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*Role of Technology in India's Foreign Relations**

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Technology is as old as civilization. Throughout history, the search for knowledge and its application through technology have been important determining factors in a society's progress. In the competition for dominance and control, societies that forged ahead in the mastery of basic knowledge and technology succeeded, sometimes far beyond expectations.

Technology's paradigm-changing, force-multiplying effect has brought about major historical changes and relations among societies. Technology's impact on warfare and military balance has been particularly striking, enabling relatively smaller forces with superior technology to prevail over numerically superior adversaries.

International relations comprise a variety of relationships among states within the international system and complex of global issues. Power, a key factor, may be described in terms of control over key resources, capabilities, and influence in international affairs. Hard power relates primarily to coercive power, such as the use of force; while soft power covers the persuasive domain, such as economics, diplomacy and influencing people. Technology plays a critical role in determining power, both hard and soft.

A society's mastery of basic knowledge and technology is a key determinant of its military and economic strength and its role in the international system. But such leadership cannot remain a monopoly indefinitely, since other competitors can acquire knowledge and technology. Success in efforts to control or limit the spread of technology will be temporary at best. At the same time, merely acquiring technology without the capability to derive it from basic knowledge offers only limited advantages; it may also negatively impact genuine indigenous capability. In other words,

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remaining ahead in knowledge and technology requires a continuous and sustained effort.

The quest for knowledge and technology requires not merely material resources. A key role is played by human resources, especially of innovative thinkers and researchers. There is a distinction between mastering the "content" or "hardware" of knowledge, and being able to "innovate and apply" or the "software" of knowledge. Both are important – mastery over content as well as ability to innovate.

The pursuit of technology requires innovation and improvisation, the ability to question conventional assumptions and beliefs, and move ahead into uncharted areas. In the early twentieth century, the fundamental conventional assumptions of classical physics were challenged and overthrown, and a whole generation of physicists developed quantum mechanics and relativity. This spirit of challenge and enquiry continued, leading to many major advances. A.P.J. Abdul Kalam has called this process as "igniting of minds", by which one can soar beyond the framework of conventional knowledge and explore new horizons.

Early Years – Nehru's Contribution

India had several internationally renowned scientists before independence – Srinivas Ramanujam, the mathematical genius, Satyen Bose, C.V. Raman, and astrophysicist S. Chandrasekhar in the US.

After independence, Prime Minister Jawaharlal Nehru gave high priority to science and technology. Dr. Homi J. Bhabha was tasked to put in place a long-term strategic plan for nuclear science and technology. With remarkable foresight, Nehru also promoted science and technology institutions, such as the first Indian Institute of Technology (IIT) in Kharagpur in 1951, the Indian Space Research programme in the 1960s, and the Council for Scientific and Industrial Research (CSIR).

This thrust in science and technology continued during Indira Gandhi's premiership, including the Pokhran I nuclear explosion in 1974. India became host to one of the two centres of the International Centres for Genetic Engineering and Biotechnology (ICGEB). Prime Minister Rajiv Gandhi also gave strong political support to science and technology, including Information Technology (IT) and telecommunications.

The driving force behind India's science and technology came from government initiatives such as those in atomic energy, space and biotechnology.

However, in later years, the private sector was the driver in areas such as IT. In the area of scientific and technical resources, the IITs proved to be a successful model.

India's Foreign Relations

The principles of India's foreign relations were initially formulated by Nehru. These included non-alignment with either of the two blocs in the Cold War, peaceful coexistence and constructive collaboration with all countries irrespective of their internal governance systems, and securing the largest possible space for India's indigenous economic, scientific and technological development considered vital for the removal of poverty. The Cold War has faded away, and in its wake there are multiple poles of power – the US, China, European Union (EU) and Russia. But the global situation is marked by instability, growing competition and lack of collaboration, requiring continuous and sophisticated adaptation of our foreign policy.

Technology and International Relations

In the post–World war II era the advent of nuclear weapons and the rivalry between the two power blocs posed a major challenge to the international system. While the basic science behind nuclear weapons was fairly simple, in practice the construction of nuclear weapons required formidable technical efforts in the enrichment of uranium and weapon design expertise. The nuclear weapon arms race resulted in numerous tests, and the rise of USSR, UK, France, and China as nuclear weapon states.

