Special Issue

ISSN-0971-8400

YOJANA

DECEMBER 2015 A DEVELOPMENT MONTHLY ₹20

Climate Change and Sustainability

Climate Change and Sustainable Development: Adaptive Strategies
K.G. Saxena

Economic Development and the Costs of Climate Change
Purnamita Dasgupta

Climate Change, Technology and Energy Sustainability
Malti Goel

Special Article
Equity and a Global Climate Agreement
T Jayaraman

FOCUS

Impact of Climate Change and Sustainable Agriculture
M S Swaminathan

Intended Nationally Determined Contribution(INDC) – What it Means.

At the 19th COP(Conference of Parties) in Warsaw in 2013 it was decided that countries would prepare and publicly announce a roadmap for climate change mitigation post 2020. This would be known as the Intended Nationally Determined Contribution(INDC) for each country and would form part of the new international climate agreement to be reached at the U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) in Paris in December 2015. The INDCs would be in keeping with national policy goals, where countries would determine their contributions in the context of their national priorities, circumstances and capabilities. This would be paired with a global framework which would work collectively towards a low carbon, climate resistant future. The INDCs will reflect each country's approach to climate change mitigation, reduction of emissions taking into account domestic circumstances and requirements of development, what help they will be able to provide to or require and from the international community to the reach the common goal of a carbon free and climate resilient future The INDCs would be placed at the U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) in Paris in Nov-December 2015 where a new international climate change agreement is scheduled to be agreed upon.

India's Intended Nationally Determined Contribution: At a Glance

India's INDC centres around its policies and programmes on promotion of clean energy, especially renewable energy, enhancement of energy efficiency, development of less carbon intensive and resilient urban centres, promotion of waste to wealth, safe, smart and sustainable green transportation network, abatement of pollution and India's efforts to enhance carbon sink through creation of forest and tree cover. It also captures citizens and private sector contribution to combating climate change. The INDC proposals are on the following:

a. Sustainable Lifestyles b. Cleaner Economic Development c. Reduce Emission intensity of Gross Domestic Product (GDP) d. Increase the Share of Non Fossil Fuel Based Electricity e. Enhancing Carbon Sink (Forests) f. Adaptation g. Mobilizing Finance h. Technology Transfer and Capacity Building

Some of the salient points of the INDC are:

- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation
- To adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development
- To reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030, with the help of transfer of technology and low cost international finance, including from Green Climate Fund
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030
- To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management
- To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap
- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

December 2015

Vol 59

YOJANA

Chief Editor : Deepika Kachhal
Senior Editor : Shyamala M. Iyer
Sub Editor : Vatica Chandra

Joint Director (Production) : V.K. Meena
Cover Design : Gajanan P. Dhope
E-mail (Editorial) : yojanace@gmail.com
E-mail (Circulation) : pdjucir@gmail.com
Website : www.yojana.gov.in
Facebook : https://www.facebook.com/pages/Yojana-Journal

Let noble thoughts come to us from all sides
Rig Veda

CONTENTS

Our Representatives : Ahmedabad: Amita Maru, Bengaluru: B.K. Kiranmai, Chennai: A. Elangovan, Guwahati: Anupoma Das, Hyderabad: Vijayakumar Vedagiri, Kolkata: Antara Ghosh, Mumbai: Umesh Sadashivarao Ujgare: Thiruvananthapuram: Dhanya Sanyal K., Gagandeep Kuar Devgan, Jalandhar: Girish Chander Das, Bhubaneshwar.

YOJANA seeks to provide a vibrant platform for discussion on problems of social and economic development of the country through in-depth analysis of these issues in the wider context of government policies. Although **published by the Ministry of Information and Broadcasting**. Yojana is not restricted to expressing the official point of view. Yojana is published in Assamese, Bengali, English, Gujarati, Hindi, Kannada, Malayalam, Marathi, Oriya, Punjabi, Tamil, Telugu and Urdu.

Chief Editor's Office : Room No. 660, Soochna Bhawan, CGO Complex, Lodi Road New Delhi 110 003 Ph: 24362971. Yojana (English): Room No. 647, Soochna Bhavan, C.G.O. Complex, Lodi Road, New Delhi - 110 003. **Business Manager (Hqs.) :** Ph :24367260, 24365609, 24365610

Correspondence address of journals unit for new subscriptions, renewals, enquiries has changed. Please contact : Business Manager (Circulation & Advt.), Publications Division, Ministry of Information & Broadcasting, Room No. 48-53, Soochna Bhawan, CGO Complex, Lodi Road New Delhi 110 003(Ph: 011 24367453).Sales Emporia : Publications Division: *Soochna Bhavan, CGO Complex, Lodhi Road, New Delhi -110003 (Ph 24365610) *Hall No.196, Old Secretariat, Delhi 110054(Ph 23890205) * 701, B Wing, 7th Floor, Kendriya Sadan, Belapur, Navi Mumbai 400614 (Ph 27570686)*8, Esplanade East, Kolkata-700069 (Ph 22488030) *'A' Wing, Rajaji Bhawan, Basant Nagar, Chennai-600090 (Ph 24917673) *Press road, Near Govt. Press, Thiruvananthapuram-695001 (Ph 2330650) *205 II Floor CGO Towers, Kavadiguda, Secundrabad-500080 *1st Floor, 'F' Wing, Kendriya Sadan, Koramangala, Bengaluru-560034 (Ph 25537244) *Bihar State Co-operative Bank Building, Ashoka Rajpath, Patna-800004 (Ph 2683407) *Hall No 1, 2nd floor, Kendriya Bhawan, Sector-H, Aliganj, Lucknow-226024(Ph 2225455) *Ambica Complex, 1st Floor, above UCO Bank, Paldi, Ahmedabad-380007 (Ph 26588669) *KKB Road, New Colony, House No.7, Chenikuthi, Guwahati 781003 (Ph 2665090) *SCO 103, Puda Market, New Bus Stand, Jalandhar. (Ph 2224243)

SUBSCRIPTION : 1 year ₹ 100, 2 years ₹ 180, 3 years ₹ 250. For SAARC countries by Air Mail ₹ 530 yearly; for European and other countries ₹ 730 yearly.
No. of Pages : 80

Chief Editor's Desk

Saving the Mother Earth

It is said that "Earth does not belong to Man but Man belongs to the Earth". However, mankind has always tried to control and exploit Earth for its own benefits without even blinking once.

According to a recent report, "Earth Overshoot Day" – the day when global demand for natural resources exceeds what the planet's ecosystems can renew in a year – has fallen six days sooner in 2015 than in 2014. It was pointed out that over the past 15 years, Earth Overshoot Day has been constantly moving forward in the calendar, from October 1 in 2000 to August 19 last year and August 13 this year. This means we have already spent earth's entire ecological budget for the year 2015.

Increasing world population and the ever increasing desire of human beings to raise their standard of living has led to technological innovations of all kinds. These innovations have made life more comfortable but at the cost of increased demands for food, air, water, minerals, and energy. However, these resources are limited by the Earth's capability to renew them. Rapid depletion of natural resources all around us has caused unprecedented changes in the global climate resulting in serious implications on the survival of both human and animal species on earth. Extinction of dinosaurs because of their inability to adapt to the climate changes is a well-established fact. It is feared that one-fourth of Earth's species could be headed for extinction by 2050.

Climate change is defined as the long term change in earth's climate due to natural, mechanical and anthropological processes which result in emission of green house gases like CO_2, methane, etc. These gases settle in the stratosphere and trap the heat within the atmosphere leading to global warming and changing climatic patterns. Shifting of seasons, increasing global temperatures, rising sea levels, changing agricultural patterns have resulted in frequent disasters like landslides, tsunamis, drought, famine, population migration and major health hazards not just for us but also for our children and grand children.

The need of the hour is to think of sustainable solutions which are not just temporary but also take into account the needs of future generations. It must be recognized that natural resources are not unlimited and hence their consumption must be rationed and planned so as to ensure sustainable development. Nature friendly alternatives like wind farms, hydro-electricity, solar power, geo-thermal and bio-mass for the generation of power need to be explored and adequately implemented into the system.

It is the responsibility of not any one nation but the entire world to work in the direction of saving humanity from the effects of climate change. Formalisation of United Nations Framework Convention (UNFCCC) in 1992 at Rio marked the beginning of serious global efforts in this direction. The 21st session of the United Nations Climate Change conference at Paris in December 2015 will see countries submitting their Intended Nationally Determined Contributions (INDCs). India has already proposed its' INDCs which aim to reduce greenhouse gas emissions intensity by 33-35% by promoting clean and renewable energy, use non-fossil fuel sources, increase forest cover to create an additional carbon sink of 2.5-3 billion tonnes of carbon dioxide equivalent, develop less carbon intensive and resilient urban centres, promote waste to wealth, safe, smart and sustainable green transportation network etc. It has also committed to mobilise new funds from developed countries and to build an international architecture for diffusion of cutting-edge technologies, as well as collaborative research and development in this regard. Through this INDC, India has shown its commitment to combat climate change and **"be a part of the solution even though it was not part of problem"**.

Gandhiji had said, "The Earth has enough for everyone's needs, but not everyone's greed.' With the entire world coming together to secure the future and pass on the legacy of the earth to our forthcoming generations we can hope to create resources to satisfy everyone's needs. ❑

Climate Change and Sustainable Development: Adaptive Strategies

K G Saxena

The goal of sustainable development is so vast and a problem like climate change is so complex that we need to adopt the best available solution(s) without delay, monitor the outcomes and further improve the tried solution with new knowledge and experiences: a flexible and adaptive problem solving strategy

Development is a perpetual process enabling humans to expand and/or realize their potentialities to achieve a greater, better fuller state of living. Utilization of natural resources forms the very basis of sustenance of human life, while nature has only limited regeneration capacity. Expansion of human population, increase in per capita demand of natural resources and release of chemicals altogether new to natural ecosystems (e.g., chemical pesticides and plastics) innovated by humans over the last two centuries has resulted in global environmental changes with adverse consequences for human well being. The thesis of sustainable development emerged in the 1980s when it was realised that betterments in some spheres of life (e.g., comforts from air-conditioning technologies, dramatic increase in food production by green revolution technologies and rapid economic growth) were achieved at the expense of creation of new problems (e.g., climate change, loss of biodiversity, depletion and degradation of soil and water resources) or aggravation of pre-existing problems (e.g., inequitable development, natural constraints to production of resources needed by humans and earthquakes). While advancements in environmental/ ecological sciences established that natural ecosystems had only a limited capacity to withstand/recover from human disturbances, those in social sciences drew attention to the importance of equitable economic development. Advancements in knowledge led to interdisciplinary approaches to development looking at environmental, economic and social problems and prospects across spatial (local to global) and temporal (short term to long term) scale simultaneously, the foundation of sustainable development. Defined in different ways, elaboration of sustainable development as "a process that meets the needs of the present generation without compromising over the ability of future generations to meet their own needs" by the World Commission on Environment and Development/ Brundtland Commission was widely accepted and appreciated in the United Nations Conference on Environment and Development held in Rio (commonly known as the Earth Summit) in 1992. With formalization of United Nations Framework Convention on Climate Change (UNFCCC) and Convention on Biological Diversity (CBD), a global strategy of saving mankind from the threats of unsustainability arising from the changing climate and loss of biodiversity was laid out and new global environment-development funding mechanisms like Global Environmental Facility (GEF) established. As climate change is confounded with other changes

The author is Faculty of Jawaharlal Nehru University, New Delhi, India and a Fellow of National Academy of Agricultural Sciences (NAAS), Leadership in Environment and Development (LEAD) and National Institute of Ecology (NIE) with research interests in ecology and sustainable development.

in biophysical environment (e.g., changes in atmospheric composition and land use, desertification and biological invasion) and in economic-social-political environment (e.g., globalization, free trade, acculturation, new intellectual property regimes and bilateral/multilateral cooperation/ alignment), sustainable development approach assumes importance for its scope of addressing multiple problems simultaneously. Global acceptance of sustainable development philosophy was further firmed up with United Nations Conference on Sustainable Development in 2002 in Johannesburg and a quantum jump in financial and human resources for environmental sound, economically viable and socially acceptable development, the core of sustainable development.

As increase in carbon dioxide concentration in the atmosphere is the prime cause of climate change, reduction in emission of this gas and its sequestration from atmosphere are the prime requirements for reducing climate change driven threats. Persistence of current climate change trend will threaten biodiversity conservation in future. Nevertheless, biodiversity, particularly, forests and tree-based organic agriculture, could mitigate climate change and enhance human capacity to meet this challenge. International Platform on Biodiversity and Ecosystem Services (IPBES) and the Reducing Emissions from Deforestation and Forest Degradation in Developing countries programme of the United Nations (UN-REDD) are the two major international initiatives of the decade targeting biodiversity management as a means of meeting the challenges posed by global climate change and a poor state of human well-being in developing countries.

While unprecedented rate of global warming in recent times is conclusively established, there is a huge variation in the estimates made on the rates of climate change. Projections on global warming rates during the 21st century vary in the range of 1.0 to 5.8^0C on a global scale and 0.4 to 2.0^0C in India. There is equally high uncertainty about the precipitation regimes, particularly the extreme events like drought and flood, in future climate. A high degree of uncertainty associated with projected global climate change scenarios is a combined outcome of variation in spatial/temporal scale of change analysis, gaps in scientific knowledge of factors and feedbacks determining climate and multiple tools/ techniques of inferring past/future climate. Nevertheless, all scientific studies point to inevitability of climate change and the necessity of adapting to this change together with reducing its magnitude. Climate change mitigation and adaptation actions therefore, are to be taken in the face of scientific uncertainty of projected climate change scenarios. Indeed, uncertainty is an element associated with virtually all scientific predictions, but this is quite high in case of climate change, more so of local level/finer scale climate change which is the prime concern of the public at large.

The earth system is such that sensitivity to and impacts of climate change vary in space as also the potential of mitigating and adapting to this change. While highlands and islands are the regions most sensitive to climate change, the areas rich in forests or having potential for development of forests and organic agroforestry systems have a high potential of mitigating climate change. Areas rich in biodiversity become significant for offering a genetic base for developing new crop varieties and livestock breeds resilient to climate change and thus for food security in the changing climate. A region like Himalayan mountain system attracts more global attention than other mountain regions as (i) it is exposed to higher magnitude of climate change and regulates the regional climate, (ii) it is one of the 34 global biodiversity hotspots and is part of one of the eight centers of crop diversity and thus harbours biological resources with potential benefits to the global community, (iii) it stores the highest ice mass next to polar regions, feeding the mighty rivers like Indus, Ganges, Brahmputra, Salween and Mekong, supporting livelihoods of millions of poor people, (iv) it is covered by partly/fully eight developing countries (viz., Afghanistan, Bangladesh, India, Nepal, China, Bhutan, Bhutan and Myanmar) where climate change mitigation/adaption and biodiversity conservation need to be coupled with socio-economic development of local people for ensuring sustainable flow global benefits from it, i.e., harmonization of the priorities for socio-economic development stressed by the local people and environmental conservation by the developed world. Climate change and biodiversity concern foster cooperation among the eight developing Himalayan countries as well as between the developed and developing countries. Responding to the global importance of the Himalayas, India has drawn a National Mission "Sustaining the Himalayan Ecosystem" as part of the National Action Plan on Climate Change (www.envfor.nic.in; www.dst.gov.in).

