huge repository of experience in tackling development challenges, and in using science and technology which could be very useful for other developing countries. Therefore, the Government of India has developed an Indian technical and economic cooperation programme (ITEC) through which India provides capacity building assistance as well as training to personnel from other developing countries. Indian Missions abroad play a vital role in this programme.

Science and Technology Ecosystem Issues

Science and technology does not function in a vacuum. It is part of the larger ecosystem of the country. Human resources or brain power is the most important element of this ecosystem. The other elements of the ecosystem include academic and research institutions, funding agencies, IPR and commercialising agencies, regulatory frameworks, and business and civil society. In many developing countries, the Science and Technology ecosystem has deficits, especially in terms of the capacity of academic and research institutions and the funding for research. This results in the so-called brain drain or migration of skilled science and technology personnel to advanced countries with more favourable ecosystems. The Diasporas from developing countries include a substantial number of highly qualified and experienced science and technology personnel working in advanced countries. Their involvement in strengthening the capacity of the home country could be extremely beneficial. Many countries have developed innovative programs to attract their Diaspora science and technology personnel to engage with their home country. India has a very large Diaspora with large numbers of science and technology personnel working in the advanced countries, and this constitutes an important resource.

Retaining highly skilled science and technology personnel is also a challenge. In a competitive world, policies need to be flexible, realistic, and responsive to the particular needs of science and technology workers. Adequate facilities, infrastructure, and funding are also important. There is global competition for attracting the best science and technology talent, and academic and research institutions must face this challenge. India has very good science and technology graduates coming out of institutions; but because they do not find enough opportunities to work within the country, they leave the profession or migrate to a country which has a better ecosystem. Apart from the USA, which attracts a considerable amount of foreign science and technology talent, other countries such as Canada, European Union members, and China are also seeking to attract foreign science and technology talent.

The commercialisation of research outputs is particularly important. For this reason, many universities and research institutions have associated business incubators and mechanisms to facilitate start-ups. In India, academic research institutions do produce high quality Science and Technology talent. However, the lack of sufficient capacity with research institutions and limited funding for research as well as the limited development of commercialising agencies are all weaknesses. As a result of these deficits in our ecosystem, India faces the problem of the so called brain drain where the best of a Science and Technology talent migrates to advanced countries in search of better opportunities. Therefore, India has to strengthen and build sufficient capacity in its Science and Technology ecosystem so that its Science and Technology talent can find adequate opportunities to work in India.

The Indian Science and Technology Ecosystem

Table 3 presents some data on India's Science and Technology ecosystem.[7,8] Gross expenditure on R and D (GERD) is around 0.7 percent of GDP, which is well below that in many other countries. UNESCO has suggested a benchmark of 2 percent of GDP for GERD. This is what India should aim at. The number of researchers per million of population in India is fairly low. The share of the private sector and academic institutions in research and development expenditure is around 40 percent, which is quite low compared with some advanced countries where it is around 60 per cent. Unfortunately, many of our academic institutions and universities, though producing high quality Science and Technology talent, do not have sufficient R&D activity. This needs to be corrected in the future.

Table 3: India Science and Technology Ecosystem Data

- India's total spending on R & D was 0.7 percent of GDP (2016 - 17), much below that in major nations such as the USA (2.8), China (2.1), Israel (4.3), and Korea (4.2).
- The number of researchers per million population in India was 218 in 2015, well below that of China (1200), Brazil (884), Russia (3000), and South Africa (473).
- Gross Expenditure on R&D (GERD): Central Government 45.1 per cent, State Governments 7.4 percent, Higher Education 3.9 percent, and Public Sector Industries 5.5 percent, Private Sector Industries contributing 38.1 percent.
- The R & D spending of central government agencies is dominated by 8 major scientific agencies.
- Higher Education Sector participation in GERD by India is quite low. Many universities lag in R & D.