For these reasons, nuclear arms control was the first area where technology impacted international relations in a big way. The various arms control negotiations such as the Nuclear Non-Proliferation Treaty (NPT), the nuclear test ban treaties, and the chemical and biological weapons conventions, etc., involved technology-related issues, especially in the verification and compliance aspects.

In the 1970s international debate focused on the North–South divide, with the developing countries under the umbrella of the G-77 demanding fundamental changes in the international order. One key area of discussion was access to technology on fair and equitable terms. Multinational corporations, which had the technology, would grant access to it only on their terms, which often included restrictive business practices that went

against the competition laws of their own countries.

In this context, India's diplomatic efforts had to take into account the growing role of technology-related issues in international relations. Some of these areas are discussed below.

Nuclear Technology and India's Foreign Relations

Nuclear technology is probably the most significant challenge in India's foreign relations. After World War II, shocked by the horrors of Hiroshima and Nagasaki, there was a strong demand for abolition of nuclear weapons, articulated forcefully but pragmatically by Nehru. However, the nuclear weapon states – US, USSR, Britain and France – opposed this. While Britain benefited from the US in access to nuclear weapon technology, China derived similar support from the USSR. The Cold War rivalry, which reached its most dangerous manifestation in the Cuban missile crisis of October 1962, and China's nuclear tests in 1964, set the stage for moving ahead with the NPT. This unequal and unbalanced treaty legitimized the possession of nuclear weapons in the hands of five states, while placing numerous curbs on access to and application of nuclear technology by other states, coupled with only lip service to reduction in nuclear arsenals. India and several other countries rejected this unequal treaty. This implied that these countries would face difficulties and restrictions in the area of nuclear technology.

India's nuclear explosion in 1974, declared as being for peaceful purposes, led to severe restrictions on India's access to nuclear technology, materials and equipment. The Nuclear Suppliers Group (NSG) was set up to enforce a technology denial regime. This led to a massive indigenous effort under the Bhabha Atomic Research Centre (BARC) and Department of Atomic Energy (DAE) to develop India's strategic and civil nuclear programmes. India's foreign policy in this sphere had to counter the efforts in the international community to isolate and strangle India's nuclear programme. The main thrust of India's policy was – to continue to develop its nuclear programme, reject the NPT as an unequal and unbalanced treaty, to call for the abolition of nuclear weapons, and support confidence-building measures such as ban on first use of nuclear weapons, measures to reduce false alerts and alarms, etc.

In May 1998 India conducted a series of five nuclear weapon tests, including one thermonuclear device. Pakistan followed, with a series of tests

conducted in the Chagai Hills. The international reaction was severe, and prospects of a nuclear war between India and Pakistan were widely discussed. The nuclear embargo on India was tightened, including economic pressures aimed at curbing its purely indigenous nuclear programme. In contrast, Pakistan, which had developed its nuclear weapons through the clandestine A.Q. Khan nuclear smuggling enterprise, plus weapon designs and political support from China, was relatively unfettered.

India's response to this international pressure was carefully calibrated. India continues to support the abolition of nuclear weapons, a goal which the US had initially described as "unrealistic", but which now finds some support under President Barack Obama. India has declared a unilateral moratorium on nuclear testing but continues to stay out of the Comprehensive Test Ban Treaty (CTBT), which it regards as a part of the unequal NPT regime. India supports a no-first-use policy on nuclear weapons, despite the existence of troubled relations with two of its neighbours – China and Pakistan. If possible, India would be ready to sign the NPT as a nuclear weapon state; but has declared it will respect the "principles" contained in the NPT, while not signing it.

India's persistent efforts yielded positive results with the July 2005 Manmohan Singh-George W. Bush joint statement on separation of India's civil and strategic nuclear programmes, the former to be placed under international safeguards, and in exchange benefit from full civil nuclear cooperation. Over the next three years intensive negotiations and discussions with internal constituents in both countries led to amendment of US domestic law, a civil-military nuclear separation plan in India, an India-IAEA (International Atomic Energy Agency) safeguards (inspections) agreement and the grant of an exemption for India by the NSG. Once the IAEA's India-specific safeguards agreement enters into force, some thirty-five Indian nuclear installations will come under safeguards, in a phased manner.