With time, it was realised that "achieving sustainable development" was an ideal approach and needed articulations in terms of concrete time bound goals. This realisation led to framing of the eight Millennium Development Goals (MDGs), with each goal, except for the 8th one (Promote Global Partnership) further broken down into specific targets, by the United Nations. Environmental Sustainability is the goal which covers climate change alongwith other environmental issues like biodiversity, water resources and human habitats. While there is a significant progress in socio-economic spheres of development like reduction in hunger, poverty and mortality and promotion of equitable development over 2000-2015 period, there has been very limited success in the sphere of environmental development. Outcomes of efforts towards climate change mitigation and biodiversity conservation met very limited success (Table 1). Biodiversity is the foundation of all ecosystem services (viz., provisioning services, regulating services, supporting services and cultural services, the benefits ecosystems provide, directly or indirectly, to humans) and the two

Table 1. Millennium Development Goals, Targets and Achievements

Goal	Targets	Achievement
1. Reduce extreme hunger and poverty	Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day	The proportion of people living in extreme poverty declined by half at the global level.
	Achieve full and productive employment and decent work for all	In developing regions, the proportion of people living on less than $1.25 a day fell from 47 per cent in 1990 to 22 per cent in 2010
	Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Proportion of undernourished people globally decreased from 23.2 per cent in 1990-1992 to 14.9 per cent in 2010-2012, this still leaves 870 million people (13 per cent) suffering from hunger .
2. Achieve universal primary education	Ensure that, by 2015, all children will be able to complete a full course of primary schooling	Literacy rates among adults and youths are on the rise, gender gaps are narrowing, the number of out-of-school children dropped from 102 million in 2000 to 57 million in 2011 and primary education enrolment in developing countries reached 90 per cent in 2010.
3. Promote gender equality and empower women	Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education, no later than 2015	Globally, the share of women employed outside of agriculture rose to 40 per cent and represented in Parliament to 20 per cent in 2012.
4. Reduce child mortality	Reduce by two-thirds, between 1990 and 2015, the mortality rate of children under five	Since 1990, the under-five mortality rate has dropped by 47 per cent, this still leaves around 17,000 children are dying each day and, in sub-Saharan Africa, one in ten children dies before age five, more than 15 times the average for developed regions.
5.Improve maternal health	1. Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	Globally, maternal mortality declined by 47 per cent per cent over the last two decades.
	2. Achieve, by 2015, universal access to reproductive health	Only half of pregnant women in developing regions receive the recommended minimum of four antenatal care visits. Most maternal deaths in developing countries are preventable through adequate nutrition, proper health care, including access to family planning, the presence of a skilled birth attendant during delivery and emergency obstetric care.
6.Combat HIV/AIDS, malaria and other diseases	1. Halt and begin to reverse, by 2015, the spread of HIV/AIDS	Worldwide, the number of people newly infected with HIV continues to fall, dropping 33 per cent from 2001 to 2011. In 2012, 290,000 fewer children under age 15 were infected with HIV than in 2001.
	2. Achieve universal access to treatment for HIV/AIDS for all those who need it	A record 9.7 million people were receiving antiretroviral therapy for HIV in 2012.
	3. Halt and begin to reverse, by 2015, the incidence of malaria and other major diseases	In the decade since 2000, 1.1 million deaths from malaria were averted and treatment for tuberculosis has saved some 20 million lives.
7. Ensure environmental sustainability	1. Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	Global carbon dioxide emissions have increased by more than 46 per cent since 1990.
	2 Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	Nearly one-third of marine fish stocks have been overexploited and the world's fisheries can no longer produce maximum sustainable yields. More species are at risk of extinction despite an increase in protected areas. Forests, particularly in South America and Africa, are disappearing at an alarming rate.
	3. Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation	More than 2.1 billion people have gained access to improved drinking water sources since 1990, exceeding the MDG target. While almost 2 billion more people now have access to proper sanitation than in 1990, 2.5 billion still do not have access to toilets or latrines.
	4. Achieve, by 2020, a significant improvement in the lives of at least 100 million slum dwellers	An estimated 863 million people reside in slums in developing countries.
8. Global partnership	No specific targets	

together constitute the backbone of our resilience to climate change as well as any other ecological or economic shocks.

Monitoring of the achievements of MDGs followed led to renaming as well as reorganization of the eight MDGs as 17 Sustainable Development Goals (SDGs) of United Nations to be achieved over 2015-30 period (Table 2). The MDG of achieving environmental sustainability has been rephrased

Table 2. The Eight Millennium Development Goals set for the period 2000-2015 and the corresponding seventeen Sustainable Development Goals set for 2015-30

Millennium Development Goals (2000-2015)	Sustainable Development Goals (2015-2030)
1. Reduce extreme hunger and poverty	1. End poverty 2. End hunger
2. Achieve universal primary education	4. Ensure inclusive and equitable quality education
3. Promote gender equality and empower women	5. Achieve gender equality
	10. Reduce inequality within and among countries
4. Reduce child mortality 5. Improve maternal health 6. Combat HIV/AIDS, malaria and other diseases	3. Ensure healthy lives and promote well being
7. Ensure environmental sustainability	6. Ensure availability and sustainable management of water and sanitation for all 7. Ensure access to affordable, reliable, sustainable and modern energy for all 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation 11. Make cities and human settlements inclusive, safe, resilient and sustainable 12. Ensure sustainable consumption and production patterns 13. Take urgent action to combat climate change and its impacts (taking note of agreements made by the UNFCCC forum) 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and halt biodiversity loss
8. Promote global partnership	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels 17. Strengthen the means of implementation and revitalise the global partnership for sustainable development

in terms of more focussed 9 SDGs highlighting the growing importance of environmental sustainability and the interconnections between environmental, economic and social problems. Solution to climate change is now being addressed through multiple approaches – reducing emissions, improving capacity of the poor to face climate change and increasing sequestration of atmospheric carbon dioxide. Equitable development within and among countries is another component of sustainable development philosophy that has received more recognition in SDG framework in the form of an explicit goal.

Climate change is one of the several dimensions of sustainable development. While averting climate change and achieving sustainable development are desired by all, there are conflicts of opinions about the solutions to achieve the goals as well as limitations of knowledge in designing perfect and universally acceptable solutions and resources to implement them. Global partnerships aim for capitalizing on the opportunities of cooperation for ground actions to the benefit of all. UN-REDD programme is one such programme providing a new opportunity of income to people in developing countries by conserving their forests and switching over to land uses with high carbon stocks; developed countries paying for carbon conserved and sequestered by people in developing countries. As climate change will affect both developed and developing countries, it has become the crucial agenda of international relations and a point of action driving convergence of social, economic and environmental development goals and synergy or the best trade off between short term and long term and local and global development goals. The goal of sustainable development is so vast and a problem like climate change is so complex that we need to adopt the best available solution(s) without delay, monitor the outcomes and further improve the tried solution with new knowledge and experiences: a flexible and adaptive problem solving strategy. ❑

(E-mail: kgsaxena@mail.jnu.ac.in; kgsaxena@gmail.com)

Impact of Climate Change and Sustainable Agriculture

M S Swaminathan

...climate change has already increased the volatility of prices of agricultural commodities. In the future, it will be difficult to import food grains at an affordable price. Therefore, the future will belong to the nations with grains and not guns. An uncommon opportunity now exists for converting a potential calamity like climate change into a tool for achieving the goal of sustainable agriculture

Recently, 17 Sustainable Development Goals were adopted by the Member Nations of the United Nations. Goal 13 urges countries to take urgent action to combat climate change and its impacts following the Conference of Parties to the UN Framework Convention on Climate Change in Paris Member Nations of the UN will have to finalise their strategies for making their respective contributions to both adaptation and mitigation of climate change. The areas of special concern to us in India, where agriculture is the predominant source of livelihoods are unfavourable changes in mean temperature, excess or deficit in rainfall, more uncertain weather behaviour including extreme weather events, sea level rise, and more frequent and severe coastal storms and tsunamis. From the action taken so far by all nations, particularly by developed countries, it seems likely that the mean temperature will rise by 3^0 C by the end of this century.

The rise in mean temperature of the order of 2 to 3^0 C will lead to a reduction in the duration of the wheat crop in North India, resulting in a loss of 6 to 7 million tonnes of wheat every year. Certain regions of the world like Siberia or Northern Canada will benefit from a small rise in temperature since this will help to prolong the duration of the crop. Thus, climate change will have both common and differentiated impact. In keeping with its policy that India will assist in arriving at a mutually agreed reduction in green house gas emissions, the Government of India had announced on October 1, 2015 the following two major decisions.

1. Reduce by 2030, the emission intensity of the GDP by 32 to 35 per cent from 2005 level.
2. Generate about 40 per cent of electric power installed capacity from non-fossil fuel based energy resources by 2030 such as nuclear, solar, wind, biomass and biogas.

The areas of particular concern to our country are a rise in mean temperature and a possible rise in sea level. We have to take anticipatory action to insulate lives and livelihoods particularly in vulnerable areas from the adverse impact of unfavourable climate. Our strategy should be to maximise the production benefits of good monsoons and minimise the adverse impact of climate change. Although, the consequences of a rise in temperature and poor or excessive precipitation will be general, the

The author is one of world's leading agricultural scientists and Father of India's Green Revolution. Among his many distinguished awards are the Ramon Magsaysay Award for Community Leadership (1971, Padma Shri (1967), Padma Bhushan (1972) and Padma Vibhusan (1989) awards. In 1986, he received the Albert Einstein World Award on Science. He became the first laureate of the World Food Prize, regarded widely as the equivalent of a Nobel Prize in Agriculture in 1987. He has served as Chairman of the U.N. Advisory Committee on Science and Technology for Development , Independent Chairman of the FAO council and Chairman of the Advisory Panel on Food Security, Agriculture, Forestry and Environment to the World Commission on Environment and Development (WCED). He has been acclaimed by the TIME magazine as one of the twenty most influential Asians of the 20th century and one of the only three from India, the other two being Mahatma Gandhi and Rabindranath Tagore. The United Nations Environment Programme described him as "the Father of Economic Ecology" because of his leadership of the ever-green revolution movement in agriculture and by Javier Perez de Cuellar, Secretary General of the United Nations, as "a living legend who will go into the annals of history as a world scientist of rare distinction".

action plans, both for adaptation and mitigation have to be local. We will have to establish at the Panchayat level, Climate Risk Management Centres and train a cadre of Community Climate Risk Managers.

An area where urgent action is needed is the conservation of Climate Smart Millets and their reintroduction in the diet. Millets and other underutilised crops are more tolerant to drought and heat and are also nutritious. Farming systems for adaptation to climate change will have to be designed by ICAR, Agricultural Universities and Krishi Vigyan Kendras and popularised through local men and women trained to become Climate Risk Managers. There will be a need for anticipatory research in several areas of farming which will need change. For example, in crops like wheat and rice, the breeder should shift attention to per day productivity from per crop productivity, since the duration of the crop is likely to get reduced. We are one of the leading countries in the production of potatoes. This has been possible due to the production of seed tubers during the aphid free season. Aphids serve as vectors of virus diseases and hence, the aphid free season helps farmers to produce disease free seed tubers. If the mean temperature goes up, this advantage will be lost and we will have to raise potato crop from true sexual seeds. Research on such problems needs strengthening.

Another area which will require anticipatory attention is the preparation for more frequent floods and hailstorms. Fortunately, genes are available now which can help plants like rice to grow over the flood level. Such elongation genes will have to be introduced in all flood prone areas. The greatest challenge will be coastal areas since we have nearly 7500 kms of shoreline as well as the Andaman and Nicobar and Lakshadweep Group of Islands. In these areas, mangrove forests should be conserved and their area be increased. Mangroves serve as bioshields. Also, nearly 97 per cent of the global water resource is sea water. There is scope now for biosaline farming involving both halophytes (salt tolerant plants) and marine aquaculture. Over 150 years ago, the farmer of Kuttanad in Kerala perfected the method of cultivating rice below sea level. This requires both salinity management and varieties like *Pokkali* which are salinity tolerant. In recognition of this innovative and important contribution of the farmers of Kuttanad, FAO has declared the Kuttanad Farming System as a Globally Important Agricultural Heritage Systems (GIAHS). The Government of Kerala has decided to establish an International Research and Training Centre in Below Sea Level Farming in Kuttanad for the purpose of equipping coastal communities in the science and art of biosaline and below sea level agriculture. Such a Centre will also be of interest to areas like Sunderbans and countries like Maldives.

Another consequence of sea level rise will be the need for finding alternative places of living to those who are living near the sea. Planning will have to start to provide suitable places to live to such climate refugees. The M S Swaminathan Research Foundation has established in Vedaranyam in Tamil Nadu, a Genetic Garden of Halophytes in order to conserve halophytes and make them available to breeders for designing climate smart coastal agricultural methods. There is also need for agriculture to make a contribution to reducing green house gas emissions. Several steps can be taken by the local climate risk management centres with the active participation of local communities. Involvement of women is particularly important since they suffer the most from the adverse impact of climate change, as for example in areas like collecting drinking water, fuel wood, fodder etc. Hence, all the programmes relating to climate change adaptation and mitigation must be gender sensitive.

Among the mitigation steps which can be taken, reducing deforestation and promoting aforestation in a people centred manner will help to reduce the CO_2 burden in the atmosphere. Methane, which is another green house gas can be used to promote biogas plants. This will help to both prevent methane accumulation in the atmosphere and at the same time, provide fuel and fertilizer to the farmer. Nitrous oxide emissions as a result of fertilizer application can be reduced through the use of neem coated urea. In fact, at the local level, the most effective method of contributing to low carbon development pathway is the principle- "a biogas plant, few fertilizer trees and a farm pond in every farm".

The Climate Risk Managers at the local level should be both rural women and men. They can be the leaders in promoting climate smart farming systems which should include pulses among the crops. Pulses can help to fix nitrogen in the soil and at the same time provide protein rich food.

Along the coast, there is now a possibility for mobilising information technology. For example, mobile phones can be used to provide information to small scale fishermen data on wave heights from different distances from the shoreline as well as information on where the fish are. Such fisher friendly applications of the internet and mobile telephony can help to serve as transformational agents in the areas of artesenal fisheries. Small scale fishermen got particularly afraid following the titanic Tsunami of December 26, 2004, but they now go with great confidence in their small boats to do Ocean fishing.

