MEA Distinguished Lecture on "Technology and International Relations – some challenges", Jammu Central University, 20th April 2018
By Dr. Bhaskar Balakrishnan

Good afternoon all of you. It is a great pleasure to be at Central University Jammu, a young University growing rapidly and bound to make a big impact in the region. It is also nice to be in the atmosphere of a University where I feel at home

Prof. Aima, Vice Chancellor, and other distinguished personalities on the dais, I thank you for your presence here today and for your support for this cooperation between Central University Jammu and MEA.

The MEA attaches great importance to cooperation and working together with Universities all over India. After all it is from the university that our future diplomats will come and even otherwise the students of our universities in one way or the other will be ambassadors of India wherever they work abroad and pursuing their careers. So our Ministry attaches great importance to its outreach programs for the students of our universities in India

The topic of my lecture today is "science and technology and international relations - some challenges". You will excuse me if some of the material is too simple for you or some of it is too advanced as I was not sure of the exact level of the audience for which I was preparing this lecture. Let us start with some definitions and concepts

Science as you know is our basic understanding of nature and how it works and what nature is all about. Technology is the practical application of that knowledge. For example a scientist discovers Nuclear fission while the Technologist would use that knowledge to produce nuclear energy or to make a weapon. Now there are many layers in the process of our development of Science and Technology. For example in Chemistry we knew that hydrogen and oxygen combine to form water, similarly carbon and hydrogen combine to form Methane. These were facts known to chemists. Why this happened was not known. But the knowledge of these facts enabled the useful application of chemistry to practical problems at that time. Later on we came to know the significance of numbers such as 2 , 8 , 18, 32, in Chemistry and the periodic table of elements. We came to understand that the chemical behaviour of a substance is governed by the outermost or valence electrons of its atomic structure. This was another layer of our understanding of the chemical behaviour of various elements and that was related to the atomic structure itself. Then we went even deeper and looked at the detailed structure of the atom and came to the nucleus which is composed of protons and neutrons. Now we have gone even deeper and we believe that the protons and neutrons themselves are composed of quarks bound together by gluons - yet another layer in our understanding of nature. So as we proceed in the discovery of nature we reach various layers and at each layer there are practical applications of the knowledge at that level So this journey of mankind in understanding nature and applying this knowledge will continue to go forward the future. In this search for knowledge the University community like yours has a great role because you are at the forefront of this quest for knowledge.

Now what comprises International relations? International relations are the set of interactions between the nation states and various International organizations which comprise the entire system. Science and Technology has a strong impact on the security and economic strength of nations and therefore has a strong impact on the international relations system as a whole. Society and nations get changed by developments in Science and Technology, as for example the mobile phone. International relations get impacted by nuclear weapons, which in the hands of a few States gives them enormous power compared with the others. The Mughals used cannons, a new weapon at that time, which gave them the advantage and secured victory at the battle of Panipat in 1526. This has been going on throughout history and there are many examples.

Science and Technology development changes societies in unpredictable ways and alters the balance of power both among states and also within States. It can make countries more powerful in the military sense. It can also make them more economically powerful if they can develop products which can be superior and can conquer markets. Science and Technology can be disruptive for societies and increase inequalities. Those who can understand and take advantage of technology benefit, while those who cannot fall behind, they might for example lose their jobs. So there is an inherent danger of increasing inequalities in this process.

Now let's talk about the role of governments. The central and state governments have to do two things and they must do them well. Firstly, they must ensure national security In the broadest sense not just limited to security at the borders but security for the nation as a whole and in all its aspects. Secondly, deliver quality of life to all its citizens. Quality of life is again to be seen in its broadest sense. These are the things that every government should do and should do it well and they should be understood in the broadest sense. Merely increasing the GDP is not sufficient, as there are many other things which are required to be done. National security for example has many elements - apart from border security, there is internal security, economic security, energy security, environmental security, social harmony, and many other aspects which are all important. Therefore the state must be able to respond effectively and in a timely manner to science and technology in order to safeguard the interest of the nation and to advance its progress towards its objectives. The political leadership of a state must therefore be aware of Science and Technology advances and their implications. If they are not aware it is our duty as informed and knowledgeable people of science and technology to make them aware by appropriate means and that is where the university community plays an important role

States interact within the international system but they have become very complicated creatures these days. There is of course the Foreign ministry of a state. But you have the Federal government with various Ministries, provincial Governments and also have local governments which all have interactions outside the national boundaries. Outside the government there are various entities – active in business, culture, political parties, labour, youth, students, women, religious organizations, academic and research institutions, etc .And you also have criminal and terrorist elements which have emerged. So now there is a whole range of actors which are

involved in the international system, making the dynamics of international relations much more complicated.

At one time it was the Foreign Ministry which exclusively dealt with the foreign interactions of a state, but now it is no longer so. All these different entities which make up the nation state have their foreign interactions and the challenge for the Foreign Ministry is to keep track of all these interactions and to try and make them work together like a conductor of an orchestra. There are also international organizations like the UN and other agencies and transnational corporations which operate in the system, and a growing number of NGOs and some coalitions built around specific issues which also operate- the so called trans governmental coalitions. This picture of international relations today is bound to get more and more complicated in the future. Globalization and ICT have now enabled all these actors to communicate very effectively across the globe. We cannot go back in time and we must harness all these developments in a constructive manner in the future.

Let us now talk about technology development. In the early days scientists usually worked individually or in very small groups in their own labs. For example Marie Curie extracted Radium from a tonne of pitchblende in her own laboratory working alone. Nowadays science and technology work goes on in big laboratories with big groups and with big budgets. For example the Manhattan Project involved a network of laboratories and institutions across the US and involved a large number of people with a large budget. So science and thas moved from small to big scale. Government and business have also increased the funding for science and technology and for building institutions .With the increase in funding and increase in S and T activities this sector should see more and more jobs being created and more and more opportunities for young scientists and technologists.

As I mentioned science and technology can have a disruptive effect on societies. It can alter the existing relations and economic patterns in society .Every country seeks to increase its economic and military power and in this pursuit science and technology has acquired an important place . Once Science and Technology advances have been discovered and commercialized, there is an effort to control its use and regulate its spread using the Intellectual Property Rights framework .There are also informal mechanisms such as knowhow and trade secrets and non disclosure agreements which scientific workers have to sign these days. There are also intergovernmental mechanisms to control the spread of technologies which might have military applications such as the NSG, MTCR, Australia group and the Wassenauer arrangement. Security as well as commercial interests might be involved. Countries which do not have technology which gives them military power will try to obtain it either by official overt and legal means or by covert means such as industrial espionage, or they would be forced to develop these technologies through indigenous efforts as was the case with India in the field of nuclear technology .