The joint effort by India and the US to get a waiver from the forty-five-nation NSG, in the face of opposition from several countries, must be seen as a landmark in Indo-US diplomatic cooperation. The NSG granted the waiver to India on 6 September 2008, allowing it to access civilian nuclear technology and fuel from the NSG-bound countries. This waiver makes India the only known country with nuclear weapons that is not a party to the NPT but is still allowed to carry on nuclear commerce with the rest of the world. India's responsible stewardship of nuclear technology and its declaration on nuclear

testing helped this process.

India will continue to face challenges in nuclear policy. It is under pressure to sign and ratify the CTBT. Moves to negotiate a Fissile Material Cut-off Treaty (FMCT) gained momentum after the Obama administration recently changed the US stance on verification, but Pakistan has blocked progress. FMCT would seek to prohibit further production of fissile material for nuclear weapons or other explosive devices. It would be difficult to accept unless the goal of a credible nuclear deterrent is achieved. Future FMCT negotiations could pose a challenge for India.

In the area of civil nuclear cooperation, India is now able to import uranium fuel for its civilian reactors, which have been run at low output due to fuel shortages. Some countries like Australia still insist that India should join the NPT before they can do business with India in this sector. The Nuclear Liability Bill, recently approved by Parliament, is a step forward in facilitating civil nuclear commerce, especially with the USA, although some changes are being called for in the legislation. But the nuclear power sector in India remains restricted to the government sector and the question is whether this model can manage the financial and technical resources for implementing India's ambitious nuclear power programme.

Space and Missile Programme

India's space programme started under the DAE in 1950. It gained momentum under the Indian National Committee for Space Research (INCOSPAR), founded in 1962 with Vikram Sarabhai as its chairman. The Indian Space Research Organization (ISRO) in its modern form was created by Vikram Sarabhai in 1969. The development of launch vehicles, which has both civil and military applications, involved critical and closely guarded technology subject to restrictions. The USSR was a strong partner in India's programme. ISRO went in for a long-term strategic plan of indigenous launch vehicle capability. Over the years, this approach resulted in successful development of increasingly powerful launch vehicles, such as SLV (satellite launched vehicle), ASLV (augmented SLV), PSLV (polar SLV), and finally the GSLV (geosynchronous SLV).

GSLV-I has a Russian-made cryogenic third stage, which is to be replaced with an identical Indian-built one for GSLV-II. In July 1993, under US pressure, Russia went back on its agreement to transfer cryogenic technology to India

on the grounds that it would violate the Missile Technology Control Regime (MTCR). In lieu of cryogenic technology, Russia agreed to sell two additional cryogenic stages to India. Following Russia's refusal, India had to develop cryogenic technology on its own, which is a formidable feat. The first launch of the rocket with Indian-made cryogenic engine in April 2010 was a failure. The next launch is likely to take place within a year.

To restrict the spread of missile technology, the MTCR was established in April 1987 by Canada, France, Germany, Italy, Japan, UK and the US and now includes thirty-four countries. The MTCR was created to curb the spread of unmanned delivery systems for nuclear weapons, specifically delivery systems that could carry a minimum payload of 500 kg to a distance of over 300 km. In October 1994, to make the enforcement of MTCR Guidelines more uniform, the member states established a "no undercut" policy: if one member denied the sale of some technology to another country, all members must adhere to the decision.

Faced with a technology denial regime, India had to develop its indigenous missile capability. This programme over 1980–2007 has successfully developed short- and intermediate-range missiles for various defence applications. Notable is the intermediate-range ballistic missile Agni III (range 3500 km), followed by Agni V with a longer range. India and Russia have collaborated in developing the world's only supersonic cruise missile, BrahMos, with a range of 290 km (below the MTCR threshold) and speed of Mach 2.8. A hypersonic Mach 8 version BrahMos II is under development.

Thus in the defence field, India has to contend with a number of technology denial and restrictive regimes, while meeting its requirements of defence equipment.