Climate change can be a mega catastrophe if we do not take action now, both in the area of adaptation and mitigation. Anticipatory preparation to potential changes in temperature, precipitation and sea level can help to introduce new technologies in farming. The technological transformation of small scale agriculture and fisheries can be a beneficial outcome. Climate change has already increased the volatility of prices of agricultural commodities. In the future, it will be difficult to import food grains at an affordable price. Therefore, the future will belong to the nations with grains and not guns. An uncommon opportunity now exists for converting a potential calamity like climate change into a tool for achieving the goal of sustainable agriculture. ❑

(E-mail: founder@mssrf.res.in
Twitter:@msswaminathan)

colour

SPECIAL ARTICLE

Equity and a Global Climate Agreement

T Jayaraman

...developed countries are sharply aware of the cumulative emissions limits, and will undoubtedly use this in their negotiations at a later stage. For India, this approach, we urge, should at the very least be the benchmark by which the validity of other proposals and mitigation actions should be judged and their relative impact on India' s own needs assessed appropriately

It is virtually a truism to point out that climate change is one of the major challenges facing the world today. Despite the articulate presence, especially in developed countries, of a body of intellectuals, political figures, industry advocates and the odd celebrity, who may be termed climate deniers, such views are increasingly in a minority globally. There is no political figure of serious worth who will seriously deny publicly the need for some level of concerted global and national action to ward off the threat of climate change. The scientific case for such action and its general contours have been laid out in length in various reports of the Inter-governmental Panel on Climate Change (IPCC) over two decades and a half, most recently in their Fifth Assessment Report (AR5).

Nevertheless, the process of evolving a global climate deal that would set definitive goals for reducing the emissions of greenhouse gases (GHG) has proved to be torturous and time-consuming. The original framework agreement, namely the United Nations Framework Convention on Climate Change (UNFCC), wherein the overwhelming majority of countries agreed on the broad principles under which such a global deal could be reached, was signed with relative ease in 1992. However, since then, it has proven difficult to operationalise the terms of this framework agreement and to agree on the specific actions required to be undertaken by various nations.

The sources of this difficulty are not hard to locate. The crux of the issue lies in the economics of climate change action. Greenhouse gas emissions, especially those of carbon dioxide, the most significant and potent of these gases, are a consequence of the vast and continuing dependence of humanity on fossil fuels and their derivatives and the manner in which their use is an integral part, indeed the foundation, of the industrial revolution that began more than 150 years ago. New technologies are on the horizon while renewable energy for non-industrial uses has certainly come of age in many respects. But despite this, considerable uncertainty attaches to the cost of climate change mitigation (namely, the reduction of greenhouses gas emissions), and all nations, developed and developing, are wary of the extent of these costs, now and in the future. Developing countries, are in a double bind, as they have not only the burden of growth to erase their development deficits to ensure decent levels of well-being for their population, but must achieve this under constraints on fossil fuel use that have no parallel in the global history of industrial growth and development.

The author is Professor, School of Habitat Studies, Tata Institute of Social Sciences, Mumbai. Trained as a theoretical physicist, he works at TISS on issues of science, technology and society. A significant part of this work relates to issues of climate change.

Sharing the Burden of Global Climate Action

The need for global climate action is however, an ethical imperative, not merely in abstract terms, but as an integral part of the UNFCCC. The convention, agreed to by all nations, recognizes clearly and explicitly this imperative. Thus, the key issue in the global climate negotiations has increasingly come to be the relative share of the global economic burden of climate action, especially the relative share of developed and developing nations, in a world that is still marked by considerable inequalities between the two.

That this burden sharing in global climate action must be on the basis of equity is explicitly recognized by the UNFCCC itself. Article 3.1 of the convention states clearly that "the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." Article 3.2 further adds:

"The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration." The Convention has other articles that detail more specific responsibilities that devolve on the developed countries, including taking the lead in mitigation, assistance with adaptation for developing countries, and assistance for developing countries in terms of finance and technology transfer.

Regrettably, ever since the signature of the convention, the developed countries have indulged in a long series of maneouvres designed to minimise their burden, while developing an entire arsenal of strategies, conceptual frameworks and arguments, and diplomatic ploys, in the negotiations and outside to dilute their responsibilities to the world at large and to developing nations in particular. In the first two decades since the Convention was signed, the effort was to persuade the developing nations to bear a disproportionate share of the burden but in ways that were still anchored in the Convention.

More recently though, developed countries have been attempting to dilute or do away with altogether the references to equity and common but differentiated responsibilites and respective capabilities altogether. This trend has been particularly noticeable since the climate talks at Durban in 2011, that set the goal of reaching a global deal by the 21st meeting of the Committee of Parties of the UNFCCC in 2015. The developing countries have been resisting this trend firmly, but there are sections from among these that are concerned at the damage that climate change could wreck on their nations and societies. Such countries are concerned to reach an early agreement, even if it appears that a part of the burden would fall disproportionately on the larger emerging economies, especially China and India.

...developing countries have tended to use equity in a defensive mode, while specific proposals that would ensure equity have not been articulated fully. It would be ideal if developing countries could articulate proposals that while ensuring differentiation and their core concerns for development would also guarantee that they are seen to bear their fair share of the burden of global action and not be accused of inaction.

It must also be noted that developing countries have tended to use equity in a defensive mode, while specific proposals that would ensure equity have not been articulated fully. It would be ideal if developing countries could articulate proposals that while ensuring differentiation and their core concerns for development would also guarantee that they are seen to bear their fair share of the burden of global action and not be accused of inaction.

Of course, in the current runup to the Paris conference, most developing nations, including China and India, have set out a wide range of climate actions that they would undertake, through the Intended Nationally Determined Contributions (INDC) that all nations have agreed to submit. The problem with this process of allowing nations to determine what they feel they can do, is that it allows the developed nations to stake their claim to undertaking such action as they can do, rather than what they actually ought to be doing. In this so-called "bottom-up" approach, the danger is that over time, the actual burden on the developing countries, India foremost amongst them, would actually substantiaally increase, being ratcheted up through periodic reviews. This is particularly because, developed nations have also indicated their long-term goals, along with short-term actions, wheres developing nations mostly, with the exception of China, have only short-term goals officially.

So the key question is then, how can developing countries, especially India, guarantee their strategic imperative for further development, while bearing a fair share of their burden within the scope of an equitable global climate deal? In the rest of this paper, we will sketch in brief an approach that provides a powerful means to address this question.

The Carbon Budget Approach:

In the IPCC Fifth Assessment Report, the idea of a global carbon budget has been noted in a major way in the report of Working Group I. The basic scientific idea is that the global temperature increase over a specified period is approximately proportional to the cumulative global emisssions of greenhouse gases in this period. This temperature increase is the maximum

instantaneous increase that occurs during this period. Earlier approaches focused on the annual rate of emissions growth and decline (and the concept of a peaking year when the annual emissions reach a maximum), and the temperature increase referred to the equilibrium temperature reached in the future after greenhouse gas emissions had ceased (and the atmosphere reached a state of equilibrium). However, it is now scientifically clear that the details of the rate of growth and decline of emissions are not the critical elements in determining the maximum temperature increase, but it is the total emissions of greenhouse gases that is the relevant quantity. In this approach, the details of the carbon cycle (such as absorption of gases by the oceans and biosphere and the remaining atmospheric concentrations of greenhouse gases) are not relevant and it is the direct cumulative emissions that is the relevant quantity.

This provides a ready, policy-friendly means of calculating how much cumulative emissions are allowed globally. This is the global carbon budget. It is then a simple matter to determine each nation's share of this budget based on some valid equity principle, per capita being really the simplest, taking into account also the cumulative emissions from an earlier base year (such as 1850, which is chosen by many as the base year for determining historical responsibility, or 1870, which has been used in the IPCC AR5 for determining past emissions). This method of providing an equitable share of the global carbon budget, or global carbon space, fundamentally relies on the principle of treating the Earth (and not only the atmosphere, since carbon is cycled between the oceans and the terrestrial geo- and bio-spheres also) as a global commons at least in terms of carbon.

This global carbon budget approach has found wide, scientific support apart from the IPCC AR5. The Committee on Stabilization Targets for Atmospheric Greenhouse Gas Concentrations of the National Research Council of the United States (NRC, 2011) studied this in considerable detail and the carbon budget approach was also the basic policy framework used in the report titled "America's Climate Choices" that the National Research Council made to the U.S. Congress in 2011. This basic scientific approach has also been used by the German Council for Global Change (WBGU, 20009) and by scientists from China, belonging to the Chinese Academy of Social Sciences (Pan, 2009). Most recently, leading climate scientists have endorsed this carbon budget approach in a commentary in the journal Nature (Frame et al 2014).

The actual global carbon budget depends on the probability that the given quantum of cumulative emissions (from 1870) would not lead to a temperature increase exceeding 2 deg C, the global temperature increase that was agreed to at the Copenhagen conference in 2009 and ratified at Cancun the following year. For a probability ranging from 67 per cent to 50 per cent of not exceeding 2 deg C, the global carbon budget ranges between 992 Gigatonnes of carbon (GtC) to 1212 GtC.

This budget of 992 or 1212 GtC represents the physical limit on emissions for the world as a whole. Past emissions from all countries have exhausted a part of this budget. It is estimated that about 445 to 585 GtC (an average of 515 GtC) have already been emitted. If we consider non-CO2 GHG emissions in the past, then this number increases from 515 GtC to 667 GtC. Future emissions will contribute further to exhausting the remaining carbon space. The mitigation component of an INDC from any country, therefore, explicitly or implicitly, is a claim on this carbon budget. For example, India's INDC of a reduction of emissions intensity by 33 per cent by 2030 translates to cumulative emissions of 18 GtC (for a GDP growth rate of 7 per cent) between 2012 and 2030. The INDC submitted by USA to reduce emissions by 26 per cent below 2005 levels in 2025 translates to cumulative emissions of 19 GtC between 2012 and 2025.

A simple per capita division of the total carbon budget available between 1870 and 2100 among all countries, results in a 'carbon budget entitlement' of 210 GtC[1] to Annex-I countries, which have already emitted about 380 GtC (about 169 GtC above their entitlements) till 2012 itself. Developed countries therefore, have already used more than their fair share of the carbon budget in the past. This is illustrated in the table below, where we have also displayed the results if we use not simple per capita allocation as the basis but also other basis including

Table : Carbon Budget Entitlements for Annex-I Countries (1870-2100) [GtC] - With past non-CO2 Emissions
Population, GDP, HDI base year- 2011

	Carbon Budget Entitlements for Annex-I Countries (1870-2100) [GtC]	**Past Emissions of Annex-I Countries (1870-2011) [GtC]**	**Over Occupation of Carbon Space by Annex-I Countries - Available carbon space for the future (2012-2100) [GtC]**
Simple Per Capita Entitlements	210	492	-281
Per Capita Entitlements weighted by per capita GDP	198		-294
Per Capita Entitlements weighted by non-income HDI	160		-332

considerations of GDP per capita or the Human Development Index of each country also as the basis for allocations.

It is clear from the table that if we use criteria other than simple per capita then the overoccupation of carbon space by developed countries is even starker.

Furthermore, the INDCs submitted by developed countries now constitute an unfair attempt to claim more than their fair share of what is left of the future carbon space as well as illustrated briefly by the calculation of cumulative emissions implied by the INDC submitted by the US. This is further discussed in the report through an analysis of key developed country INDCs.

Once the carbon budget is used by a country or group of countries, it is not available to others. Therefore, if a long-term goal in terms of the carbon budget is not declared by a country now, it may prove difficult to obtain an adequate share of this carbon budget in the future, since other countries, notably all large emitters have already made a claim for their share of the global carbon budget. If, in particular, India does not declare a long-term goal now, it is in danger of not having an adequate carbon budget available by the time our energy and developmental future in terms of emissions becomes clearer. What is not claimed today in terms of future global carbon budget will not remain available as others will effectively exhaust a major part of it. From these considerations, it is essential that India secures its long-term developmental future with an adequate safeguard in terms of a claim on the global carbon budget.

What would be a fair share for India in this global carbon budget? Here we must take into account the fact that the over-occupation of carbon space by the developed countries ensures that no developing country, including India, will have actual physical access to its fair share of carbon space. What is available physically is only a fair share of the remaining carbon space. From this point of view, then India's legitimate claim would be approximately 182 to 186 GtC for the period 1870-2100, depending on whether non-CO_2 emissions are included are not. However what is physically accessible on an equitable basis would range from 83-109 GtC depending on whether non-CO_2 emissions are included or not. The gap between the physically accessible and the overall entitlement could form the basis of computing the technology transfer and the financial assistance from the developed world that would be India's legitimate due. Such an entitlement perspective can be developed for all countries which has been done in other publications (some of these by the author and Ms. Kanitkar are listed in the references). Some few countries in the developing world may need a small entitlement of carbon space beyond their fair share due to their historical dependence on oil or other resource extraction (See Kanitkar et al in Winkler, 2011).

Many other proposals, especially from other developing countries focus on equity as the guiding principle for any mitigation regime and propose a differential allocation of responsibility between developed and developing countries. Proposals for mitigation can broadly be divided into two categories – stock based proposals and flow based proposals. Flow based proposals cannot ensure equity in mitigation as different cumulative emissions are implied by different emissions trajectories. Flow based proposals that apportion mitigation burdens on the basis of a 'deviation from business as usual trajectories' are even more problematic as the mitigation burden is solely determined by the 'business as usual' trajectory which is liable to fairly arbitrary determination. Such arbitrary determination can lead to significant lowering or increasing of the mitigation burden. Stock based proposals that use cumulative emissions as the basis to allocate mitigation targets are more robust and scientific. As we have already noted, stock based proposals have received significant support, especially recently in the scientific literature. However, such proposals from many developed countries tend to ignore historical responsibility.

Unfortunately though, the role of NDCs (nationally determined contributions) as the basis for distributing mitigation responsibility, even among developing country parties forms the main substance of the proposals. There is therefore, an implicit agreement to a bottom up approach to mitigation – with parties voluntarily submitting the extent and form of their mitigation actions - without a discussion on how to ensure that these actions would add up to the total mitigation required to limit temperature rise to below 2 degree C while ensuring equity at the same time.

Would the carbon budget approach be the actual form that an eventual global climate deal would take? That is indeed hard to predict, and as of now, the developed countries have been firmly against it while even many developing countries have not understood the scope of this proposal entirely. Nevertheless, developed countries are sharply aware of the cumulative emissions limits, and will undoubtedly use this in their negotiations at a later stage. For India, this approach, we urge, should at the very least be the benchmark by which the validity of other proposals and mitigation actions should be judged and their relative impact on India' s own needs assessed appropriately.

Readings

Frame, D.J., Macey, A.H. and Allen, M. (2014) Cumulative emissions and climate policy. *Nature Geoscience*, 7: 692-693.

National Research Council (2011), Climate Stabilization Targets: Emissions, Concentrations, Impacts over Decades to Millenia, Washington.

National Research Council (2011), America's Climate Choices, National Academies Press.

Pan Jia Hua and Ying Chen (2009), The Carbon Budget Scheme: An

Institutional Framework for a Fair and Sustainable World Climate Regime, Social Sciences in China.