Policymakers and civil servants will continue to face challenges as a result of science and technology advances which are taking place at an increasing pace .The number of research papers and the areas of science and technology research has increased enormously since the

20th century To succeed in science and technology a country must devote sufficient resources and funds for science and technology. A rough benchmark would be about 2% of the GDP coming both from public and private sources .Apart from the level of resources it is also important how the resources are utilized in generating productive research.

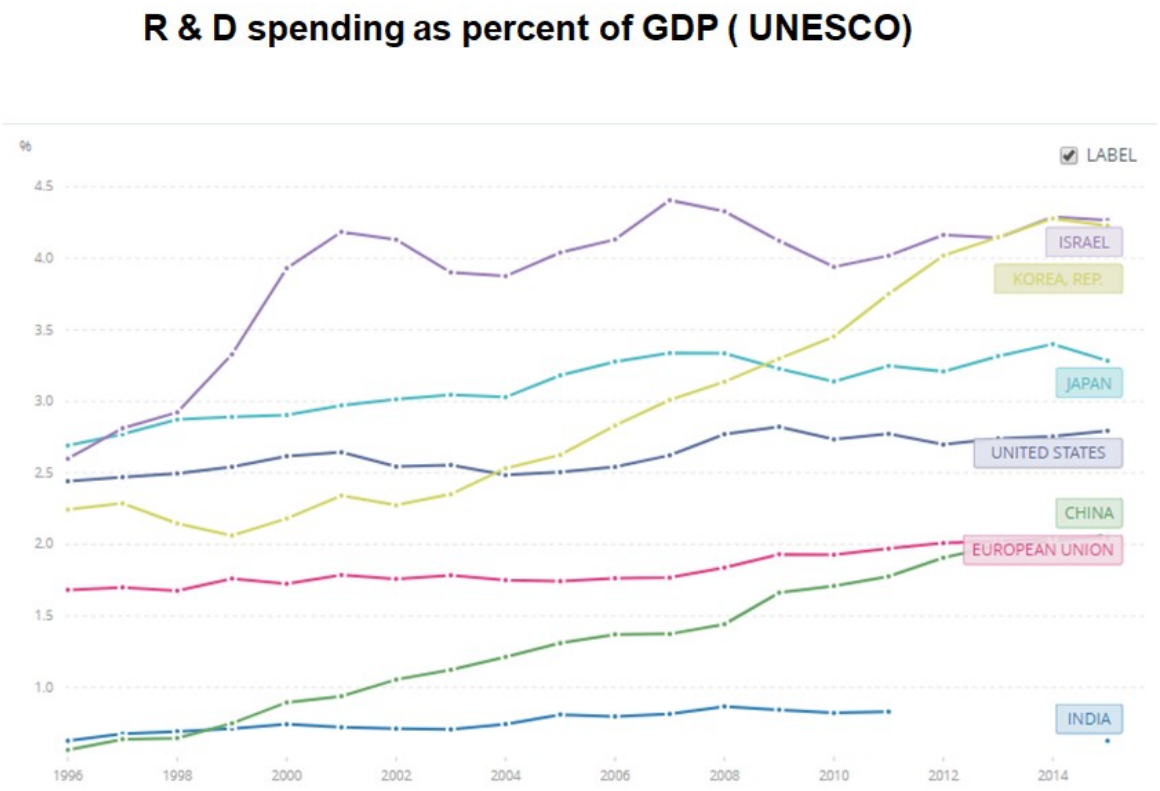


Fig 1

A look at some figures of research spending as percentage of GDP by various countries does not present a very optimistic picture as far as we're concerned .Fig 1 shows some trends. The lowest line which is almost flat represents India which is around 1% of GDP. The line representing China is going up sharply. A few countries like Israel and South Korea have rather high levels of GDP percent spent on research. What comes out clearly is it that India is lagging far behind China in terms of research spending as a percentage of GDP. In addition, the funding for research in India is heavily dependent on government. In most of the advanced countries the research spending is largely from the private sector.

India faces the challenge of stepping up sharply the spending on research by the private sector. If we look at total research pending we can see that China is already over taken the European Union in the recent past and is set to overtake the United States within a few years. Here I

would like to throw up an interesting suggestion. We have Corporate Social Responsibility under which companies are required to spend 2% of their net profits on socially important projects. Why can't we have a similar Corporate Technology Responsibility in which companies have to invest 2% of their revenue on technology? This would stimulate private sector spending on research. If you think about it, a company which spends on research and technology would actually be protecting and promoting its own interests. They might discover new products or new processes or new technology which may give them new products or services to make for the market. There are a lot of things which companies can do in the area of technology which can be of benefit to them.

Coming to human resources, we have a lot of scientists and technologists coming out of our universities which is a great asset .Once they graduate, instead of working in the scientific and technological field, many of them go into business management, government administration, finance, or other fields so that scientific and technological potential is not utilized. So while we do produce a lot of Science Technology, Engineering, and Management graduates so called STEM, which is in short supply in countries like the US, we are not actually able to exploit it. There is a lot of movement of STEM human resources from India to the US where there are jobs available. Even in India some of the large multinational corporations such as GE and Microsoft have established research centres and they make use of the STEM graduates available in India at low cost. They have these scientists and technologists and carry out their own projects and whatever knowledge comes out of these activities goes into their hands. So they get this knowledge at a fraction of the cost in the US .They are doing this in many countries of the world including countries like Israel as well.

As I said before China's research spending is increasing rapidly and is going to overtake that of the US in the near future. It is building huge and lavish research facilities Including some of the world's best. For example the world’s largest particle accelerator is expected to come on stream sometime in 2022 .They are also offering a Green Card type of scheme to attract the best of global S & T talent. R and D work carried out by Indians and Chinese working n the US is quite significant. The same could be said about the European Union. If we look at most of the scientific papers which are being published you would probably find that in many cases there are Indians and Chinese among the co-authors .The Indian diaspora community is therefore a rich source of high quality Science and Technology human resources .

Science and technology development does not take place in isolation. It requires a mature ecosystem which Is embedded in the country's economy and national life .The S & T ecosystem has several components. Firstly the human resource policy of the country must facilitate and promote S & T education as well as research. Secondly financial resources must be available for research and development. Then there must be Institutions and infrastructure which are capable of playing the necessary role .These could be laboratories and Institutions in the government, private sector, or in universities. Next there should be mechanisms and Institutions which can commercialize the research output into useful products and services and derive concrete economic benefits. That requires a good IPR framework and system as well as mechanisms for encouraging and incubating startups. Then there must be an enabling and

favourable business environment, including markets, stability, predictability, and effective regulation .Then there must be constructive engagement between the scientific community, political leaders and civil society. For example, differences and conflicting views over issues such as nuclear power plants and GMOs should be resolved in a constructive manner. If any of these factors are insufficient on missing in a country is ecosystem then it will drive the participants to migrate outside to other countries where the ecosystem is more favourable. That is what leads to the huge attraction of places like Silicon Valley in the US for STEM workers .