Wassenaar Arrangement

The Wassenaar Arrangement is a multilateral technology export control regime (MTECR) with forty participating states. Restricted technologies include a Munitions List, a Sensitive List and a Very Sensitive List. The last includes materials for stealth technology, equipment that can be used for submarine detection, advanced radar, and jet engine technologies. India is not a party to this arrangement, which is a successor to CoCom (Coordinating Committee for Multilateral Export Controls), a group set up during the Cold War to prevent leakage of technology from the West to the East bloc.

US Technology Control Regime

The US, a leading country in terms of technology development, has put in place a system of controls to prevent sensitive technology leaking to hostile entities. The Bureau of Industry and Security (BIS) of the Department of Commerce deals with issues involving national security and high technology. It regulates the export of sensitive goods and dual-use technologies; enforces export control, anti-boycott, and public safety laws; cooperates with and assists other countries on export control and strategic trade issues; assists US industry to comply with international arms control agreements. Many sensitive goods and technologies (for example, encryption software) require a permit from the Department of Commerce for export. Recently, India and the US signed an end-user verification agreement enabling the US to monitor high-end defence and sensitive technology supplied to India.

International Scientific Collaboration

Research in frontier basic sciences is becoming increasingly costly and beyond the reach of individual nations, even the US. One such example is the Large Hadron Collider Project (LHC) under CERN (Counseil européen pour la recherché nucléaire, European Council for Nuclear Research), Geneva. India has participated in this $9 billion project both in supplying components for the LHC as well as software services and is also a partner in some of the scientific experiments. The value of Indian-supplied components and services to the LHC is calculated at European rates, and the amount this represents is available for funding Indian scientific workers. This is a particularly effective way for countries such as India to participate in frontier research in basic sciences. Another such project is the International Thermonuclear Experimental Reactor (ITER) at a cost of some $6–18 billion, scheduled for completion in 2018. Other examples are the Human Genome Project and the International Space Station. Such international scientific collaboration opportunities are likely to increase in the future, and need to be exploited effectively.

Intellectual Property Rights

India faced a difficult challenge during the TRIPS (Agreement on Trade Related Intellectual Property Rights) negotiations in the WTO (then GATT) during the Uruguay Round (1986–1994). Intense lobbying by the US, EU, Japan and other developed countries forced India to yield ground especially on the issue of product patents, which India had not recognized. This had enabled Indian

pharmaceutical companies to reverse engineer drugs and discover alternative production processes and produce drugs at lower costs. Indian patent law had provided for process patents and not product patents, and had also several provisions regarding working of patents and compulsory licensing in the public interest. The US pharmaceutical lobby was opposed to these provisions in Indian legislation and mounted a campaign against India, Brazil and other major developing countries. Indian industry also softened its position, perhaps due to the emergence of research and development (R&D) capability. Public and consumer awareness of these issues was not deep.

The situation involved a compromise on India's interests in the fields of trade, copyright and patents, with the country being a creator as well as a consumer of intellectual property. India joined the TRIPS agreement and amended its laws by the deadline of 2005. Many critics contended that this would lead to higher prices for drugs in India. The 1994 TRIPS agreement has been widely criticized as being unbalanced in favour of patent protection as against the public interest.

The Indian negotiations were handled by the Ministry of Commerce as the nodal ministry handling GATT, with participation by the Ministry of External Affairs and the Ministry of Industry. Due to the complex nature of negotiations within the WTO, and growing awareness of the issues, in later years, the consultation and coordination within government as well as with other stakeholders and developing countries has become much stronger and broad based. For example, during the ongoing Doha Round launched in 2001, India's key interests, including those involving TRIPS, were much more forcefully articulated both on its own, as well as through platforms such as the G-20 group of major developing countries. As a result the Doha Round negotiations have been much more difficult and long drawn out.

Chemical Weapons Convention

The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (Chemical Weapons Convention, 1993) is an arms control agreement which outlaws the production, stockpiling and use of chemical weapons. While the main purpose is the prohibition of production and use of chemical weapons and destruction of all chemical weapons, the convention also has provisions for systematic evaluation of chemical and military plants and for investigation of allegations of use and production of chemical weapons based on intelligence of other

state parties. The convention distinguishes three classes of controlled substance, chemicals which can either be used as weapons themselves or used in the manufacture of weapons.