WBGU (2009), Solving the Climate Dilemma, The Carbon Budget Approach, *www.wbgu.de/fileadmin/templates/dateien/.../wbgu_sn2009_en.pdf*

Winkler et al (2011), A South African approach – responsibility, capability and sustainable development, published in `Equitable access to sustainable development: Contribution to the body of scientific knowledge', A paper by experts from BASIC countries, Winkler H. et al, 2011.

Further references on the carbon budget approach:

Kanitkar, T., Jayaraman, T., D'Souza, M., & Purkayastha, P. (2013). Carbon budgets for climate change mitigation- a GAMS-based emissions model. *Current Science*, *104*(9), 1200-1206.

Jayaraman, T., Kanitkar, T., D'Souza, M. (2011), `Equity and burden sharing in emission scenarios: a carbon budget approach' published in Handbook of Climate Change and India: Development, Politics and Governance, Dubash N.K. (ed), Nov. 2011, Routledge http://www.cprindia.org/seminars-conferences/3364-handbook-climate-change-and-india-development-politics-and-governance

Jayaraman, T., Kanitkar, T., D'Souza, M.(2011) , `Equitable access to sustainable development: An Indian approach', published in `Equitable access to sustainable development: Contribution to the body of scientific knowledge', A paper by experts from BASIC countries, Winkler H. et al, 2011 *ww.erc.uct.ac.za/Basic_Experts_Paper.pdf*

Global Carbon Budgets and Burden Sharing in Mitigation Actions: Discussion Paper, Supplementary Notes and Summary Report', Jun. 2010 http://climate.tiss.edu/attachments/carbon-budgets-2010/at_download/file

Kanitkar, T., Jayaraman, T., D'Souza, M., Purkayastha, P., Raghunandan, D., Talwar, R. (2009), `How Much 'Carbon Space' Do We Have? Physical Constraints on India's Climate Policy and Its Implications', Economic & Political Weekly, Vol XLIV No. 41, Oct. 10, 2009 http://www.epw.in/epw/uploads/articles/14044.pdf

Endnotes

I am especially grateful to my colleague, Ms. Tejal Kanitkar, for a long-standing collaboration, based on which this review note has been writen.

This calculation is done using a carbon budget of 1136 GtC between 1870 and 2100 corresponding to a 55 per cent probability of limiting temperature rise to below 2 deg. C. This value is used merely for illustration. ❑

(E-mail: tjayaraman@tiss.edu)

J&K WINDOW

EIGHTY THOUSAND CRORE RUPEE PACKAGE FOR JAMMU AND KASHMIR

The Centre has announced a development package of eighty thousand crore rupees for the State of Jammu and Kashmir.This money would be used for infrastructure-building, tourism, skill development and information technology, Pashmina ,saffron cultivation and problem of unemployment. Rs 34,000 crore would be spent on upgradation of the Srinagar-Jammu national highway. The J&K government had submitted a proposal of Rs 44,000 crore to the Centre for rehabilitation of the victims and to rebuild the infrastructure damaged by the floods.

The package of Rs 80,000 crore was meant for all the three regions of the state, including Jammu. This package will ensure rehabilitation of 1947 refugees and displaced Kashmiri Pandits from Valley with honour and dignity. ❑

DEVELOPMENT MEASURES IN JAMMU AND KASHMIR

The foundation stone was laid for the Leh-Kargil-Srinagar power transmission line, at Leh. Built with a cost of Rs. 1788 crore, this transmission line will be 245 km long. A 45 MW installed capacity Nimmo Bazgo hydroelectric power project on the River Indus WS also dedicated to the nation .These projects are expectd to connect Ladakh, and the state of Jammu and Kashmir with other parts of the country through energy and would enable Ladakh to join the mainstream of national development. Also, Prakash (energy), paryavaran (environment) aur paryatan (tourism) were described as the strength of Jammu, Kashmir and Ladakh region.

As part of the development strategy, the natural resources of Himalayan states will help build a development model for the entire country. Various provisions have been made for Himalayan states which include organic farming - for which we will provide a global market. This will boost the incomes of farmers in rural areas.A research institute would be built for the conservation of the natural and environmental resources of the Himalayas.A big boost will be given to saffron cultivation for which a new unit for saffron will be established in Spices Development Board.Stressing on Pashmina being the pride of Jammu and Kashmir, a special scheme will be launched to enhance the skill of Pashmina producers and craftsmen. An additional funding of Rs. 8000 crore has also been given by the Centre for the four important road projects that were stalled due to price escalation. ❑

Economic Development and the Costs of Climate Change

Purnamita Dasgupta

The role of the government and public sector funding in the Indian economy for ensuring a basic quality of life is critical for building coping capacities and autonomous adaptation through providing basic amenities, public health care provisioning, biodiversity conservation, and investing in facilitating technology transfer, knowledge sharing and addressing social and economic inequities

Theories and narratives on economic growth (Malthusian, Classical, Marxian and many others such as the Stiglitz Commission) have created and contributed in building an understanding on what is economic development; what are the most important factors that determine it; and what are the key dimensions for assessing economic development. The role played by natural resources in the process of economic development, and its relevance in answering these questions is by no means new. Population, human capital, social capital, resource endowment, technology, institutions and political economy have featured prominently in understanding economic development. Climate change has contributed in bringing in an important additional dimension to the understanding of the role of nature in development, in particular because of certain characteristics peculiar to climate change and its impacts. An improved understanding of the science of climate change and the high levels of consensus reached among scientists in the past decade on the adverse consequences of global warming has contributed to furthering the focus from economic development to sustainability of the development process. This is also reflected in the way definitions of sustainable development have evolved. A widely used articulation of sustainable development is that of the UNDP's(1995): of development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987), and assumes the conservation of natural assets for future growth and development. The very recently adopted Sustainable Development Goals (SDGs) (UN 2015) explicitly incorporate a goal on climate change: take urgent action to combat climate change and its impacts. The first target mentioned under the climate goal of the SDGs is to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. In fact, many of the other goals have interlinkages with the environment, calling for conservation and sustainable use of natural resources. This is also in keeping with the thinking on *well-being* as the true measure of progress in human society.

Recent studies on observable and likely impacts of climate change as assessed in the latest report of the IPCC provide evidence that climate change poses risks for regions across the world. The adverse consequences are likely to be higher in future for those communities and ecosystems which

The author is Chair & Acting Head, Environmental Economics Unit, at Institute of Economic Growth, Delhi. She has been Visiting Professor at University of Cambridge, UK and Johns Hopkins University, USA. Currently she has been researching on issues related to climate change mitigation and adaptation policy, with particular focus on impact assessment, costing and modelling of GHG emission scenarios.

are already vulnerable. These include the poor, those whose likelihoods are natural resource dependent such as in rural areas, and fragile ecosystems and species, which are already under threat. Risk levels vary from low to very high, and differ by region and sector. For instance, the risks to coral reefs increases to very high levels with even a 1 degree C rise in temperature whereas on average, the risk to crop production does not reach high levels for most regions and crops till a 2 degrees C or higher temperature rise (IPCC AR5 2014).

Three key risks identified for Asia, include increased flood damage to infrastructure, livelihoods and settlements, heat related human mortality, and increased drought related food and water shortage (IPCC AR5 2014). In short, as per the current understanding of climate related risks, the likely impacts from climate change will have adverse impacts on the growth and development of the Indian economy in a manner that cuts across sectors and regions of India. Some of these projected impacts will be felt in the near term (say by 2040) while others are projected to occur in the longer term (by 2100). Considering flood risks and associated losses, India is among the top 20 countries most at risk from extreme events, and could experience an 80 per cent increase in population at risk from sea level rise by 2050, with Kolkata and Mumbai as the two major cities facing risks to population and assets. Heat stress can adversely impact labour productivity and also poses a heightened risk of heat strokes in India, particularly for those whose work exposes them outdoors for long hours such as workers in construction and agricultural activities. There are several other sectors that are likely to feel economic impacts such as beach and mountain tourism, and health impacts from increased cases of malaria and diarrhoea.

Substantial economic impacts from climate change in India can be expected to occur given the current low levels of adaptive capacity, the country's geographical location, large numbers dependent on natural resource based livelihoods, and impacts on agriculture. Some idea of the magnitude of the economic impacts can be gauged from studies relating to the projected impacts on food production systems and food security due to rising air temperatures. Sorghum grain yield is projected to decline between 2-14 per cent by 2020, with worsening yields by 2050 while in the Indo-Gangetic plain, reduction in wheat yields upto 51 per cent in the most favourable area is projected. In rice plant cultivation, current temperatures are claimed to be already approaching critical levels during stages of growth, e.g. in Northern India (October), Southern India (April, August) and Eastern India (March-June). One recent study projects an overall decline in foodgrain production by 18 per cent by 2050 (Dasgupta 2013).

In sum, the impacts are projected to be wide-ranging and can impose a substantial economic burden. Risk levels are influenced by the factors that influence the probability of hazards occurring and by interventions that can reduce the impacts when these occur. The former relates to activities that can reduce the emissions of greenhouse gases (or mitigation) and the latter aspect includes actions that reduce vulnerability to these impacts or increase coping capacities (or adaptation). Consumption patterns, population growth, availability of technology and knowledge, and institutional capacities are some of the factors that influence adaptation and mitigation responses. Economic decision-making with regard to the prioritization of resource allocation and the use of economic policy instruments is crucial in determining the responses to the climate challenge. Costing of the projected impacts and the resources required to take up appropriate mitigation and adaptation responses is an important input into decision-making.

The economic costs related to climate change can be considered in different ways. On one hand, the adverse impacts are losses for the economy that have to be carefully assessed. On the other hand, there are costs for reducing these losses through adoption of mitigation and adaptation activities. Note that the two are not the same. Climate science provides evidence that impacts are already being felt, some of which could be irreversible, and some amount of warming is inevitable. Even if resources to take action for reducing the impacts were fully available, there are limits to what adaptation can achieve.

For instance, the risk levels for heat related mortality are high even if a hypothetically defined high adaptation state can be attained in the long term while in the case of increased risk of drought related water and food shortage causing malnutrition, high adaptation brings down the risk level to low in the near term (2030-2040) and it can be maintained at low to medium in the long term under a 2 – 4 deg C rise in temperature by 2080-2100. The adaptation responses for tackling heat stress would include investing in heat health warning systems, urban planning to reduce heat islands, and improvement of built environment. The adaptation responses for the latter would include investing on disaster preparedness, early warning systems, and strengthening local adaptive capacities (IPCC AR5 2014).

A range of models have been used to capture the impacts on economic growth and the costs of climate change from the mitigation perspective. A number of such models have been experimented with for the Indian economy as well ranging from top down to bottom up models, and integrated assessment models. The general approach is to model the impacts of climate change on economic growth which are expected to be felt through changes in productivity, resource endowments, production and consumption patterns. Typically, the studies build alternative scenarios for the future, using a reference scenario of no new climate change (mitigation) policy versus alternatives with target reductions in GHG emissions. Costs are derived in terms of the investments required to meet the scenario with climate action, or more often expressed as a per centage of the GDP. The economic cost is measured as a loss

of GDP to the economy. The objective function is usually designed such as to maximize economic growth (or consumption expenditure over time), minimize the costs of mitigation or implement a macroeconomics rule such as maintaining national income accounting identities on savings and investment.

To overcome computational challenges, most models make simplifying assumptions and concentrate on a few sectors so many aspects are actually left out. Social and institutional aspects and non-market values tend to be ignored in such approaches. Sectoral approaches which address specific concerns, such as to what extent costs in a particular industry would increase due to adoption of cleaner technology, or hurt the industries competitiveness in global markets, provide more detailed information. As of now, there is a large variation in the available estimates of the aggregative economy-wide costs of climate change. Estimates differ due to varying specifications regarding mitigation scenarios, timelines and assumptions such as those on growth in technical factor productivity and energy efficiency. Parikh (2012) estimates a 12.5 per cent loss in GDP over 2005-2050, Shukla and Dhar arrive at a 6.7 per cent loss in GDP over the same period while Pradhan and Ghosh (2012) get a 1.1-1.3 per cent loss in the GDP growth rate till 2030.

Mitigation strategies as stated in India's submission to the UNFCCC (INDC 2015) includes a target to achieve 40 per cent cumulative electrical power installed capacity from non-fuel based energy resources by 2030. It also intends to create an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent through forest and tree cover by 2030. Apart from these, there are other responses such as improving energy efficiency, developing climate resilient infrastructure in 100 smart cities, developing public transport systems and other such initiatives.

Costing with regard to adaptation requires an assessment of the impacts of climate change in terms of the damages and losses attributable to climate change, and calculations of the costs of addressing these. Conventional approaches that rely on static analysis, or use of standard techniques in arriving at monetary values (cost effectiveness analysis, cost benefit analysis, and other cost curve approaches) may prove inadequate since these are unable to take note of the risk and uncertainty aspects that are central to climate change analysis. A plurality of methods is required for such costing which would include cost-benefit approaches that include a time dimension, to newer and heterodox ones including multi-metric approaches and other decision-support tools.

Since climate change is projected to impact economies and populations across the world differentially, a key economic concern is that costing of climate impacts or responses to these, should give due weightage to those whose values can be excluded or understated and, against ecosystems where there are uncertainties about ecosystem services. The valuation of the costs and benefits requires the weighing of differing values against each other (Chambwera, Heal, et al 2014). This is of course a challenge that economists using cost-benefit analysis have grappled with for many years now, but climate change magnifies the concerns due to the projected scale and scope of impacts. Costs incurred for adaptation and mitigation responses range from technological, managerial, personnel and institutional costs to investing in R & D, awareness and capacity building.

When planning for adaptation and mitigation, resource constrained economies make choices; calculate opportunity costs of actions keeping in view the multiple goals that they have for reaching threshold levels of a quality of life for the population. The economic decision-making context for responding to climate change in a developing economy like India, is one that recognises the multiple non-climate stressors that exist, and the interaction between, adaptation, mitigation and sustainable development. This will also enable researchers to capture the values of co-benefits and co-costs of climate action which arise from the trade-offs and synergies between adaptation, mitigation and sustainable development.

There is substantial variation in globally available estimates of both mitigation and adaptation costs. The incremental economic impact of emitting carbon dioxide (the social cost of carbon) lies between a few dollars and several hundreds of dollars per tonne of carbon. These estimates vary strongly with the assumed damage function and discount rate, with larger ranges for lower discount rates. Similarly, adaptation cost estimates for developing countries range from 4 to 109 US$ billion per year from 2010 to 2050. At a global level, there is a huge deficit in adaptation needs and available funds(IPCC Synthesis Report).

India's INDC submission cites an ADB study, that the economic damage and losses in India from climate change will be around 1.8 per cent of its GDP annually by 2050. It also cites estimates from the NITI Aayog that the mitigation activities for moderate low carbon development would cost around USD 834 billion till 2030 at 2011 prices. As per the INDC, preliminary estimates indicate that around USD 206 billion (at 2014-15 prices) between 2015 and 2030 would be required for adaptation actions in agriculture, forestry, fisheries infrastructure, water resources and ecosystems, and additional investments would be needed for strengthening resilience and disaster management. In India, most adaptation strategies are addressed within the framework of the National Action Plan on Climate Change and the National Missions.