The government plays a key role in ensuring that the Science and Technology ecosystem is fully functional and is integrated into the national economy .This is crucial in order to ensure that the benefits from Science and Technology go into the national economy and add to growth and development. In the S & T ecosystem the academic and research Institutions play a critical role and they must be oriented towards national needs. Human resources are the key to S & T development as knowledge resides in the brains of humans. Mobility across and within States is also very important. People should be able to move freely between institutions and even between countries. Therefore mobility of faculty, researchers, and students across institutions is very important. This means that students should have the ability to move from one university to another and do courses whose credits can be transferred into their programmes This has been recognized since long by the European Union which has embarked on what is known as the Bologna process to transform European universities into one large European education space This involved a massive reform process to change traditional universities which were largely isolated from each other into a modern integrated network of institutions. Giving the faculty and researchers the option to move freely between Institutions will enable cross fertilization and transmission of best practices. Our own higher education reforms seem to be moving in this direction in the future.

Next comes flexibility in HR management .This should permit short term exchanges of personnel and faculty and researchers. Mobility implies that HR practices and management will have flexibility. Flexibility in HR management is also important in taking advantage of national S & T human resources as well as S & T human resources available in the diaspora. There is also a lot of S & T talent available in the alumni of our universities which could be tapped more effectively to help our research and teaching programs. There must be an effective way to leverage the Indian diaspora in S & T and a lot of highly qualified Indian S & T personnel working abroad are very keen to participate in activities with Indian Institutions and Universities. Even when they visit India on vacations they do look for ways in which they can work with Indian Institutions and Universities and specially their alma mater. It is a pity that academic Institutions often fail to keep track of the alumni and their future career progression. With modern ICT we can easily build a very comprehensive alumni registry and interactive platform. After all it is the alumni which know the Institution and the environment best and they are one of the best partners for promoting collaboration. Flexibility in curriculum, better use of internet enabled learning through online courses etc, could also enrich and make our programs much more competitive.

Another issue is the fact that a lot of work which goes on in Indian research institutes and Universities does not get commercialized and does not lead to useful economic benefits for the national economy. Scientists would need a supportive structure such as business incubators in order to convert the results of the research into economically useful products and services. Our researchers also need to have some training in order to write highly quality funding proposals so that their proposals can attract funding. Management of intellectual property rights and transfer of technology is also an important element. In some of these aspects our universities can benefit from International linkages with Institutions and Universities abroad. Our universities could also be more aggressive in pursuing International global ratings. The moment we try for a global rating for our universities we will find the deficits and shortcomings which need to be overcome. As you get higher and higher ratings, your status improves, and this can result in a virtuous circle in which you attract better faculty, students, and attract more funding for activities. For example, the Association of University Technology Managers (AUTM), based in the US is a good network to participate in for accessing best practices and knowledge on technology management in the university setting.

Let me now come to one of the areas which is most important for us and that is the challenge of development .The fundamental objective of development is to achieve a better quality of life for all people .What is development? The international community has defined development in terms of 17 sustainable development goals (SDGs) which all countries are to achieve by 2030. The sustainable development goals were adopted by the UN General Assembly and cover the period 2015 to 2030. Unfortunately public awareness of the SDGs is very low but they are perhaps the most important things to be achieved for all people. There are a whole set of targets, indicators, deadlines and reporting requirements which all countries should try to meet.

Civil society plays a key role in putting pressure on government to achieve these goals .All Institutions should sensitize stakeholders about the importance of achieving the SDGs. Technology plays a crucial role in achieving the SDGs .These goals apply not only to developing and developed countries, but could also be applied to provinces , and even at lower levels to districts. These goals were identified after a lot of consultations including with civil society and they apply to all countries and we have about 169 indicators to monitor the progress towards these goals. The 17 SDGs are clearly interrelated and interconnected, and progress is not possible unless it takes place towards all the goals. Achieving the SDGs will require major transformation of societies and countries. Fig 2 shows what the 17 SDGs are.

Fig 2

How do we implement the SDGs? The national governments are responsible for implementing them. The SDGs are not legally binding but only a voluntary framework. The active involvement of civil society is essential. And public dialogue and debate to sensitize the community and political leadership Is very important. For example the SDGs could very well be made into an election issue. This is something very important. Fig 3 shows the SDG progress index of different countries prepared in 2017. Sweden has the highest index (85.6). Going down the list of top 30 countries you find Cuba. It is a poor country but it has managed to score 75.5 and is ranked 29. The performance is good because Cuba has done a lot in the field of education and health care of its people. The indicators for health and literacy for Cuba are among the best in the Western hemisphere. The US has a rank of 42 coming behind Cuba. Coming to Asia you can see the figures for China and other Asian countries. .Sri Lanka has the best performance in our region of South Asia. Bhutan is also doing quite well. The laggards in South Asia are India, Pakistan, Bangladesh, and Afghanistan - three of them with large populations. This means we have to do much more in health, education, environment, reducing inequality, etc. Afghanistan of course has a special situation being affected by internal conflicts. So South Asia faces a formidable challenge in achieving the SDGs. As we move towards 2030 people in these countries are going to ask their governments to account for failures in achieving the SDGs.

SDG Performance Index and Global Ranking, 2017

Sweden	85.6	1
Denmark	84.2	2
Finland	84.0	3
Norway	83.9	4
Germany	81.7	6
France	80.3	10
Japan	80.2	11
U.K.	78.3	16
Canada	78.0	17
Australia	75.9	26
Cuba	75.5	29

USA	72.4	42
Malaysia	69.7	54
Thailand	69.5	55
Brazil	69.5	56
Mexico	69.1	58
Russia	68.9	62
Turkey	68.5	67
Vietnam	67.9	68
China	67.1	71
Sri Lanka	65.9	81

Bhutan	65.5	83
Egypt	64.9	87
Iran	64.7	89
Indonesia	62.9	100
Saudi Arabia	62.7	101
Nepal	61.6	105
South Africa	61.2	108
India	58.1	116
Bangladesh	56.2	120
Pakistan	55.6	122
Nigeria	48.6	145
Afghanistan	46.8	150

In South Asia, India, Bangladesh, Pakistan with large populations are at the bottom of the rankings
[Source: http://www.sdgindex.org]

Fig 3

Science and Technology plays an important role in achieving all the 17 SDGs. For this purpose a Technology Facilitation Mechanism (TFM) has been set up to enable countries to make use of technology for achieving the SDGs .The TFM will facilitate collaboration and partnership through sharing of information. Participation is open to government agencies, civil society, scientific establishments, as well as business. Participation by research entities is important and if they develop some useful product or service they could find a good market in various countries. So it is important for research Institutions and universities to focus attention on the kind of research and technologies which will be needed for achieving the SDGs. In addition the UN has established an Inter Agency Task Force and also holds annual meetings of a Stakeholders Forum to discuss aspects of Technology for achieving the SDGs.