The control regimes depend on the nature of the chemicals and their use in industry. The complex nature of the chemical industry as well as the toxic nature of many chemicals makes the implementation of the convention difficult. Chemicals that are used in industry, but which can also be used as weapons either directly or indirectly as precursors (dual use), must be registered, monitored, and are subject to export clearances. India, which has a large chemical industry, has had to make a special effort to implement the provisions of this convention. Nevertheless, the CWC is widely accepted, with 188 of 195 UN member states having signed it.

Services Trade

The rapid development of information technology especially since the 1990s has generated a number of technology-related issues which have become important in international negotiations. Trade in services has become an important issue.

Services trade has been a subject of intense international negotiations. A General Agreement on Trade in Services (GATS) was negotiated during the Uruguay Round and finalized in 1995. The development of information technologies and the internet have expanded the range of internationally tradable service products to include a range of commercial activities such as medicine, distance learning, engineering, architecture, advertising and freight forwarding. While the overall goal of GATS is to remove barriers to trade, members are free to choose which sectors are to be progressively liberalized, under which mode of supply to a particular sector would be covered, and the extent to which liberalization will occur over a given period of time.

GATS covers four modes of delivery of services in cross-border trade. Mode 1 is cross-border supply where services are generated within a supplier country and delivered to consumers in another country, for example telephone calls, business process outsourcing across firms, etc. Mode 2 is where services from the supplier country are consumed by consumers moving in from abroad, for example tourism. In these modes the service supplier does not move out of his country. In Mode 3 – Commercial presence – and Mode 4 – Presence of a natural person – the service supplier is present within the territory of the recipient country. In both these cases, it is the service supplier that moves abroad.

For India, Mode 4 service delivery is important, since it is via this mode that India's skilled workers are able to travel to and provide services abroad. However, many developed countries have sought to regulate this mode and restrict the numbers of foreign personnel entering their territory. The US H-1 visa scheme is an example. Similarly, in the EU there are efforts to develop a temporary work visa regime for professionals providing services though there are considerable differences within the EU on this issue. As against this, there are concerns over unemployment in the developed world, where foreign workers are seen as taking away jobs from nationals.

India clearly has a major stake in pressing for a liberal regime for service delivery, especially in Modes 1 and 4. This will require persistent efforts both in multilateral trade negotiations such as the Doha Round, as well as under various bilateral free trade arrangements with various countries. At the same time, India would also have to allow foreign skilled workers to work on specific projects in its own territory.

Given the shortage of skilled workers in the developed countries, and the lower cost of engaging such personnel from the developing world, the issues related to various modes of service delivery are likely to engage active attention in the future. Related issues would arise regarding security clearances of personnel for certain activities, taxation, social security coverage and transfer of amounts withheld, etc.

Information Technology and Security Issues

Information technology has witnessed rapid development especially in India, where a large pool of low-cost skilled workers is available. This has given India a comparative advantage in IT and related services. Many foreign companies have tapped this resource to become more competitive. Many governments have ambitious plans for IT enabling various services. Low-cost bandwidth has enabled business processes to be outsourced across borders and India has benefited from this trend. The services range from call centres at the lower end to sophisticated engineering and technical work.

While this revolution is a win-win situation for the foreign entity as well as the Indian partner, there has been some concern over information security issues, especially where financial services are involved. The growth of cyber crime and prospects of cyber terrorism have led to increased attention to cyber security. The legal framework as well as technical measures to thwart such crimes have developed considerably.

However, an international convention against cyber crime and cyber terrorism has not yet been put in place. The Council of Europe has worked on such measures to pool resources amongst nations to combat this menace, but a truly global effort is still lacking. As national and international networks dealing with various services grow and become more vulnerable to attack by criminals, this issue will gain more prominence and urgency.

Biotechnology – The ICGEB Example

The field of biology has witnessed rapid advances following fundamental advances in our understanding of the structure of DNA and its functioning. This revolution has had its inevitable consequences in the international field.

Developing countries were apprehensive that they might be left behind in the biotechnology revolution. To bridge this gap, they promoted a project for the setting up of an International Centre for Genetic Engineering and Biotechnology (ICGEB). The ICGEB came into existence in 1987 and now has sixty-one member countries and has centres in Trieste, Italy; New Delhi, India; and Cape Town, South Africa.