The public sector's role in providing incentives, regulation and the right instruments for leveraging climate funds to meet costs has been advocated in recent years (IPCC AR5 2014). The role of the government and public sector funding in the Indian economy for ensuring a basic quality of life is critical for building coping capacities and autonomous adaptation through

providing basic amenities, public health care provisioning, biodiversity conservation, and investing in facilitating technology transfer, knowledge sharing and addressing social and economic inequities.

Reading

Chambwera, M., G. Heal, C. Dubeux, S. Hallegatte, L. Leclerc, A. Markandya, B.A. McCarl, R. Mechler, and J.E. Neumann, (2014): Economics of adaptation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 945-977

Dasgupta, P., A. Kumari and D. Bhattacharya (2013) Socio-Economic Analysis of Climate Change Impacts on Foodgrain Production in Indian States, Environmental Development, Elsevier, vol 8, 2013. http://authors.elsevier.com/sd/article/S2211464513000900.

INDC (2015) India's Intended Nationally Determine Contribution: Working towards climate justice. Submission to the UNFCCC, Government of India. http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf Accessed on 9 Nov 2015

IPCC Synthesis Report (2014) "Interactions between adaptation, mitigation and sustainable development" (Section 4.5), Synthesis Report, AR5, IPCC, UNEP-WMO.

IPCC (2014): Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-3

Parikh, K. (2012) Sustainable development and low carbon growth strategy for India, Energy, 40: 31–38.

Parikh, K. Parikh, J. et al (2014). Low carbon development pathways for a sustainable India, IRADe, Mimeo February.

Pradhan, B. K. and Ghosh, J. (2012) The Impact of Carbon Taxes on Growth Emissions and Welfare in India: A CGE analysis. IEG Working Paper No. 315, 2012

Shukla, P.R. and Dhar, S. (2011). Climate agreements and India: aligning options and opportunities on a new track. International Environmental Agreements: Politics, Law and Economics 11, 229–243.

Stiglitz, J. E., A. Sen, J-P Fitoussi (2009). Report by the Commission on the Measurement of Economic Performance and Social Progress http://www.insee.fr/fr/publications-et-services/dossiers_web/stiglitz/doc-commission/RAPPORT_anglais.pdf

UN (2015) Sustainable Developmental Goals, United Nations (http://www.un.org/sustainabledevelopment/sustainable-development-goals/)

UNDP (1995) Glossary http://data.un.org/Glossary.aspx?q=undp+1995

World Commission on environment and development (WCED) (1987), Our Common Future: Report of the World Commission on Environment and Development, WCED, Switzerland. (http://www.un-documents.net/our-common-future.pdf) ❑

(E-mail: purnamita.dasgupta@gmail.com)

Climate Change History

- Historical Emissions since 1880 has resulted in rise in global temperature by 0.85° Celsius
- Historical carbon space occupied by various countries in 2009 (1850 as base year):

USA:	29%
Other Developed countries:	45%
China:	10%
Other Emerging Economies:	9%
India:	3%

- India, even though not part of problem, wants to be part of solution.

Climate Change Mitigation-Background

- United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 1992(Rio Earth Summit) – 172 countries participated, 108 at level of heads of State or Government - Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity
- 1997 Kyoto Protocol- Annex I Parties commit to take binding reduction targets
- 2007 Bali COP: Introduction of Nationally Appropriate Mitigation Actions (NAMA), to engage developing countries in voluntary mitigation effort
- 2009- 2010 (Copenhagen & Cancun COP): comprehensive international system for collective action and major developing countries (including India) announced voluntary mitigation pledges
- 2011 Durban COP: ADP launched for evolving a new agreement for post-2020 period
- Warsaw & Lima COP : INDC concept for all countries
- 19th COP in Warsaw (2013): All countries required to prepare INDCs and present them before COP 21 in Paris
- 20th COP in Lima (2014) : Further clarity on form of INDC: not mitigation centric and can include other components as per country priorities

Climate Change, Technology and Energy Sustainability

In the 1890s, New York City was swamped - not by storm but something smellier, horse manure

- USA Today, Dec 30, 2013

Malti Goel

Planners and researchers would have to realign their goals for meeting climate change objectives. New energy equipment has to be manufactured for energy efficiency. Solar thermal generators and concentrators have to be designed. Simultaneous work is also required in multi-disciplinary carbon sequestration technology development. These technologies are not commercially proven yet and current S&T perspective among energy industries need to be shared. Integrated look at industrial growth, good agriculture management and agro-forestry practices has become necessary

Horses were primary means of transport then. Soon technology found the solution for roads clogged with thousands of tons of manure. Automobiles came, replaced the horses and cleaned up roads. Almost a century later, increasing exhaust fumes from automobiles started adding to pollution and in the 1990s became a cause of global concern - the *climate change*. Crisis of global warming, rising sea levels, intense weather events, water shortages have shaken up the humanity. From automobiles to industries, time is ripe for new technology to resolve the catastrophe.

Greenhouse gas emissions including carbon dioxide are potential global warming threats and are accepted physical manifestations of increasing anthropogenic and development activities around the globe. Globally, coal continues to be the fuel of the future (The Economist, April 19th 2014) and is much needed for energy industry. Fig. 1 shows sector wise global GHG emissions in 2005. Energy supply has highest share of 28 per cent followed by agriculture, transport and industry sectors.

India has 17 per cent of the world's population. As third largest producer of coal and also greenhouse gas (GHG) emissioner, its total emissions are only 5 per cent of the global emissions. India's greenhouse gas inventory from various sectors is shown in Fig.2. Energy supply has a share of 37 per cent; agriculture, transportation, building and industry are other major stakeholders.

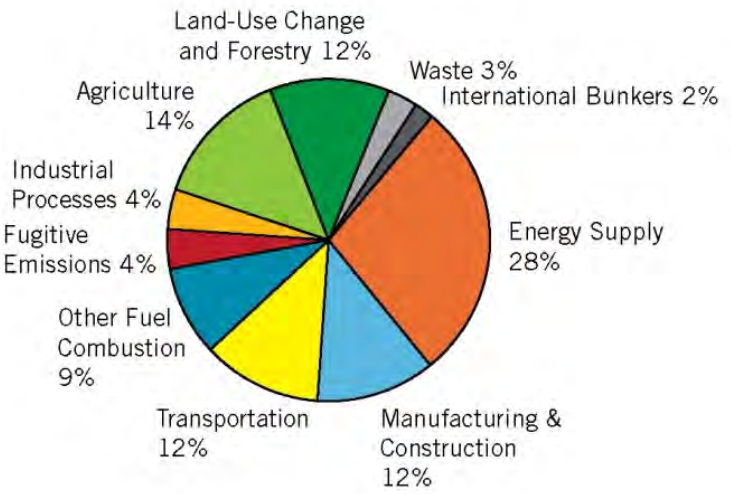
Climate Change Mitigation

International protocols and conventions on climate change namely; United Nations Framework Convention on Climate Change and Kyoto Protocol are binding all countries of the world to make greenhouse gas inventories for taking action towards stabilization of CO_2 concentration in the atmosphere. The CO_2 emission reduction commitments/ targets of coal dominant countries including India are shown in Table 1.

India as an emerging coal dominant economy has to find its own solutions to climate change. It needs to have a credible response in terms of green technology, to fight greenhouse gas emissions. As a signatory country to Kyoto Protocol, no commitment for reduction of emissions was required to be made then. However, in the Copenhagen Summit, India volunteered GDP intensity reduction of 20-25 per cent by 2020 from 2005 level. In the

The author represents Climate Change Research Institute and is Visiting Professor, Faculty of Science, Jamia Hamdard. She is a physicist having vast experience in research and science administration and has been Emeritus Scientist in CSIR and INSA. She became Fellow of National Environment Science Academy in 2008 and was conferred Bharat Jyoti Award for her outstanding contribution to science and society in 2012.

Fig. 1: Global Emissions by Sector in 2005



(Source-World Resources Institute, 2010)

Post Kyoto phase, UN secretariat has desired all countries to give their Intended Nationally Determined Contributions (INDCs). These will be finalized during the Paris Summit in December 2015. India's stated objectives in (INDCs) are

i) to bring down GDP intensity reduction of 33-35 per cent by 2030 from 2005 level,

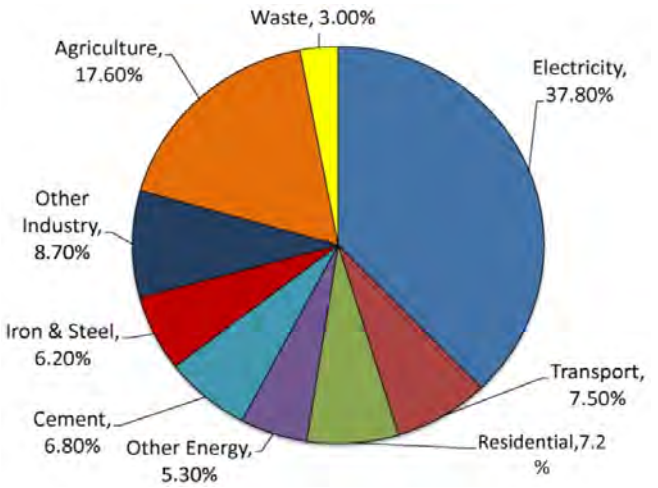
ii) to have 40 per cent non fossil fuel based electricity capacity and

iii) to add carbon sinks for 2.5-3 billion tons of carbon dioxide by 2030.

We have achieved electricity capacity of 272, 432 MW on 31st July 2015. In this, coal is around 1,65,000 MW, gas 23,000 MW and diesel 993 MW. We have a total thermal capacity of 1,89,313 MW. From renewable source 35,776 MW, hydro 41,632 MW and nuclear is 5717 MW. When we analyze the good and bad of various sources of energy, we come to the conclusion that energy sustainability has to be achieved by exploring all energy sources.

The most significant aspect in this forward looking policy is that technology would have to find ways through new research and optimum resource utilization. Let us have a look at the current perspectives of INDCs three objectives in India.

Fig. 2: India Greenhouse Gas Inventory, 2007



Energy Efficiency Improvement

Under National Action Plan on Climate Change, the National Mission on Enhanced Energy Efficiency (NMEEE) has a focus on improving energy efficiency across the sectors. The first phase of Perform, Achieve and Trade (PAT) mechanism completed in 2015, has nine designated largest energy demand sectors namely; Aluminum, Cement, Chlor-alkali, Fertilizers, Pulp & Paper, Power, Iron & Steel, Sponge Iron and Textiles. Use of energy efficient technologies in fossil fuel based power plants, such as super critical and ultra supercritical boilers has been encouraged. It reduces demand on fuel and the GHG emissions per unit of electricity generated. The second phase of PAT is being launched incorporating three more sectors of Electricity Distribution, Railways and Oil Refineries. Incentivized through participation of private sector, a large number of technologies would have to be implemented, many of which are existing and can be applied across the sectors.

Efforts towards efficient technology adoption have to be mounted in other demand sectors as well. In the transport sector, new standards have been set for fuel economy and a 15 per cent reduction in fuel consumption is targeted by 2021-22. The 20 per cent blending of ethanol and biodiesel in automobile fuel is the target for 2017. The up gradation of existing technologies including search for alternative fuels and electric vehicles to achieve their commercial viability has to be the main goal towards a climate change solution.

In the building sector, we have National Mission on Sustainable Habitat demand technologies for green buildings and smart cities. With India's target to create 100 'Smart Cities' with energy efficient transport and energy networks, water conservation and waste management, many challenges are there before the urban planners. Adoption of new technologies is imperative for making carbon neutral cities. Use of energy efficient home appliances and

Table 1: CO_2 Emission Reduction Commitment of Nations							
Country	**Gross Domestic Product Per Capita in US $ (2011)**	**Emission Reduction Target and Pledges**				**Date of Ratification**	
		By 2020 (Unconditional)	**By 2020 (Conditional)**	**By 2050 (Conditional)**	**Other**	**UNFCCC**	**Kyoto Protocol**
Australia	67,039	–5 per cent relative to 2000	Up to –15 per cent or – 25 per cent relative to 2000	–80 per cent relative to 2000		30 Dec 1992	12 Dec 2007
USA	49,922	–17 per cent by 2020 relative to 2005		towards a goal of – 83 per cent relative to 2005	–30 per cent in 2025, –42 per cent in 2030 relative to 2005	15 Oct 1992	not ratified
SA	8,090	none	–34 per cent relative to BAU	n/a	–42 per cent by 2025 relative to 2005 and missions to peak between 2020 and 2025	29 Aug 1997	31 Jul 2002
PRC	5,439	none	–40 to –45 per cent of CO_2 per unit of GDP to 2005	n/a	–17 per cent of CO_2 per unit of GDP by 2015 relative to 2005	5 Jan 1993	30 Aug 2002
India	1,528	none	–20 per cent to –5 per cent emission intensity per unit of GDP relative to 2005	n/a		1 Nov 1993	26 Aug 2002

(Source: Compiled using data from various sources including http://unstats.un.org)

better heating and cooling systems in offices, use of light emitting diode (led) lights, bioclimatic architectural designs and use of environment friendly building materials are other options to be implemented for achieving the set reduction of 33-35 per cent in GDP intensity.

Non Fossil Fuel Energy Technology

Non fossil fuel energy technologies produce no GHG emissions during operation and if they can be harnessed on large-scale and become cost competitive, they are possible climate change solutions. The Integrated Energy Policy 2006 has projected 800 Gw of electricity installed capacity in 2031-32. 40 per cent of this would mean that that 320GW should come from non fossil fuel energy.

Currently, renewable energy, hydro power and nuclear power add to 83 GW. The current share of renewable electricity capacity is 13 per cent in total generations in India. The revised National Solar Mission target is 100 GW installed capacity by 2022. At present, solar energy capacity has reached 3.5 GW which is almost eight times compared to 47 MW in 2010. The goal is to have a total of 175 GW by 2022 from all renewable energy sources. Application of solar photovoltaic technologies viz. solar rooftop and solar parks is being significantly enlarged. 25 solar parks and 4 mega power plants are expected to come up. Research has shown that new materials like gallium arsenide, carbon nanotubes have potential to increase the efficiency to as high as 50 per cent. Key technologies of solar thermal and solar concentrators are also to be pursued. In solar PV energy, solutions have to be found for large land requirement and mammoth use of cells, which would result in severe waste disposal problems in 10-15 years.

For wind energy growth, the energy capacity targets are 50 GW by 2022. It may be necessary to have installation of mega off-shore plants. The technology of wind towers has to be optimized using advance techniques. At the same time, boost to other technology for the growth of bioenergy, waste management, geothermal and ocean energies is also necessary. The balancing contribution will come from additions in hydroelectric power and nuclear

power capacities. All these would require advancement in technology and planned investment.