Now let us come to the International Solar Alliance. Its objective is to combat climate change by producing Clean Energy to also meet the energy demands of the population. It aims at boosting Solar Power capacity. Its members are countries located between the Tropics of Cancer and Capricorn . So far 61 countries out of 122 eligible countries have joined the alliance and formally signed the agreement while 61 more countries have yet to sign the agreement. This includes some major countries such as UK, USA, Japan, China, etc. It would be important in future to get these countries to join the ISA as well as expand the role of countries outside the tropical zone

so that they could also participate as full members. Many countries lying outside the tropics also have considerable amount of activity, interest and capability in Solar power.

The objective is to mobilize resources on a large scale for solar power technology, equipment , services ,and knowledge and implement projects. In partnership with the World Bank and Financial Institutions the target is to mobilize 1,000 billion dollars. This is a major initiative which India has launched and put in a lot of effort including contribution to setting up the headquarters in Delhi .We hope that this small plant will grow into a big tree and yield a lot of fruits .The diplomatic challenge is to get as many countries as possible to join this Alliance. Some factors are quite promising. The cost of producing solar photovoltaic cells has dropped conmsiderably and continuous to do so. Research and development has yielded considerable increases in efficiency of solar photovoltaic cells and there are promising developments in new materials and energy storage devices. Installed solar power capacity has been going up sharply over the years.

Now let us take Science and Technology and the way it is handled in diplomacy .There are three main streams of science diplomacy .First there is science in diplomacy in which scientific inputs are given in to diplomatic policy and activity. Secondly there is diplomacy for science in which we use diplomacy to gain concrete benefits in the field of science and technology for development, international influence, or advantages in various markets etc. This is somewhat similar to economic diplomacy. Thirdly there is science for diplomacy in which we try and use scientific activities to bring countries together despite political or other differences. There are several examples of these starting from the cold war between the US and the USSR and other situations. Some activities may involve more than one of these three dimensions.

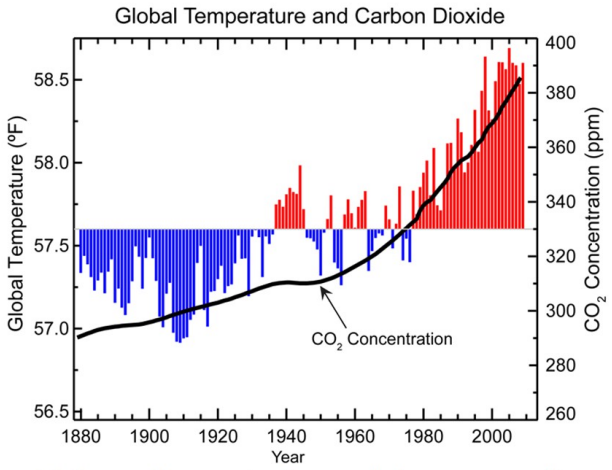
How do we manage Science and Technology diplomacy? Given our limitations in human and material resources we cannot put highly qualified scientists in embassies all over the world. Successful science diplomacy requires that the ministries dealing with scientific subjects and the Ministry of External Affairs work closely together, and in addition involve other stakeholders such as private research Institutions and the business sector. Since Science and Technology has both civilian as well as strategic applications, science diplomacy necessarily involve both aspects.

I mentioned South Asia. Can science and technology help bring India and its neighbours closer together? We are already working with several countries to protect the living resources of the Bay of Bengal Large Marine ecosystem under a FAO led project. There is a similar Large Marine Ecosystem for the Arabian Sea and here the protection of the living resources would require the cooperation of all the countries involved. But it is still an orphan. Some other promising cooperation areas in South Asia could be - air quality monitoring and pollution control, control of infectious diseases, meteorology, tele-medicine, tele-education, and energy . The Energy Charter Treaty which was evolved in Europe to provide a framework for energy exchanges, cooperation and trade between East and West blocs could provide a useful model for cooperation in energy in this part of the world. Networking among academic and research Institutions could also be fruitful.

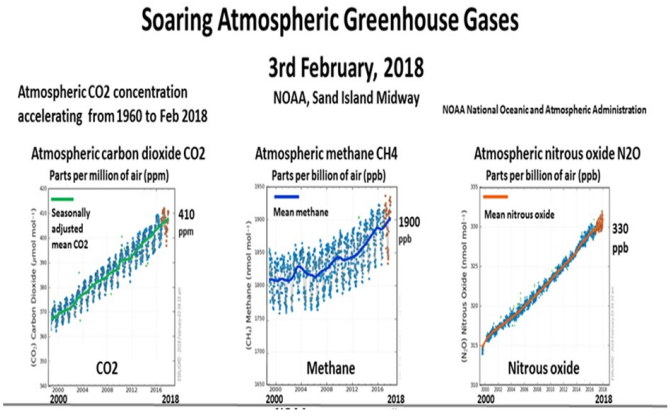
I will now briefly touch upon some science and technology areas and challenges which are emerging and important. In nuclear technology India has been very active and has successfully overcome the nuclear isolation which was imposed upon it especially since 1998. We have maintained our independent nuclear weapons program like other Nuclear Weapon States.There are challenges facing us in the form of the CTBT, the Fissile Material Cut-off Treaty and the new nuclear weapons Ban Treaty which was adopted in 2017. India continuous to pursue an ambitious civil nuclear program using natural uranium fuel reactors with heavy water moderator based on Canadian technology and also plans to use imported enriched uranium reactors. India is also developing fast breeder reactors and advanced reactor technology. India will therefore remain actively engaged in all aspects of nuclear technology and diplomacy related with this subject.