The R & D expenditure in the government sector in India (Table 4) is dominated by 8 science departments. The biggest share of expenditure is by three departments: DAE, DOS, and DRDO, which undertake both civilian and defence related research and development. There are 5 other science departments whose expenditures are relatively lower. There are also a number

Table 4: Central Government Science and Technology Related Departments[9]

Department/Agency	**Budget 2018-19 (Rs. Crores)**
Principal Scientific Adviser to the GoI	**NA**
Defence Research and Development Organization (DRDO)	17861
Dept of Atomic Energy (DAE)	13970
Department of Space (DOS)	10783
Department of Agricultural Research & Education (DARE/ICAR)	7800
Department of Science and Technology (DST)	5110
Department of Scientific and Industrial Research (DSIR)	4800
Department of Biotechnology (DBT)	2410
Department of Health Research (ICMR)	1800
Other Ministries with significant R & D activities: Ministry of Electronics and IT; Ministry of Environment, Forests, and Climate Change; Ministry of Earth Sciences; Ministry of New and Renewable Energy; Ministry of Food Processing Industries; etc.	N/A

of other line Ministries, which are not regarded as scientific Ministries but which do play an important role in R and D. This is a rough picture of R & D activity in the government sector. The data collection on R & D spending in India needs to be further refined, and there are many R and D activities not included at present.

It is important to look at the large research centres which are being set up in talent rich countries, like Israel and India, by multinationals such as GE, Microsoft, etc., and to examine how they interact with the host country. An advanced economy with a sophisticated ecosystem develops linkages with ecosystems of countries such as India and Israel in order to benefit from the human Science and Technology talent present within the latter. There are basically two modes of interaction. The first involves the recruitment of Science and Technology talent from the less advanced country to work in R & D institutions in the more advanced country. This mode is important, where the physical proximity to R & D facilities and infrastructure in the advanced country is essential. The second mode involves the setting up of research centres in the less advanced country where talented Science and Technology professionals can be hired to work and generate knowledge. This mode is more cost effective where large R & D physical facilities are not required - for example in software and information technology products. In both these modes, the fruits of R & D are largely captured by the advanced economies through their institutions and enterprises. They are able to exploit the generated knowledge and commercialise it in the larger and global markets. A small part of the benefits of these modes of R & D activity may be shared with the less advanced economy. This may be regarded as a normal and inevitable phenomenon, but policy makers need to be aware of its consequences, and seek to negotiate the best outcomes possible.

India’s Science Diplomacy Outreach

India’s bilateral cooperation in Science and Technology with various countries presents some noteworthy features. India’s bilateral Science and Technology agreements are fairly simple in structure. They are based on cost sharing, joint implementation, agreed programme of cooperation activities, and periodic review meetings. The DST has such agreements with over 80 countries. Out of these, 44 agreements are considered to be active. The DAE and DOS also have bilateral agreements with various countries. Better coordination of external engagement of various science departments could enable synergies to be exploited, and prove to be beneficial.

India's present network for science diplomacy is small. It has science counsellors located in the Indian missions in Russia, USA, Germany, and Japan. In addition, there are some personnel from DAE, DOS, and DRDO in a few other missions. In all the other countries, Science and Technology cooperation work is handled from India. The work tends to be episodic, and mostly event driven. It is necessary to have capacity for handling Science and Technology cooperation in Indian missions in several important countries. This can be achieved by training Indian diplomats to handle Science and Technology cooperation activities in a manner similar to training given for economic diplomacy. The Ministry of External Affairs of India has recently decided to set up a Division for New, Emerging, and Strategic technologies, recognising the increasing role of technology in international engagement. The Office of the Principal Scientific Adviser to the Government of India plays a key coordinating role in advancing Science Technology and Innovation in the country.

The networks operated by other countries for science diplomacy are quite diverse. The UK has an independent science innovation network which has personnel located in 30 countries. The USA gives its career diplomats training in Science and Technology cooperation work, and stations them abroad. Given India's increasing role in Science and Technology, it is clear that India will have to further expand its external Science Diplomacy network in the most appropriate way. Operational guidelines for diplomats to carry out Science and technology work in the field can be devised similar to that for economic diplomacy.

Building Bridges through Science Diplomacy

Science for diplomacy involves promoting Science and Technology cooperation to build bridges between countries which have troubled relations. There are several examples of this in the past. The USA has used science cooperation to build bridges with countries such as the Soviet Union during the Cold War, as well as with China, North Korea, Cuba, and Iran. The underlying idea is that scientists being more objective can work together on problems of common interest to countries, and they can serve as a channel of communication if required. Among South Asian countries, one can envisage a Science and Technology effort aimed at tackling common problems such as air pollution, weather forecasting, energy and environment as well as health and disease control. The potential is there, but so far it remains to be exploited.