Carbon Capture, Storage and Utilization Technologies

In the total energy generations dominance of coal is expected to continue in the coming decades. Targets are 1 billion tons of coal by 2020 and 2 billion tones or more by 2030. India's INDCs envisage additional sinks for carbon dioxide for 2.5 to 3 billion tones in the next 15 years. In this respect development of perspective technologies such as carbon dioxide capture and storage – CO_2 sequestration, becomes inevitable.

The CO_2 sequestration involves capture of excess CO_2 from its point sources and its permanent fixation through storage or utilization away from the atmosphere. Captured CO_2 is sequestered by means of surface processes or by sub-surface storage and/or by utilization in recovery of energy fuels and minerals. If the source and the underground fixation sites are not near to each other, transport of liquid CO_2 over long distances is required. The CO_2 sequestration technology is a multi-disciplinary scientific and engineering topic. As this approach is new, we describe various technology sub sets requiring research inputs from diversified fields in more detail.

Clean Coal Technology

All technologies for reduction of pollution from coal combustion can be termed as clean coal technology. CO_2 can be captured in a coal based plant either in pre-combustion or during combustion or post combustion stages. All three processes involve physical, chemical or biological means of separation. In Pre-combustion capture, coal is first converted into syn gas or liquid fuels before the power is generated. The coal syn gas comprises mainly of carbon monoxide (CO) and hydrogen (H_2). H_2 is used as fuel for pollution free power generation. For capture of CO_2 processes such as hydrogen membrane reforming, shift gas reaction in association with Integrated Gasification Combined Cycle and Fischer-tropch synthesis are adopted. Pre-combustion CO_2 capture is preferred option at high temperature and high pressure as compared to post combustion capture. Post combustion capture is end-of-pipe alternative in which CO_2 is separated from the flue gas stacks. Chemical separation using amine based CO_2 capture techniques have been developed, but their application in large-scale operation leads to almost doubling the cost of electricity. Research is therefore needed in developing other processes like use of polymeric membranes for carbon capture, physical adsorbents and using nanotubes.

In-combustion CO_2 capture has two technology possibilities; (i) supercritical and ultra-supercritical coal combustion, where efficiency is more, CO_2 emissions per unit of generation are reduced, (ii) advance technologies like oxy fuel combustion and chemical looping which produce higher CO_2 concentrations in the fuel gas. Research is directed towards development of materials for ultra-supercritical boilers and reduction in the cost of oxygen separation from air for oxy fuel combustion technology.

CO_2 Sequestration and Industrial Energy

The industry sector contribution to GHG emissions is 37 per cent of total emissions. Industry consumes about 40 per cent of the total energy generated worldwide. The application of CO_2 capture and utilization processes for industry are similar to those of power plants. Industrial waste and slag are proving good absorber of CO_2. Appropriate technology needs to be developed for a greater push to carbon management in Post Kyoto regime.

Terrestrial CO_2 Sequestration

Terrestrial sequestration of CO_2 is chiefly biological. Carbon assimilation occurs in forests, trees, crops and soil and act as as CO_2 sinks. Currently, research in enhanced photosynthesis fixation in plants, advance technique of micro mediated CO_2 sequestration using algae and carbonic anhydrate enzyme catalysis are being pursued in R & D laboratories and universities. Advances are taking place in genomic sciences and are providing new ways of CO_2 fixation. Reclamation of waste lands together with afforestation has potential for CO_2 sequestration for both below and above the ground, while it may also add to growing carbon markets.

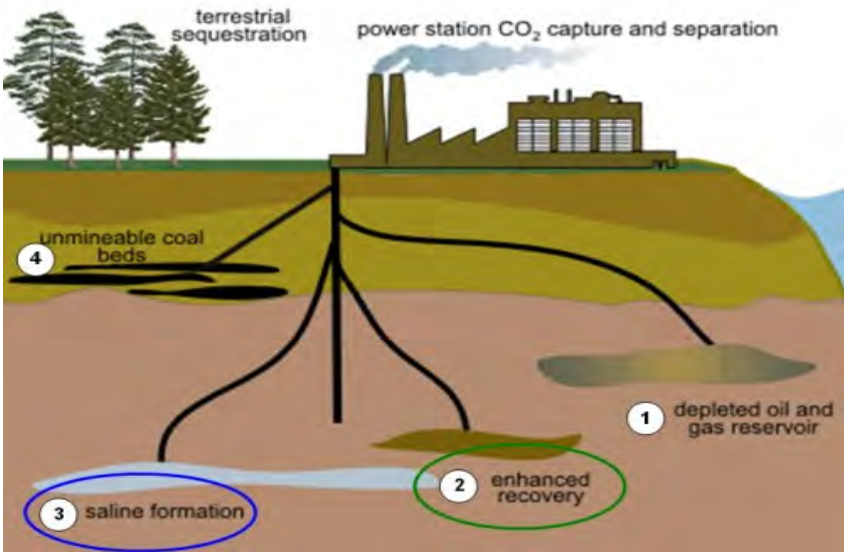
Underground CO_2 Trapping

Research on both active and passive underground trapping of CO_2 is being attempted. CO_2 can be buried in deep saline aquifers as well as in rocks and minerals. CO_2 storage is in demonstration stage and several large-scale experiments have been undertaken worldwide. Sleipner, Norway has proved to be the first successful project in CO_2 storage in the underground deep aquifers under the sea bed. It has injected 1Mt of CO_2 every year in saline aquifers, since 1996. Basaltic rocks offer possibility of conversion of calcium and magnesium silicates into carbonates minerals. In underground spaces, CO_2 is stored in the supercritical phase, which is attained at a temperature of 304.1 K and pressure of 73.8 bars. Each geological setting is different and underground CO_2 trapping studies require geomorphology studies. Various trapping mechanisms under study include physical or stratigraphic trapping, mineralogical trapping, geochemical mixing, and residual gas mixing. There is a need to develop methodologies for long-term tracking of CO_2 injected and carry out 3D seismic studies for safe storage.

Energy Fuels by CO_2 Sequestration

Injection of CO_2 in depleted oilfields for producing enhanced oil can provide an economic synergy to CO_2 sequestration process. A CO_2-EOR project designed to minimize CO_2 emissions back to atmosphere with appropriate incentives would

Fig.3. CO_2 source, capture, terrestrial and underground storage options



have an important role in assuring energy security. Underground storage of CO_2 and consequent changes in the viscosity of fluids in depleting oil reservoirs can provide additional fuel for energy. Like oil fields, unmineable coal seams can also prove to be potential reservoir for CO_2 storage. On average three molecules of CO_2 are absorbed in coal and displace one molecule of methane (CH_4) resulting in enhanced coal bed methane recovery. Research studies are being carried out in USA, Japan, China as well as in India.

CO_2 Utilization Technologies

As a first step towards carbon management, utilization of captured CO_2 makes it an attractive proposition, it is a risk free option and results in value-added products. In biological route, CO_2 in photosynthesis helps in producing carbon sinks and increase forestation. Chemically, as such, CO_2 has low chemical reactivity, but it is possible to activate it towards chemical reaction by application of temperature or pressure or by use of appropriate catalysts. CO_2 can be converted into production of fuels like ethanol or methanol or fertilizers, as feedstock in food processing and carbonated drinks, etc. In a bio-reacting medium such as microalgae in waste water or oceans, it can be converted into fuels, pharmaceuticals, and value added products.

Storage of CO_2 in Oceans and Iron Fertilization

The oceans are mammoth reservoirs of CO_2 and have been suggested as candidate for CO_2 sequestration. CO_2 can be injected into sea water at different depths. Dispersal at shallow depths of less than 300m may however release it back to the atmosphere through surface plumes. Injecting it to a depth of 1000m or so is likely to delay the process of atmospheric release, but this may endanger the survival of marine species. Liquid CO_2 injected at a depth of 3000m would confine it to form a permanent lake, being denser than water, is safer. The other options are; disposal of frozen CO_2 in thermohyline zones, CO_2 fixation in marine cynobacteria – and use of iron filings on the upper surface of oceans to catalyze production of phytoplankton as well as marine food. Large-scale experiments undertaken to test the efficacy of CO_2 catalyzed ocean fertilization in different marine zones have met with little success. There should be regulations before the experiments are carried out.

Various options of CO_2 capture and sequestration are pictorially depicted in Fig. 3.

India is giving thrust to CO_2 sequestration research through government and industry support. Some of the areas like CO_2 capture and sequestration are getting highlighted while sporadic work is being done in others. Technology is vast and work is required to be pursued in all. We held a capacity building workshop on CCSU in energy industry in Delhi, wherein stakeholders from academic and industry participated from across the country. The following recommendations were made:

- A CO_2 capture test facility which can help in making the process cost-effective,
- A multi-sectoral research program for development of ammonia based CO_2 capture with the participation from ministries of chemicals & fertilizers, agriculture, steel and power as well as academic institutions.

A nodal institution is needed to organize knowledge sharing among the various stakeholders in order to accelerate the pace of work in the country.

Way Forward

The energy in 21st century is undergoing transformation. The emphasis is shifting from demand sectors to energy supply sectors. Climate and energy sustainability policies would affect all coal consuming sectors and therefore will go into the core of economic activities. Planners and researchers would have to realign their goals for meeting climate change objectives. New energy equipment has to be manufactured for energy efficiency. Solar thermal generators and concentrators have to be designed. Simultaneous work is also required in multi-disciplinary carbon sequestration technology development. These technologies are not commercially proven yet and current S&T perspective among energy industries need to be shared. Integrated look at industrial growth, good agriculture management and agro-forestry practices has become

necessary. As India gears to achieve a global presence in energy industry, through such initiatives, investment in R&D would increase and knowledge sharing among the various stakeholders can be organized on the national scene.

Readings

Integrated Energy Policy, 2008, Report of the Expert Committee, Planning Commission 2006, Government of India and Ministry of Coal, Govt of India, Annual Report

Goel malti, S.N. Charan, A.K. Bhandari, 2008, CO2 Sequestration: Recent Indian Research, IUGS in Indian report of INSA 2004-2008, Eds. A K Singhvi, A Bhattacharya and S. Guha, INSA Platinum Jublee publication, pp 56-60

Bachu, S., W. D. Gunter, and E. H. Perkins. 1994. Aquifer disposal of CO_2: Hydrodynamic and mineral trapping. *Energy Conversion Management* 35:269–279

Accelerating the uptake of CCS: Industrial use of captured carbon dioxide. 2011. Parsons Brinckerhoff in collaboration with the Global CCS Institute, Report no., March

Malti Goel, Perspectives in CO_2 Sequestration technology and an Awareness Programme, in CO_2 Sequestration Technologies for Clean Energy, Eds. S.Z. Qasim & Malti Goel, Daya Publishing house, p. 22-39, 2010.

Wisniewski, Joc, R. K. Dixon, J. D. Kinswan, R. N. Sampson, and A. E. Lugo. 1993.Carbon dioxide sequestration in terrestrial ecosystem. *Climate Research* 3:1–5

(E-mail: maltigoel2008@gmail.com)

Renewable Energy: Pillar of Climate Change Mitigation

Amit Kumar

It is very obvious that for the climate change to be stabilized at a level that does not endanger the humankind, globally low-carbon pathways have to be pursued. Over the past decade, several renewable energy technologies have attained maturity and are on the way to be cost competitive in their own right

The Earth's climate has been changing continually, for hundreds of thousands of years. What has been the cause of concern, however, is the rate of this change, specifically that of earth's temperature. In normal course, the heat gained by earth gets dissipated to the atmosphere, maintaining the general balance. But increasing concentration of greenhouse gases (GHG) like carbon dioxide and others act as a barrier to this dissipation thereby resulting in warming of earth. They simply block heat to escape to the atmosphere. As per National Aeronautics and Space Administration (NASA) "*…Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years……The year 2014 ranks as the warmest on record.*"

In the scientific community now, there is a consensus that human activities have altered this delicate balance of greenhouse gases, which in turn, has contributed to the warming of earth's surface. Over the last century, burning of fossil fuels has increased the concentration of carbon dioxide in the atmosphere.

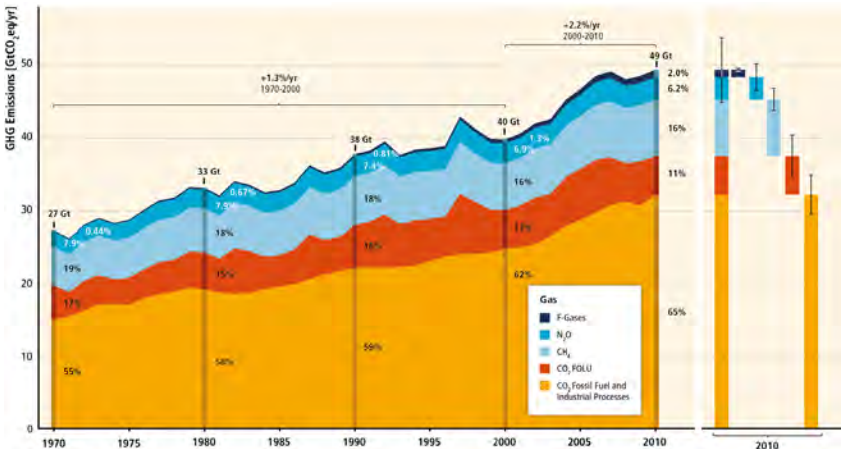
As per the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) "*Total anthropogenic GHG emissions have continued to increase over 1970 to 2010….annual GHG emissions grew on average by 2.2 per cent per year from 2000 to 2010 compared to 1.3 per cent per year from 1970 to 2000*" (as depicted in Figure 1). It further states that "*CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78 per cent of the total GHG emission increase*". The sectoral contribution has been energy supply (47 per cent), industry (30 per cent), transport (11 per cent) and buildings (3 per cent).

These climatic changes have very serious repercussions such as increased incidence of extreme weather conditions like droughts and snow storms; changing patterns of precipitation that affect agriculture; sea level rise impacting the coastal habitations; and health impacts to name a few.

While the historical occurrences cannot be reversed, the global efforts were mounted to stabilize the

The author is Dean (Distance and Short-term Education) and Coordinator, SE4All Capacity Building Hub TERI University, one of the global hubs of the UN supported Sustainable Energy for All initiative (SE4All). He has been working on the development and diffusion of cleaner and renewable energy resources based technological solutions in India for over 32 years. His experience ranges from policy and programme formulation, through project implementation, to the design and development of renewable-energy technologies, as well as manufacturing of solar energy devices. His exposure combines different facets of renewable energy industry as well as research domain.

Figure 1: Total Annual GHG Emissions (1970-2010)



temperature rise to some acceptable level. The objective of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) is therefore *"to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"*. Accordingly, in Cancun, the nations agreed with the scientific view, as articulated by IPCC, to limit the temperature rise to below 2° C above pre-industrial levels (on the global average temperature, the IPCC reported an increase of 0.85°C since 1880). However, some new studies show that a limit of even 2° C may not be enough and instead, it should by 1.5° C.It may be noted that in business-as-usual scenario, the expected temperature rise would be in the range of 3.6 to 4.2° C by 2030.