As regards climate change India is a key player in In this field .Despite many years of efforts we are still lagging behind in global efforts to reduce the emissions of greenhouse gases in the atmosphere (Fig 4). The recent unprecedented increases in Methane levels, a very potent greenhouse gas might possibly be linked to the surge in exploitation of non conventional gas, including fracking in recent years. More research needs to be done into this matter.The rise in average temperature of the Earth is now quite well established. The warming is more pronounced in the polar regions where the effect on the ice caps is more severe (Fig 5). Our global climate models are still not accurate enough to give us detailed connections between the rise in greenhouse gas concentrations and the global warming and its distribution across the earth. The full impact on warming of various regions of the Earth on activities such as agriculture, coastal live, extreme climate events, etc. is still uncertain.

Fig 4



Globally averaged concentrations for CO2 reached 403.3 parts per million in 2016, 145% of pre-industrial (before 1750) levels.



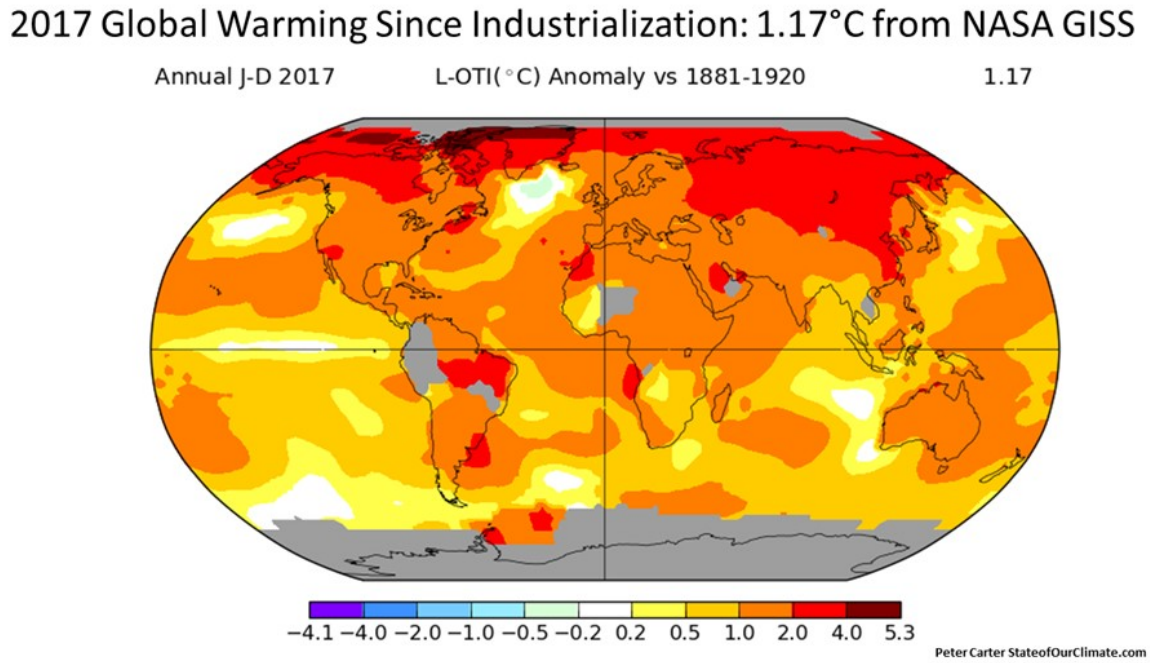


Fig 5

Dealing with the climate change therefore requires International cooperation on an unprecedented scale. Our lifestyles may well have to move to a more frugal one. Civil society plays a crucial role in pushing governments to take action . Because of its huge size, population, and economic activity, India plays a central role in climate change, and no climate change agreement can work without India. Therefore India along with China will have to find ways of maintaining their economic development and growth while minimizing the impact on climate change. The International Solar Alliance is very much a part of this effort. Meanwhile Greenhouse gas concentrations continue to rise and there are more frequent and severe extreme climate events causing hardship and suffering. There is also the danger of feedback loops operating in the climate system which could amplify the effect of small changes. Some people believe that the planet Venus is an example of a runaway greenhouse effect

Let us come now to the ICT revolution .The internet, computing, and mobile devices have totally transformed society. We are still going through many exciting developments in this field .Digital manufacturing and artificial intelligence are rapidly developing. Digital manufacturing could result in large scale changes in the pattern of labour involved. Similarly artificial intelligence may also result in large-scale changes in the work force involved in computer programming, call centres etc. Social media is rapidly exploding. Governments are facing challenges on how to manage the social media revolution through regulation, control etc. Use of ICT and social media by terrorists and criminal elements also poses formidable challenges In terms of cyber security and cyber crime. Instances of deliberate spreading of false news on social media in order to cause panic and destabilize societies and to interfere in elections have been reported. A

Cybercrime Treaty was evolved in Europe around 2000, but this needs to be updated and improved. Some countries are developing cyber warfare and cyber defence systems. Unlike the Geneva conventions which apply to conventional warfare there are no such conventions in the field of cyber warfare. Another issue which has come up recently is the question of lethally armed intelligent systems and the ethics of using such systems .

Nanotechnology is the technology of the small at the scale of a nanometre. It is a rapidly expanding field. The nano world is one where electromagnetic, quantum, and surface effects predominate. This gives rise to very interesting behaviour of matter and possibilities of new materials which are nanoscale in one two or three dimensions. Graphene which is a nanostructure using carbon has opened up a new world of wonderful properties. New devices and sensors using nanotechnology are being developed. Nano materials are finding applications in field such as medicine, textiles, environmental monitoring and cleanup, and solar energy and energy storage. It is a very rich field to do research in and it does not involve very high costs.

In life sciences, discovery of the structure of DNA has opened up a revolution .There has been a rapid increase in our ability to sequence DNA and to modify and edit it including moving DNA segments between different life forms as well as creating synthetic and artificial DNA. All this has huge impact on human health, agriculture and animal husbandry, and the environment. Some applications of gene editing could have harmful effects especially is in the hands of terrorists who could modify viruses and bacteria to make them more lethal. In human reproduction the development of in vitro fertilization has become widespread. This has recently been followed by preliminary research results on in vitro gametogenesis. This could enable reproduction from any one or two individuals raising numerous ethical and other issues. Similarly gene editing of human embryos while being justified to treat disease conditions could raise ethical issues if it is used to introduce certain desirable characteristics into embryos.