And an interesting case of science for diplomacy is the SESAME project.[10] This is a research facility located in Amman, Jordan. This accelerator produces several beams of X Rays of widely varying energies which are useful for scientific experiments. The facility started operating in 2017. The 8 members include Israel, Iran, Palestinian authority, and Pakistan. It is located in Jordan, which is the only country which has diplomatic relations with all the other members. Despite troubled political relations among several countries, their scientists are managing to work together. About 20 other observer countries are supporting this project.

Another important upcoming project is the EU's Horizon Europe (2021 - 27),[11] with funding of about Euros 100 billion. This project is an important opportunity for universities and research institutions in India to participate with EU counterparts in various research activities. It is, therefore, important to follow the development of Horizon Europe. It is hoped that India will get the same opportunities for its researchers to participate that was available in the previous EU programmes – Horizon 2020 and the Framework Programme.

India and Science Diplomacy Challenges

There are some science and technology areas where India has had to face diplomatic challenges. The first such area is nuclear technology. India did not sign the discriminatory Non Proliferation Treaty, and has developed its own independent strategic nuclear capability. This resulted in India being put on a nuclear embargo as far as nuclear technology, equipment, and materials are concerned. Therefore, India had to make a big indigenous effort to develop its capability in the nuclear field. Finally, during 2005-08, through difficult negotiations with the USA, IAEA, and other countries, India was able to secure recognition of its responsible nuclear posture, and get a waiver from the NSG that enabled normal nuclear commerce. This was the result of a major effort in science diplomacy on the part of our scientists and diplomats working together.[12] Today, India is treated as a de facto nuclear weapons state as far as the nuclear regime is concerned. India has also embarked on an ambitious nuclear power programme involving both indigenous reactors and imported reactors, and a unique Thorium based fuel cycle.

In the area of aerospace, India was denied access to certain space technology such as cryogenic engines. It had to develop this technology through its own efforts. Its space programme has now gained international recognition. India has recently joined the MTCR and two other Technology Control Groups.[13]

In the area of Climate Change and energy, India's role is crucial. A solution to global climate change requires the support of large countries such as India and China. India has committed to reducing the carbon intensity of its GDP, and has also launched a major initiative - the International Solar Alliance (ISA) - with France. India is making a major effort to move away from fossil based energy production. However, its needs for economic growth are great, and cannot be sacrificed. Both technology and finance are critical for India and other developing countries to move into a low carbon pathway. Despite the lack of commitment on the part of certain countries, India will continue to make all possible efforts to tackle climate change, especially by bringing down the carbon intensity of its GDP, and going in for renewable energy on a large scale. The ISA, launched recently, is a global platform to bring together technology and finance for solar energy projects. Its membership can now include all members of the UN. There has been rapid progress in solar photovoltaic technology and energy storage technology, which has brought down the cost of solar energy considerably, and future developments look promising.

Emerging Challenges for Science Diplomacy

In the Information and Communication Technology Sector, India has made good progress, and is a major supplier of IT related services to the world. This sector has witnessed rapid change and technological development which is continuing in areas such as artificial intelligence, digital manufacturing, the internet of things, etc. There is concern over the disruptive effect of these technologies, especially on employment. In addition, the emergence of cyber crime, cyber terrorism, cyber warfare, and the misuse of social media has created new problems which require action at the international level. Lethal autonomous weapons, which integrate artificial intelligence into weapons platforms, are being rapidly developed. Concern over the use of "killer robots" has led to international discussions about how to regulate the use of these weapons. These global challenges will have to be met through science diplomacy.

Rapid advances in life sciences have also thrown up new challenges for science diplomacy that are being discussed in international forums. Today, the genomes of organisms can be rapidly sequenced, modified with high precision, and even synthetic genes can be introduced. This has tremendous potential applications in health, agriculture, food, environment, energy, and industry. But concerns have emerged, including the use of genetically modified agricultural and food products, assisted human reproduction, the genetic modification of humans, and the potential for the creation of deadly bio weapons and bioterrorism.

Managing the oceans has also given rise to science diplomacy challenges. Marine biodiversity in the oceans is under threat due to over exploitation, pollution, and climate change. Efforts are going on in the UN to negotiate a new wide ranging international treaty that will protect marine biodiversity in the areas beyond national jurisdiction. Discussions indicate that there are many divisive issues involved which will require difficult negotiations. India has an important stake in two large marine ecosystems (LMEs):[14] the Bay of Bengal and the Arabian Sea. Both have been assessed at being at high risk, and need the protection of their biodiversity.