Given that the production and use of energy account for two-third of global greenhouse gas emissions, the role of energy – its production as well as utilization- becomes central to any climate change mitigation strategy. One major way of climate change mitigation is essentially through reducing GHG emissions by way of reducing the reliance on their sources i.e. burning of fossil fuels like coal and oil for electricity generation, heating and cooling, and for transportation. In this context, energy conservation and renewable energy on the demand and supply sides respectively become two pillars of climate change mitigation plan of any nation.

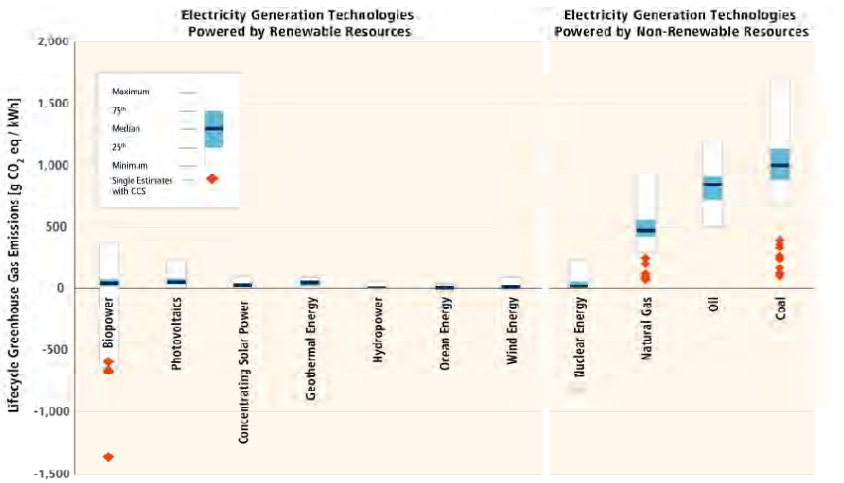
Why Renewables

The paradox is that while energy contributes the most to global GHG emissions, it is also an essential ingredient of socio-economic development and economic growth of the world. The production and consumption of energy is often linked to other major issues in the society, including poverty alleviation, environmental degradation, and security concerns. International experience shows that there is a definite correlation between access to energy on one hand, and educational attainment and literacy on the other, among the rural and urban poor. Consequently, the goals of poverty eradication, improved living standards, and increased economic output imply increasing energy requirements, which are further exacerbated by rising population and urbanisation. Thus, to contain the climate change, the key lies in reducing the energy intensity of the economy and to the extent possible, meet those energy needs through renewable energy resources like solar, wind, biomass, or hydro energy.

Renewable sources of energy assume importance in the present context because unlike fossil fuels, they are proved to be much cleaner and with negligible carbon footprint, as shown graphically in Figure 2 from IPCC `Special Report on Renewable Energy Sources and Climate Change Mitigation'. It is also becoming clear that this goal cannot be achieved by carrying out minor adjustments in the conventional energy systems. What is required, instead, is a major shift towards renewable sources of energy.

Realizing that renewables are the mainstay of any effective climate change mitigation strategy, there is now a global thrust on renewables. As per REN21 `Renewable Energy 2015: Global Status Report' in 2014, renewables made up an estimated 58.5 per cent of net additions to global power capacity. Cumulatively speaking, by year's end, renewables comprised an estimated 27.7 per cent of the world's power generating

Figure 2: Life Cycle Greenhouse Gas (GHG) Estimates for Different Electricity Generation Sources



capacity, supplying an estimated 22.8 per cent of global electricity. Table 1 gives some key renewable energy indicators.

Indian scenario

India's rapidly growing population, along with increased economic development, has placed a strain on the infrastructure, and ultimately on the country's environment. Environmental conditions, in terms of degradation of the natural resource base and increasing industrial pollution, continue to worsen. While deforestation, soil erosion, and land degradation are hindering economic development in rural India, rapid industrialization and urbanization in India's metropolisesdre causing serious concerns.

In India the energy sector is the largest emitter of CO_2, contributing 55 per cent to the national emissions. Business As Usual projections for 1990-2020 estimate that CO_2 emissions from this sector will increase fourfold (TERI Energy & Environment Data Director and Yearbook 2000). The incremental GHG emission and flyash will pose very serious environment and health hazards. Obviously, energy supply options to meet the demand in the business as usual approach, are not only capital intensive, but environmentally unsustainable.

This means that utilization of environmentally sound technologies must increase substantially to counter these negative impacts. Fortunately, the country has an abundance of renewable energy sources e.g. the sun, wind, biomass and hydropower. By adopting energy conservation measures and by carefully matching different forms of renewable energy to different end-uses, such strategies can reduce per capita energy demand (of conventional sources) while still allowing for continued economic growth.

Renewable energy sources are indigenous, and can contribute towards reduction in dependency on fossil fuels. Renewable energy also provides national energy security at a time when decreasing global reserves of fossil fuels threaten the long-term sustainability of the Indian economy. Renewable energy sources assume special significance in India when viewed in the context of the geographic diversity and size of the country, not to mention the size of its rural economy. Since renewable energy resources are diffused and decentralised, they are more appropriate as local energy systems, meeting ever expanding and diversified energy needs. In this perspective, they offer numerous possibilities for meeting the basic energy needs of the rural poor. This apart, renewable energy offers significant possibilities for job creation. Such jobs would also help to arrest rural to urban migration.

Table 1: Key Renewable Energy Indicators

		Start 2004	2013	2014
Investment				
New investment (annual) in renewable power and fuels	Billion USD	45	232	270
Power				
Renewable power capacity (total, not including hydro)	GW	85	560	657
Renewable power capacity (total, including hydro)	GW	800	1578	1712
Hydropower capacity (total)	GW	715	1018	1055
Biopower capacity	GW	<36	88	93
Geothermal power capacity	GW	8.9	12.1	12.8
Solar PV capacity	GW	2.6	138	177
Concentrating solar thermal power capacity	GW	0.4	3.4	4.4
Wind power capacity	GW	48	319	370

Source: REN21 `Renewable Energy 2015: Global Status Report'

Our country showed its visionary approach when it actively started working in the field of renewable energy way back in the early seventies, just after the first oil shock. Since then, our renewable energy programme has come a long way with India having a distinction of being the only country with a separate ministry for renewable energy, namely, Ministry of New and Renewable Energy. Indeed, our National Action Plan on Climate Change (NAPCC) lays special emphasis on energy efficiency and renewable energy with two missions dedicated specifically to enhanced energy efficiency and solar energy. NAPCC further sets up a goal of 15 per cent of total electricity to come from renewable energy by 2020.

In its recently submitted `Intended Nationally Determined Commitments (INDC)' to UNFCCC, India has again reiterated its focus on renewable energy by aiming to have (a) 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 and (b) reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level. In fact, the government has set an ambitious target of 175 GW of electricity to come from renewable resources by 2022, up from a level of over 37 GW existing as on September 30, 2015.

Conclusions

It is very obvious that for the climate change to be stabilized at a level that

does not endanger the humankind, globally low-carbon pathways have to be pursued. Over the past decade, several renewable energy technologies have attained maturity and are on the way to be cost competitive in their own right.

The successful penetration of renewable energy depends on several factors: cost-competitiveness, and the structure and operation of markets for energy and energy based services. Each of these factors is driven by the policy environment. The current policy environment in India has been successful in creating one of the largest and most diverse renewable energy programmes in the world, with a broad technological base and large human capacity. In any future energy scenario, energy efficiency on the demand side and renewable energy on the supply side become intrinsic parts of the overall strategy. And more and more attention is paid to them not only from the climate change perspective, but more importantly, from energy security point of view. Moreover, with a huge section of our populace without having access to modern energy, renewable energy could very well help in bridging that gap in a more equitable and sustainable fashion. ❑

(E-mail:akumar@teri.res.in)

India's INDC Goals-
Technology Development &Transfer

- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.
- Critical technologies need to be facilitated via GCF
- Global collaboration in R&D
- Preliminary and illustrative list of select technologies given in India's INDC propasals

First-Ever Hindi Atlas Book on Mars Mission

The first-ever Hindi Atlas Book on "Mars Orbiter Mission (MOM) has been released by the Centre, with the aim to serve as a medium in Hindi for spreading further awareness within the country about recent Space missions, particularly the Mars Orbiter Mission. It will also provide useful information which is being shared by the most advanced nations of the world the literature has been provided by Department of Space and Department of Atomic Energy .

The use of Hindi language among the native scientists will also become a motivation for foreign scientists to pick up working Hindi for easier communication with their Indian counterparts. The promotion of Hindi as a medium of instruction in scientific departments like Space technology and Atomic Energy, will also provide the best of the young scientific minds in India, an opportunity to contribute their talent even if they do not possess the knowledge of English language.

Climate Change and Disaster Management: Perspective

Anil Kumar Gupta

The time calls for improving the planning process and implementation with adequate awareness and effective governance and safety of people and their resources are crucial components of sustainable development. A "national mission" on environment and value education as part of National Action Plan for Climate Change may be incorporated to create social and professional environment for sustainable development

Climate change has posed a major threat to developmental pace firstly due to increased frequency and intensity of hydro-meteorological hazards such as floods, droughts, heat waves, cyclones, storm surges etc. and secondly, due to degradation or alteration of ecosystems (structure, extent and services), decreased food production, reduced availability of water and negative impacts on livelihoods, etc, and thereby increasing peoples vulnerability to the impacts of natural and human-induced disasters. The challenge is particularly more serious in the developing countries like India, where agriculture and other natural resources serve as primary resource base for livelihood and economic development. Impacts of climate change related disasters were reportedly much higher than those of geophysical disasters like earthquake, volcanic eruption, landslide, etc (Figure 1).

The history of scientific awareness on global warming dates back to 1980s or even before, which was then followed by an intense socio-political awakening. I recall the first brainstorming workshop in August 1989 organised in Central India by the Environmental Science Council I presided then, as a voice aloud alerting on increasing risk of glacial lake and other devastating floods, desertification and drought, windstorms and disease epidemics. However, scientific recognition of the causes of this increase has been poor. The Inter-governmental Panel on Climate Change (IPCC) played a key role in bringing science based realization on climate change impact on disasters.

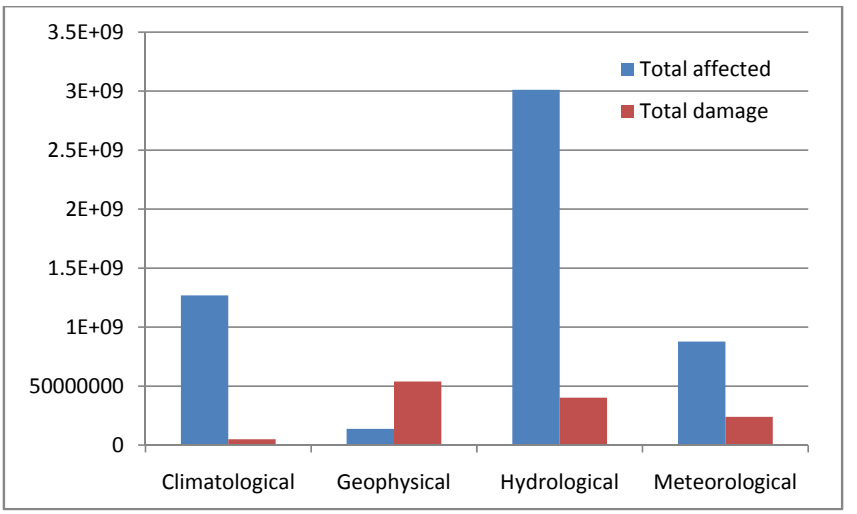
2nd Paradigm Shift in Disaster Management

IPCC's 4th Assessment Report (2007) was instrumental in bringing political recognition globally for converging climate change adaptation with disaster risk management. We termed this as 2nd paradigm shift in disaster management which focussed on three aspects: (i) addressing hazard risk, (ii) reducing vulnerability, and (iii) environmental-knowledge based approaches. The 1st shift in paradigm was from 'response and relief' to 'prevention and preparedness' centric approach in disaster management.

'Disaster management' globally is in transformation as is economics and engineering, with the realization of environmental changes. There are three aspects of environmental changes: the climate change, land use and, ecosystem alterations, known for

The author is Associate Professor and Head of Policy Planning Division at National Institute of Disaster Management, New Delhi. He has more than 25 years experience in advocacy and law, developing national plan, EIA, risk and vulnerability, damage and loss analysis, capacity building, institutional administration and international cooperation. He has more than 130 international/national publications including 20 books and 47 papers in journals.

Figure 1. Disasters by types (people affected, total damage '000 US$) in Asia Pacific region (1985-2014).



Source: EMDAT, CRED, Belgium.

aggravating threats and increasing vulnerabilities. Working in field of ecology and disaster management since the period of the United Nations International Decade for Natural Disaster Reduction (IDNDR 1990-99) to the Hyogo Framework of Action (2005-15), I witnessed the initial engineering based mitigation principles moved to a broad community and socio-economic based vulnerability focused approach with emphasis on preparedness. Yokohama Strategy and Plan of Action for a Safer World adopted in the World Conference (1994) clearly "recognised the close interrelationship between disaster reduction and sustainable development", citing the United Nations Conference on Environment and Development and the Agenda 21. However, review of the Hyogo Framework found its priority for "addressing underlying causes of disaster risk and vulnerability" as unfulfilled by nations.

Recognition of climate change impacts not only on hazards but at the same time, on vulnerabilities and risk management capacities (as explained in Table 2), brought in the subject of climate change adaptation integration with disaster risk reduction. As a clear message, we emphasized in the Bankgok Declaration and Asia-Pacific Input Document on Post-Hyogo Framework, adopted in the 6th Asian Ministerial Conference on Disaster Risk Reduction held in Thailand in June 2014. Call for this integration clearly spells in the Sendai Framework for Disaster Risk Reduction (2015-30), an outcome of the World Conference 2015.

Vulnerability to Climatic Disasters

As shown in the Figure 1, occurrences and impacts of climate change related disasters were reportedly much higher as compared to disasters of purely geophysical origin in the Asia region. Tough talks about the implications of climate change started with the devastating urban flooding in Mumbai followed by many Asian cities, for example, Dhaka, Islamabad, Surat, Bhopal, Bangalore, Kolkata, Delhi, Hyderabad, etc. Increasing frequency and intensity of cyclonic disasters affecting Indian coastal and sub-coastal states, other nations and islands in the region, Phailin and Hudhud for example, devastating flooding in Uttarakhand and Kashmir, intense heatwave in Maharashtra and Andhra Pradesh, spreading coverage of drought regions year by year, has made the scientific and strategic communities to come closer and work towards sustainable and safer development. Countries of Asia Pacific are mostly in different states of development or underdevelopment and therefore, suffer not only with vulnerability of the land and climate, but more intensely of their socio-economic resources. Recent floods in Thailand and Myanmar are known to have long impeding impacts on community and public infrastructure, ecosystem services and, thereby, their livelihood and economic sustenance. Ancillary effects of Nepal's Gorakha earthquake 2015 and aftershocks triggered landslides in the hill slopes with risk aggravated by impact of climate change and ecological degradation. Shifts and spread of disease outbreaks of chikungunya, dengue, etc. are also associated with the changes in regional weather patterns and climatic regimes.