Managing the oceans is another important subject .The law of the sea divides the ocean space into different zones where countries have different degrees of sovereignty and rights. But marine life moves through the oceans without any consideration for the zones created by the law of the sea. Managing the living resources be oceans therefore requires a holistic and integrated approach not based on territorial zones. These resources are an important source of livelihood especially for millions of people living in the coastal areas, and as food for large populations. Therefore new patterns of sustainable management of living resources of the oceans and control of marine pollution are badly needed. The concept of Large Marine Ecosystems pioneered by the World Bank and supported by the GEF fits into this category. India has a very large coastal area and a very large economic zone with considerable living resources. The oceans represent a crucial part of India's connectivity with the outside world. Two of the 66 LMEs - the Arabian Sea and the Bay of Bengal LME involve India. It should be a natural role for India to take the lead to bring together the different countries in these LMEs to work together to protect the marine living resources therein. Also fishing has to move away from the traditional hunting type of fishing activity to the new farming or aquaculture based activity.

Let us now come to Aerospace. Space exploration and exploitation are becoming very important with civilian and military applications. Today we use satellite systems for things such as Communications, broadcasting, precision navigation, meteorology and Remote Sensing. GPS based on satellite systems has both civilian and military aspects such as guidance of missiles. The dual use of satellite capability has led to efforts especially by three countries, US, Russia, and China to test and develop anti-satellite weapons called ASATs. There is also an effort to evolve a discriminatory type of Treaty similar to the NPT, allowing ASATs for only three countries and prohibiting the development of ASATs by others. Manned space stations are also well known such as the International Space Station. This could be followed by space colonies outside the earth. These would be new types of habitats where new types of legal systems and frameworks would be required. Space junk continues to grow and poses a serious threat to satellites and spacecraft.

Exploration of the moon and nearby planets and their surface by robotic craft has already taken place. Exploration of the other planets of the solar system by spacecraft has been accomplished, providing a treasure trove of information. The application of AI and Robotics systems could make a big difference to space exploration and exploitation. An increasing number of exoplanets outside our solar system have been discovered with interesting properties including some with the ability to support life as we know it. India has a significant role in aerospace .it has a well developed space program and has the capability of launching satellites at extremely low cost for many countries.

Let me conclude at this point and thank you all for your attention .The world now belongs to you young people. I would be very happy to see India achieve the SDG targets by 2030 which would probably be around the end of my life.

Science, Technology and International Relations – Some Challenges

Dr. Bhaskar Balakrishnan

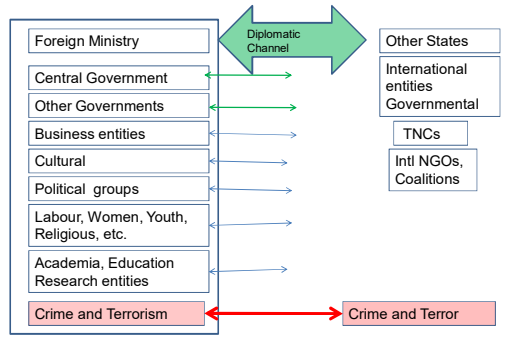
20 April 2018

Concepts

- Science is the basic knowledge of nature- Technology is the practical application of such knowledge.
- There are many layers in our progress in S & T understanding.
- IR- interactions among states and international entities.
- S & T has a strong impact on society and international system – its ability to confer military power and economic advantages – it often has very disruptive effects and increases inequalities
- Governance objectives – national security, quality of life for the people. To be understood in broadest sense. They are interlinked. GDP per capita is only one aspect. There are many other dimensions
- The State must respond to S & T advances to secure its interests. Political leadership must be aware of S & T advances and implications

2

State structures, complexity and IR dynamics



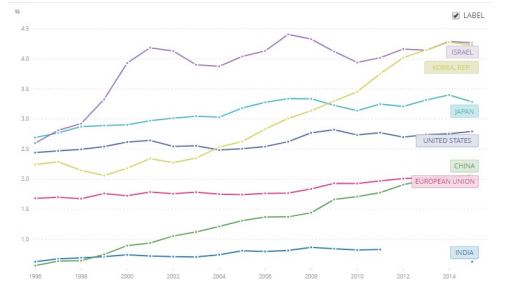
State structures are becoming more complex, with more entities involved in IR. Globalization and ICT have boosted this trend

S & T development

- S & T has moved up from small groups and individuals to large institutions and large budgets.
- Governments and business have increased funding of S & T, built institutions, put in place policies.
- Disruptive effect – changes the balance of power, and economic activities – can increase inequalities.
- Pursuit of economic and military power – efforts for control over technology –IPRs - formal and informal – denial regimes
- Means to acquire technology by overt and covert means. Indigenous development of technology.
- Policymakers and civil society face challenges – which will continue in the future.
- Total funding for S & T must be adequate, benchmark is 2% of GDP- but quality and focus are important.

4

R & D spending as percent of GDP (UNESCO)



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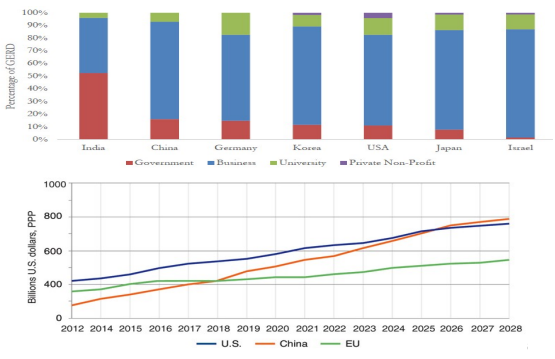
Gross R & D Expenditure trends



R & D Expenditure trends

- India's figure of around 1 % of GDP is much too low compared to other comparable countries.
- Share of Indian private sector is far too low. More effort is needed, given the availability of S & T HR. Corporate Technology Responsibility (CTR) of 2% of gross revenue?
- MNCs such as GE, Microsoft, etc. using Indian S & T HR in research centres, and exploiting benefits
- China's R & D expenditure in PPP $ has overtaken EU and is will soon overtake the US. Building lavish facilities and attracting global S & T talent.
- R & D by non resident Indians and Chinese is significant in areas such as US, EU etc.

7

S & T ecosystem – main components

- Human resources policies and practices
- R&D funding from all sources
- Institutions and infrastructure
- Commercialization (IPRs , Venture capital)
- Business environment (Markets for products and services, stability and predictability, effective regulation)
- Constructive engagement with political leaders, civil society and all stakeholders.
- if any of these factors is missing then actors will tend to seek them elsewhere; in today's world such ecosystems interact across states;
- Key role of governments in effective S & T ecosystem and integration into national life.