The birth of the ICGEB was a difficult one. Leading developed countries, especially the US, were not supportive of the effort and did not join. Given the lack of participation by wealthy countries, funding for the ICGEB and its viability became a major problem. However, Italy and India made generous contributions including hosting facilities and made diplomatic efforts to convince more countries to participate. With these efforts, the ICGEB has managed to secure for itself a respected place among the biotechnology R&D centres in the world, providing research fellowships and collaboration opportunities for many institutions in member countries.

Biological Weapons Convention

The Biological Weapons Convention, 1972 (formally, Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction) currently commits the 162 states that are party to it to prohibit the development, production and stockpiling of biological and toxin weapons. However, the absence of any formal verification regime to monitor compliance has limited its effectiveness. The convention includes all microbial and other biological agents or toxins and their means of delivery (with exceptions for medical and defensive purposes in small quantities). The rapid advances in biotechnology have opened up

prospects of non-state actors obtaining access to organisms deliberately modified to cause harm. These are challenges to be faced.

Convention on Biological Diversity

Increasing public awareness of the damage caused to the environment by human activity and especially loss of biodiversity and the threat of extinction of species led to the adoption of the Convention on Biological Diversity (CBD) in 1992.

The convention recognized that the conservation of biological diversity is "a common concern of humankind" and is an integral part of the development process. The agreement covers all ecosystems, species and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use. Importantly, the convention is legally binding; countries that join it ("Parties") are obliged to implement its provisions. The convention highlights the precautionary principle that where there is a threat of significant reduction or loss of biological diversity, one should not wait for full scientific certainty in order to take measures to avoid or minimize such a threat. Currently, 193 countries are parties; the US has signed but not ratified the convention.

Bio-Safety and Genetic Engineering

Advances in biology have made it possible to modify DNA in organisms to alter their characteristics. Genetic engineering technology can now transfer genetic material across species, and even between the animal and plant forms. A synthetic gene has recently been inserted into a life form by Craig Venter's group. These developments have provoked concern and opposition in various countries.

Reacting to these issues, the international community has adopted the Cartagena Protocol on Bio-safety as an addition to the CBD. The objective of the protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of "living modified organisms resulting from modern biotechnology" that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.

Genetically Modified Foods

In recent years, the issue of genetically modified food has been intensely discussed including in India. The international community is deeply divided over the issue. India has followed a middle path, allowing non-food GM crops such as cotton. However, recently the government has cleared the release of GM Brinjal, which has generated much controversy. A number of other GM food crops are under field trials, and the government may have to take a decision in the near future on releasing these. Meanwhile, the long-pending proposal for a single-window National Biotechnology Regulatory Authority (NBRA) has been activated. The regime finally adopted in India for GM crops will have an impact on its agricultural and food exports especially to markets like the EU.

Ozone Layer and the Montreal Protocol

Growing international concern over depletion of the earth's ozone layer, which shields us from harmful ultraviolet solar radiation, led to the adoption of the Montreal Protocol. The depletion of the ozone layer had been noticed since the 1970s, due to the effect of various chemicals, particularly chlorofluorocarbons (CFCs) used in the refrigeration industry. The Montreal Protocol, 1987, seeks to phase out the use of ozone depleting substances. It has been ratified by 196 countries and is an outstanding example of international collaboration including the chemical industry. A special fund was set up to help developing countries to phase out use of ozone depleting substances. Recent studies indicate that the ozone layer may have started to recover.

Global Warming – The Threat to Humankind

The global warming threat and international responses pose a particularly difficult challenge for India's foreign relations. Over the years, increasing scientific data have accumulated attesting that the earth's average temperature has been rising steadily. In the twentieth century the rise was 0.74ºC. This rise is primarily due to increasing emission of greenhouse gases such as carbon dioxide (CO_2), methane and nitrous oxide emanating from human activities. CO_2 levels in particular have risen dramatically from 284 parts per million by volume (ppmv) in 1832 to 390 ppmv in 2010, and are rising at 1.9 ppmv per year. The rise in CO_2 levels has been linked closely with use of carbon-based fuels especially after the Industrial Revolution. Methane and nitrous oxide emissions arise mostly from agricultural activity.