There are also a number of science diplomacy challenges in outer space. The fact that satellites can be used for both civil and military purposes has given rise to anti-satellite weapons technology. This has been already tested by countries such as the USA, Russia, China, and now India. There is a growing concern over militarisation and weaponisation of outer space. The USA, Russia and China are testing and developing a new class of hypersonic powered and gliding vehicles that can travel and manoeuvre at very high speeds on the fringes of the earth's atmosphere. These vehicles could carry nuclear weapons, and could be practically impossible to defend against. Space debris, which has accumulated around the earth over decades, is now posing a threat to space flight. As mankind moves from the exploration of the Moon and Mars to exploitation, questions of mineral and other rights on extra terrestrial bodies (principle of common heritage of mankind versus first come first serve) are likely to surface.

The future agenda for science diplomacy is likely to become increasingly complex and challenging. New developments in the future will bring new challenges for scientists, diplomats, and policymakers. Therefore, it is important for developing countries to be adequately prepared to tackle these challenges, and protect their interests. Developing countries will need to strengthen South-South cooperation to achieve the sustainable development goals, together with willing partners from the North.

Notes :

[1] The Coordinating Committee for Multilateral Export Controls (CoCom) was established by the Western Bloc after the end of World War II, during the Cold War, to put an embargo on Comecon countries. CoCom ceased to function in 1994, and the then-current control list of embargoed goods was retained by the member nations until the successor, the Wassenaar Arrangement, was established.

[2] These include the Nuclear Suppliers Group (NSG), the Missile Technology Control Regime (MTCR), the Wassenaar Arrangement (WA), and the Australia Group (AG) for controls over nuclear technology and materials, missile technology, high-end technology, and chemical technology.

[3] India was denied access to nuclear technology and materials following its nuclear explosion test in 1974. This embargo was lifted after negotiations with the USA in 2005 and the NSG in 2008, giving India the same status as a nuclear weapons state.

[4] Turekian, V. A., et al., "Science Diplomacy: A Pragmatic Perspective from the Inside", *Science and Diplomacy*, January 2018, at http://www.sciencediplomacy.org/article/2018/pragmatic-perspective

[5] For example, the review conference for the Nuclear Non-proliferation Treaty will be held in 2020, and the review conference for the Biological Weapons and Toxins Convention will be held during 2021. Such review conferences are held every 5 years.

[6] The International Centre for Genetic Engineering and Biotechnology (ICGEB) was initially established as a project of the United Nations Industrial Development Organization (UNIDO) in 1983 and, since 1994, is an autonomous entity with three components and 65 members. The Centre for Science and Technology of the Non-aligned and Other Developing Countries (NAM S&T Centre) has been established in New Delhi, India, in August 1989.

[7] "Research and Development Statistics at a glance, 2017 - 18", National Science and Technology Management Information System (NSTMIS), DST; at http://www.nstmis-dst.org/Statistics-Glance-2017-18.pdf

[8] "R & D expenditure ecosystem- current status and way forward", July 2019, Office of the Principal Scientific Adviser to the Government of Indiahttp://psa.gov.in/sites/default/files/pdf/RD-book-for-WEB.pdf

[9] Union Budget 2018 - 19, Government of India, at https://www.indiabudget.gov.in/budget2018-2019/vol2.asp

[10] The Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) is an independent laboratory located in Amman in Jordan. The founding members are: - Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority, and Turkey. The project was launched in 1999. See, https://www.sesame.org.jo for details.

[11] Horizon Europe is a European Union scientific research initiative for 2021 - 2027, successor to the current Horizon 2020 program. The proposed spending for Horizon Europe is approximately €90 billion compared to €77 billion for the current Horizon 2020.

[12] Grover, R. B., "Resumption of International Civil Nuclear Cooperation, Dr RIS Case Study, 2019", contains a detailed account, see, http://fisd.in/sites/default/files/FISD%20Case%20Study_NEW_R%20B%20Grover-min.pdf

[13] India joined the Missile Technology Control Regime (MTCR) in 2016, the Wassenaar Arrangement in 2017, and the Australia Group in 2018.

[14] Large Marine Ecosystems (LMEs) are wide areas of ocean space along the Earth's continental margins, spanning 200,000 square kilometres or more, and extending from coastlines seawards. The world's coastal oceans are divided into 66 LMEs. For details see, http://www.lmehub.net

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