8

S&T development and Academia

- Academic and Research entities play a key role – they must adapt to national needs.
- Human resources are the key – knowledge resides in brains – training, motivation, and innovation are critical
- Mobility across and within states –mobility of researchers, faculty and students across institutions is vital
- Flexible HR practices including short term exchanges of personnel are needed
- HR management of nationals and leveraging Diaspora S & T resources. Alumni registry and leveraging of alumni capabilities.
- Flexibility in programmes of learning – use of OCs and internet enabled learning resources – transferable credits- and choice of core and electives.
- Knowledge management , business and research incubation, research funding and negotiations, IPR and ToT management are important
- Key role of international and cross institutional linkages – best practices and use of support entities. Pursue higher global ratings.

9

Networks for Technology

- Association of University Technology Managers (AUTM), Washington DC. USA
- More than 3,200 members represent managers of intellectual property from more than 300 universities, research institutions and teaching hospitals around the world as well as numerous businesses and government organizations.
- To support and advance academic technology transfer globally (www.autm.net)

The Development Challenge

- Quality of life requires achievement of development.
- Development is defined by international community as the 17 SDGs to be achieved by 2030. Targets, indicators, and deadlines are identified, periodic reporting requirements set up
- Civil society plays a key role in demanding progress from governments.
- All institutions should sensitise their stakeholders about the importance of achieving the SDGs
- Technology plays a crucial role in achieving the SDGs

11

SDGs what are they ?

- SDGs are a set of 17 goals to be achieved during 2016-2030
- There are 169 specific targets to be met.
- These SDGs apply to all countries, regions, cities, and all sectors and entities which are challenged to act.
- SDGs have been drawn up with much wider consultations unlike the MDGs (2005-2015)
- The 17 SDGs are interrelated and interconnected. We must achieve them all together.
- Achieving the SDGs will require major efforts and transformations in societies.

12

13

Implementation of SDGs

- National governments will be responsible for implementation of the global goals from 2015 through to 2030.
- The SDGs are a voluntary framework, governments are not legally required to implement them, or report on progress towards them.
- Civil society will need to be actively involved and keep pressure on governments and other entities to ensure implementation.
- Actions such as public dialogues and debates within community, parliament and local government, making SDGs an election issue, National conferences , public forums, and meetings with decision-makers to discuss implementation and share best practices can strengthen implementation

14

SDG Performance Index and Global Ranking, 2017

Sweden	85.6	1
Denmark	84.2	2
Finland	84.0	3
Norway	83.9	4
Germany	81.7	6
France	80.3	10
Japan	80.2	11
U.K.	78.3	16
Canada	78.0	17
Australia	75.9	26
Cuba	75.5	29

USA	72.4	42
Malaysia	69.7	54
Thailand	69.5	55
Brazil	69.5	56
Mexico	69.1	58
Russia	68.9	62
Turkey	68.5	67
Vietnam	67.9	68
China	67.1	71
Sri Lanka	65.9	81

Bhutan	65.5	83
Egypt	64.9	87
Iran	64.7	89
Indonesia	62.9	100
Saudi Arabia	62.7	101
Nepal	61.6	105
South Africa	61.2	108
India	58.1	116
Bangladesh	56.2	120
Pakistan	55.6	122
Nigeria	48.6	145
Afghanistan	46.8	150

In South Asia, India, Bangladesh, Pakistan with large populations are at the bottom of the rankings [Source: http://www.sdgindex.org]

Technology aspects

- S & T has important role in achieving all the 17 SDGs
- Technology Facilitation Mechanism (TFM) has been set up to support the implementation of the SDGs.
- TFM will facilitate multi-stakeholder collaboration and partnerships through the sharing of information, experiences, best practices and policy advice.
- Participants will include Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders.
- Academic and Research entities have a key role to play in the above areas.

16

TFM components

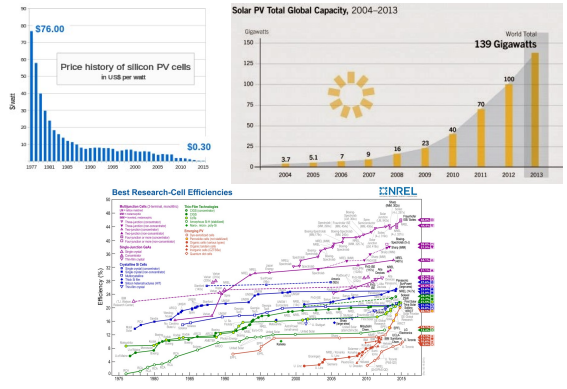
- A United Nations Interagency Task Team on Science, Technology and Innovation for the SDGs (IATT), including the 10-Member Group of representatives from civil society, the private sector and the scientific community
- A collaborative Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum)- next (3 rd) meeting is in June 2018.
- An online platform as a gateway for information on existing STI initiatives, mechanisms and programs

17

International Solar Alliance

- Aims at boosting solar power capacity especially in tropical region countries (within 23.5% degrees latitude N and S)- 61 member states so far and 60 more eligible states (including UK, China,Japan,USA, S.Africa)
- Outreach to other partner countries (Germany, Italy etc) - they may be included in future as full members.
- Aims to mobilize all kinds of resources including finance, technology, equipment, knowledge for solar energy projects and implement them. Networking approach.
- Partnerships with World Bank and IFIs to mobilize $ 1000 bn by 2030 for solar energy.
- Sharing of research and development knowledge and best practices. Stimulate related industries and create employment.
- Help in achieving climate change targets. National solar power plans to be supported.
- International treaty and agency created based in Delhi

18



Evolution of SPV technology, cost and capacity

19

S & T and diplomacy

- Has been defined in terms of three dimensions -
- **Science in diplomacy** - S&T inputs into foreign policy making and operations, which includes ensuring full briefing of policy makers on S & T subjects and implications.
- D**iplomacy for science** - using national S & T knowledge in international engagement to advance national interests - to gain access to S & T knowledge that can make the nation stronger , keep up international pressure for Technology for SDGs and forge coalitions – ISA example.
- S**cience for diplomacy** - use S & T to build bridges among conflicting nations and thus support diplomatic engagement- CERN, SESAME, South Asia etc..
- Some activities may involve more than one dimension – such as CERN, JET, etc.

20

S&T diplomacy management

- How to manage S & T diplomacy with limited human and material resources –
- Many organizational, strategy, and policy aspects.
- Ministries dealing with EA, S&T and the Business and Research community and other stakeholders need to cooperate closely on long term and continuing basis, not merely event driven
- There are both civilian and military dimensions and implications.