The increased CO_2 levels result in greater absorption of solar energy by the earth, resulting in global warming. Various models have been developed to attempt to predict the exact rise in temperature, and these show considerable variations. The International Panel on Climate Change (IPCC), a global scientific group, has nevertheless estimated that if the present trends continue, the global average temperature would rise by an additional 1.1–6.4ºC by 2100. This would lead to significant, large-scale and irreversible changes in the earth's climate, including increase in extreme climate events such as storms, floods, droughts, and rise in sea levels that could submerge coastal and island areas.

The prospect of such changes has generated increasing international concern and led to demands for effective action to combat these effects. In response, the international community adopted a Framework Convention on Climate Change (UNFCC, 1992), and subsequently the Kyoto Protocol, 1997, in which thirty-nine industrial countries and the EU committed themselves to reduce their collective greenhouse gas emissions by 5.2 per cent over the 1990 levels. The protocol contains several mechanisms to help developing countries reduce greenhouse gas emissions, including financial mechanisms. The first commitment period under the protocol will expire in 2012, and therefore intensive negotiations are going on to evolve a future arrangement.

The fundamental issue in these negotiations is the need to provide for developing countries to continue their economic development which inevitably would lead to higher emissions, although the per capita emissions of developing countries are far below those of industrial countries. Developed countries are seeking ways to avoid their people making sacrifices for fighting global warming which entails political costs, while putting the burden of these on developing countries. This in essence is the root of the conflict, behind the various charts and technical reports. A smaller constituency rejects the claims of global warming altogether, stating that the scientific basis is still doubtful. However, it is generally accepted that humankind must follow a path based on the precautionary principle.

Protracted negotiations, including the Copenhagen Climate Change Summit in December 2009, failed to reach agreement. The summit came out with a non-binding Copenhagen Accord among some key players – the United States and in a united position as the BASIC countries (China, India, South Africa and Brazil). It is not legally binding and does not commit countries to agree to a binding successor to the Kyoto Protocol. But it represented a minimal gain.

So far countries representing over 80 per cent of global emissions have engaged with the Copenhagen Accord and many have submitted emissions reduction targets by 2020, including India (20–25 per cent). The next climate change conference in Cancun, Mexico in December 2010 made limited progress on certain issues but the fundamental issues remained unresolved.

Climate change represents a very difficult challenge for India's foreign policy. The complex scientific nature of the issues involved makes it particularly difficult to generate public awareness and informed discussions. Yet the implications for India's economic development, especially in meeting its energy needs, are enormous. Seen against the targeted economic growth rate of 10 per cent, the target of emission reduction of 20–25 per cent by 2020 will call for a great effort in energy production, distribution and consumption, cutting across the entire economy. It will require massive injections of advanced technology and financial resources to achieve. At Copenhagen, the solidarity displayed by the group of BASIC countries caught the industrial countries by surprise, and prevented an unbalanced outcome. The position taken by the BASIC countries is based on fairness and equity and this needs to be more forcefully articulated through public diplomacy targeted at the industrial countries.

Nanotechnology – The Emerging Enabling Technology

Nanotechnology, which covers the applications of materials science at the scale nanometres, is emerging as an important enabling technology. Many governments have invested funds into nanotechnology initiatives. The US launched a National Nanotechnology Initiative in 2000 with a funding of $4 billion. The Department of Science and Technology in India has launched a Mission on Nano Science and Technology (Nano Mission) in May 2007, with an allocation of Rs. 10 billion for five years. Nanotechnology has potential applications over the entire range of human activities, and could render many existing industries obsolete. It opens up the possibility of competitive, small-scale, scalable, transportable, dispersed production of useful materials. As its development proceeds, international relations will be impacted by its consequences.

To sum up, we have given several examples where there is increasing and close interaction between scientific and technological development and India's foreign relations environment and the challenges this has thrown up. Given the pace of technological development, India will need to remain vigilant

and react with an agile foreign policy response to safeguard its interests in a world where technology is a key determinant of global competitiveness and power. In this effort, much closer collaboration between India's scientific and technical establishments and India's foreign policy establishment will be needed to generate wide awareness and sensitivity to key issues and effectively respond to future challenges. Technology issues will need to be carefully factored into foreign policy strategy and policy discussions, formulation, and practice.