21

S & T in India's neighbourhood

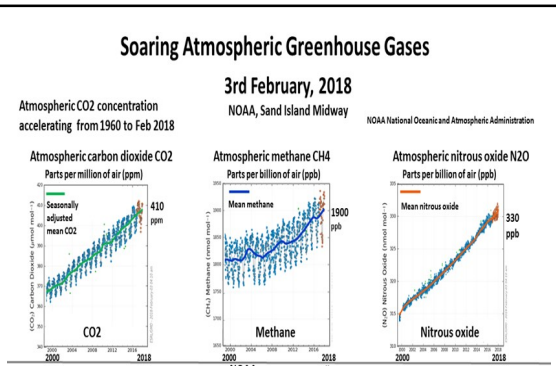
- Can S&T bring India and its neighbours closer together ?
- Indian lead role on management in the Bay of Bengal LME-34 (FAO supported project)- with Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, & Thailand.
- Similar LME project for LME-32 (The Arabian Sea)
- Possible other cooperation projects – Air quality monitoring and pollution control, Infectious disease surveillance and control, etc.
- Meteorology research, telemedicine and tele-education, Energy Charter Treaty,
- Academic and Research networking and research activities, Academic Institutional linkages,etc.

22

Nuclear Technology

- India has emerged from nuclear isolation, NSG waiver, agreements for nuclear fuel and civil rectors.
- Maintained its independent strategic nuclear programme like other NWSs.
- Facing challenges to join CTBT, FMCT, N-weapons ban treaty of 2017, etc. Challenges of dealing with nuclear armed Pakistan and China.
- Ambitious civil nuclear programme – natural Uranium fuelled Pressurized Heavy Water reactors (Candu type), and imported enriched Uranium fuelled Pressurized Water Reactors.
- Developing Fast Breeder reactors using Thorium for third stage of nuclear programme.
- India will need to be actively engaged in all aspects of nuclear technology discussions at global level.

23



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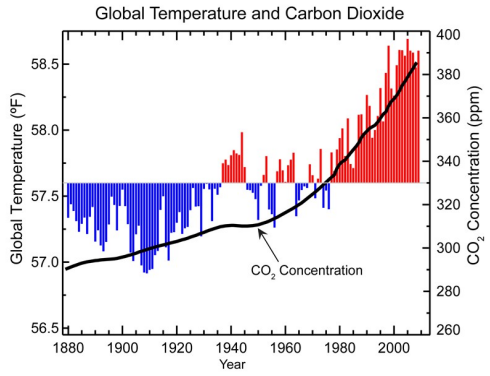
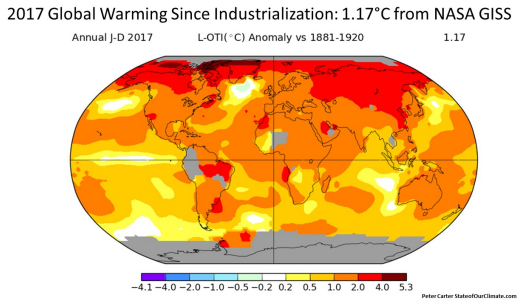


Globally averaged concentrations for CO2 reached 403.3 parts per million in 2016, 145% of pre-industrial (before 1750) levels.



Energy and climate change

- International cooperation needed- Our life styles will have to move to a more frugal mode. Civil society plays a leading role.
- India plays a key role due to its size and growing energy needs along with China and other major developing countries – need to adopt the lowest possible carbon path to development – need for technology and finance.
- Initiatives like International Solar Alliance deserve more support.
- Technology still advancing rapidly - advances in photovoltaic devices and energy storage devices.
- GHG concentrations continue to rise –global average temperatures continue to rise – data points to increasing and more severe extreme climate events like hurricanes, floods, droughts, etc. Danger of feedback amplification.

27

ICT revolution

- Use of internet, computing and mobile devices rapidly increasing - major transformative ongoing change.
- Digital manufacturing and Artificial Intelligence hold out new promises but also challenges – job disruptions.
- Explosion of social media poses new challenges – deliberate misuse for destabilizing societies-elections interference. Cyber terrorism.
- New problems of information and cyber security, and cyber crime - Cyber crime treaty needs revision
- New kinds of warfare in cyber space- need for rules similar to Geneva Conventions.
- Regulation of use of AI enabled Lethal Machines for warfare.

28

Nanotechnology

- Technology of the very small - rapidly expanding field
- Nano-world is a strange one, where surface, electrical, and quantum effects predominate.
- Nanomaterials - Graphene and its many useful properties
- New devices and sensors, and processing devices are being rapidly developed, with numerous economic and military uses - Many uses for SDGs
- Cross fertilization of several disciplines such as nanobioinformatics are evolving - implications for policy are emerging.

29

30

Life Sciences

- Life sciences -rapid expansion of knowledge about life itself- DNA revolution. Growing capability to manipulate and change life forms poses challenges – transgenic life forms, artificial genes, IPRs.
- Great potential impact on human health, agriculture, and environment protection.
- Measures needed to contain potential harmful effects of application of biotechnology especially by non-state actors. May require regulation of research and strengthening of the BW Convention.
- Ethical issues arising from genetic modification of human embryos, and new technology for human reproduction, for example, need to be addressed.

31

Managing the Oceans

- Present approach emphasizes different levels of sovereignty over ocean space and national interests such as navigation rights, security, fishing, and mineral resources . But the oceans and the living resources therein are in a single inter connected space.
- Conflicts and disputes arise - South China Sea, the Arctic, etc.
- Living resources of the oceans are an important source of food and livelihood for millions - risks due to overexploitation, pollution and failure to adopt sustainable management practices
- New patterns and models for managing the oceans are needed. The LME concept under GEF. Marine Protected Areas.
- India has a big role with two LMEs around it and large ocean spaces.

32

LME 32 The Arabian Sea

Bordering countries: Bahrain, Djibouti, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, United Arab Emirates, Yemen. Risk Assessment – Very High Risk
LME total area: 3,950,421 km^2 **Coastal population** 28 mn(2010) 109 mn(2100 proj)

LME 34 The Bay of Bengal

Bordering countries: Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, Thailand. Asesment of risk – Very High Risk
LME total area: 3,657,502 km^2 **Coastal Population** -323 mn(2010) 502 mn(2100 proj)

Aerospace

- Shift from space exploration towards exploitation with civilian and military dimensions. Satellite systems are now a vital part of global connectivity and precision navigation as well for as military uses.
- ASAT a new weapons system – NPT type of approach.
- Manned space stations are now well known – ISS and beyond
- Space junk or pollution a growing menace.
- Exploration of the surface of the Moon, Mars - AI and robotics will transform space exploration and exploitation. Exploration of other planets by unmanned probes.
- An increasing number of exoplanets discovered, some of which seem capable of supporting life as we know in earth.
- India has a big role in aerospace –applications of remote sensing, communications, telemedicine, education etc.

35

Thank you

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36