Table 1. Scenarios - A: Observed changes in temperature and precipitation extremes, including dryness in South Asia since 1950, with the period 1961-1990 used as a baseline. **B:** Projected changes in temperature and precipitation extremes, including dryness, in South Asia. The projections are for the period 2071-2100 (compared with 1961-1990) or 2080-2100 (compared with 1980-2000) and are based on GCM and RCM12 outputs run under the A2/A1B emissions scenario.

Scenario	Trends in maximum Sub-region temperature (warm and cold days)	Trends in minimum temperature (warm and cold nights)	Trends in heat waves/ warm spells and drought[11]	Trends in heavy precipitation Trends in dryness (rain, snow)	Trends in Dryness and drought
A	Increase in warm days (decrease warm days)	Increase in warm nights (decrease in cold nights)	Insufficient evidence	Mixed signal in India	Inconsistent signal for different studies and indices
B	Likely increase in warm days (decrease in cold days)	Likely Increase in warm nights (decrease in cold nights)	Likely more frequent and/or longer heat waves and warm spells	Slight or no increase in %DP10 index More frequent and intense heavy precipitation days over parts of S. Asia	Inconsistent Change

(Source: Gupta & Nair, 2012).

An Indian reference on 'Environmental Extremes – Disaster Risk Management' for addressing climate change, released on 5th June 2012 in New Delhi, interpreted South Asia contexts from Special Report on Extreme Events and Disasters published by the Intergovernmental Panel on Climate Change (Table 1). Chapter 4 of the Report, referred that climate extremes may result in a broad range of impacts on both human and ecosystems including economic losses, impacts on different sectors such as tourism and agriculture, on urban settlements and on small island states. Extreme events have the greatest impacts on sectors that are closely linked with or dependent on the climate, for example water, agriculture and food security, forestry, health and tourism.

How Climate Change Aggravates Disasters?

Primarily, most policy interventions related to climate change were mitigation centric and based on the geophysical parameters. The focus is now shifting towards vulnerability centric approach, as was called in the "Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, 2012" by the Inter-governmental Panel on Climate Change. The Global Assessment Report on Disaster Risk Reduction: Risk and Poverty in a Changing Climate, 2009, identified ecosystems decline as a key driver in exacerbating the natural hazards in the future. The World Bank group, through their publication entitled "Managing Climate Risk: Integrating Adaptation into World Bank Group Operations" observed in 2006, the consequences of the environmental changes in South Asia, especially affecting the poor people, include:

- decreased water availability and water quality in many arid and semiarid regions;
- an increased risk of floods and droughts in many regions;
- reduction in water regulation in mountain habitats;
- decreases in reliability of hydropower and biomass production;
- increased incidence of waterborne diseases such as malaria, dengue, and cholera;
- increased damages and deaths caused by extreme weather events;
- decreased agricultural productivity, adverse impacts on fisheries, and;
- adverse effects on many ecological systems.

Impact of climate change on disasters need not be seen in isolation, but with other aspects of environmental changes, viz. land use changes and natural resource degradation. Increasing, unplanned or poorly planned urbanization and industrial agglomerations, and occupancies in hazardous areas like flood plains, erodible slopes, passive drainage channels in hill slopes, shift to monoculture in farming and other agriculture practices, and shift from traditionally safe housing to modern yet unsafe structures, besides lack of technology applications, make such risk being realised into disasters. A pictorial representation of this relationship is shown in Figure 2.

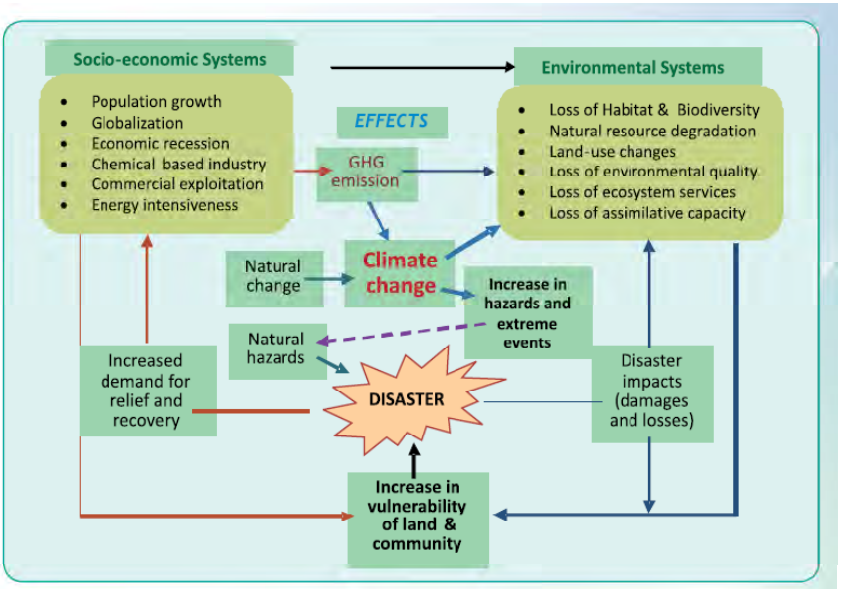
Climate Change Adaptation through Disaster Risk Management

Disaster risk reduction is understood to be a systematic blend of three layer objectives: addressing hazards, reducing vulnerability and increasing capacities (aimed at prevention-mitigation and effective emergency preparedness). Things may get much worse when the climate changes, as hundred-year return

Table 2: Implications of climate change effects on hazards and vulnerability for different disaster types, and their impact/relief phase

Climate Change Impacts	Hydro-met disasters	Ecological Disasters	Chemical Disasters	Geophysical Disasters	Biological Disasters
Aggravating hazards	Flooding, Drought, Cyclone, Windstorms, Heatwave, Coldwave, etc.	Forest Fire, Mass movement/ Landslides, Coastal erosion, Invasive Species, etc.	Fire, Explosion, Toxic release, Radioactive release, etc.	Earthquakes can trigger landslides, erosion, GLOF, LLOF, etc.	Vector Borne, Water borne and allergic disease epidemics, Pandemic, etc.
Increasing vulnerability	Degraded ecosystems, Altered hydrology, Poor natural defence, Lost socio-economic resilience	Loss of moisture – increase fire weather, Green cover loss, Change in climatic niche – alien species	Shift in safety and process thresholds, Climatic stress on operability, Altered atmospheric features	Change in vegetation regime, Change in 'albedo', Glacial and ice melting, Change in drainage	Change in climatic niche – vectors / pathogens, Loss of socio-economic resilience and health resources
Disaster Impacts/ Relief Phase	Shelter, water-sanitation, waste and environmental-health issues. Effect on ecosystems and natural resources.	Soil contamination, Risk of pests and diseases, Effect on biodiversity, drainage and ecosystems	Local climatic changes, Effects on ecosystem services and community livelihoods	Landscape alterations, Effects on ecosystems, geo-systems and natural resources	Shelter, water-sanitation, waste and environmental-health issues, Loss of human capital for natural resources

Figure 2. Causative interactions of socio-economic, climate change, and disasters



period floods become ten-year floods; coastal storm surges are amplified by sea level rise and more frequent, powerful hurricanes; destructive tornados increase in frequency and magnitude; drought-induced wildfires become larger and more widespread; and farmers are forced to cope with unfamiliar weather regimes. Vulnerability is understood as the degree to which people, property, ecosystems, resources, and cultural, economic, and social activity is susceptible to a harmful condition or event. It refers to the inability to withstand the effects of a hostile environment. A Window of Vulnerability (WoV) is a time frame within which the defensive measures are reduced, compromised or lacking.

The term 'mitigation' refers to broad range of activities starting from prevention of a stress to tolerance, remediation and resilience of the exposed 'component' of the environment of 'socio-economy', and thereby, has a different notion in climate change remediation than in the context of disaster management. 'Adaptation' is concerned with addressing the consequences, and therefore, "Adaptation to Climate Change Impacts" as the magic theme is closest to a blend of "prevention-mitigation and preparedness" field as new paradigm in disaster management. It aims at developing a set of abilities to sustain in the given complex scenario of influences along human environment (Table 3).

"Disaster Mitigation" refers to a sum of human interventions taken for reducing the risk, minimizing impact or effects of a hazard or threatening disaster situation. Disaster mitigation may include different 'structural' and 'non-structural' interventions. While designing adaptation plans at district and local levels, therefore, a visible consideration of disaster risk mitigation concerns in all stages of planning and implementation, and in the strategic documents, is called for.

Broadly, there have been four principal approaches of dealing with disaster risk and its management, viz:

- Engineering centric structural mitigation,
- Community centric preparedness based approach,
- Centralized coordination based Incident Command System (for emergency response), and
- Environment based integrated approach to disaster risk management.

Recent global emphasis of 'Ecosystem Approach to Disaster Risk Reduction (ecoDRR)' through the United Nations Partnership for Environment and Disaster Risk Reduction (PEDRR) and Ecosystem Based Adaptation (eBA) have significant overlap in their objectives and approach and, therefore, offers co-benefits in terms of livelihood resilience, food security, health resources and other ecosystem services to communities. This, in turn, strengthens their economy and reduces their vulnerability.

Legal and Institutional Framework

Climate change related disaster risk management covers all aspects including prevention, mitigation, preparedness, rehabilitation, reconstruction and recovery, and provides for:

- Establishing techno-legal and institutional framework for effective planning, implementation and finance;
- Inclusion of multi-sectoral disaster risk management concerns into process of development and disaster risk mitigation measures through schemes and projects and
- Integration of disaster risk reduction policies and planning in a holistic, participatory, inclusive and sustainable manner.

Looking at the current gaps and resultant challenges in strategic

Table 3. Components of Adaptation, aimed at Disaster Risk Management:

(a) Reducing the risk of occurrence of a hazard event by:	(i) hazard prevention	(ii) mitigation or	(iii) control
(b) Reducing exposure to hazardous event:	(i) avoidance/ migration	(ii) resilience	(iii) impact control
(c) Capacity to contain:	(i) prevent damages	(ii) prevent losses	(iii) early normalcy

implementation of sustainable development objectives through climate change adaptation and disaster risks in an integrated manner, initiatives and innovations of many small countries like Myanmar, Cambodia, Philippines, Indonesia, Bangladesh, etc in the Asia Pacific region are noteworthy where disaster risk reduction issues and interventions have been integrated across sectors, governance and institutions. A suggestive national framework is drawn in Figure 3.

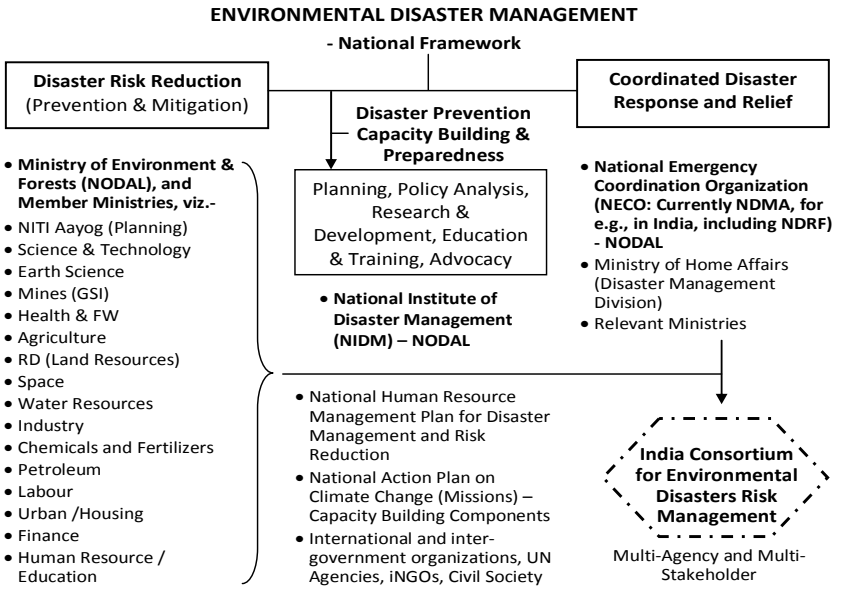
Regulatory provisions related to environment and its constituents natural resources; procedures and planning; and environmental services, primarily aim at environmental quality and resource management.

Sectors and their related regulatory provisions and laws related with following three segments of sustainable human development offer relevance to disaster risk management: (i) Infrastructure and industry, (ii) Environment and natural resources, and (ii) Social welfare and cultural services. Their legal provisions offer significant role in addressing hazards, reducing underlying causes of vulnerability and enhancing capacity, and thereby, relate to climate change adaptation and disaster risk management. We have undertaken a study of different international and national environmental legislation in this regard.

Disaster Focussed Adaptation Interventions – Some Examples

There are many initiatives world over, and in the countries of Asia Pacific as a well to strengthen disaster management in the background of changing climate and its consequences. Disaster law in India clearly recognized "environment" as major aspect in disaster management, and thereby, offers significant opportunities for integration. As per the Disaster Management Act of India (2005), disaster is defined as "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property or damage to, or degradation of environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected areas". Besides the above referred legal provisions, following policy provisions in India offer significant opportunities for adaptation integration with disaster risk reduction:

Figure 3. Suggestive National Framework for Climatic and Disaster Risk Management



- National Environment Policy 2006;
- National Disaster Management Policy 2009;
- National Water Policy 2002 (under revision 2012);
- National Forest Policy;
- National Urban Sanitation Policy;
- National Agriculture Policy;
- National Land-use Policy (draft/ pending);
- Strategy on Climate change (National Action Plan);

Some specific interventions of disaster risk management to address the increasing risk of extreme events and disasters are following:

- **National Plan for Disaster Management:** It is required to be developed as per Disaster Management Act, 2005, in a holistic, consultative way with inputs from relevant Ministries/ agencies and State Governments. After the Uttarakhand disaster of 2013, we undertook a rapid action to formulate the national plan under the aegis of National Executive Committee. Its components were: Hazard risk and vulnerability profile, Mitigation Plan, Response Plan and Human Resource Capacity Building Plan. We utilized this opportunity to integrate climate change issues across the entire process including into financial strategies and emergency response plan.
- **National Human Resource Plan 2012**: While drafting the plan, as a legal mandate, based on critical assessment of state of capacity building institutions and activities across sectors and different levels, resource mapping for addressing climatic risk was a key criterion. Plan envisaged roles and responsibilities to different agencies, institutions and stakeholders.

- **National Guidelines for Disaster Management:** National Disaster Management Authority has developed guidelines for climate change related disasters, viz., floods, urban floods, drought, cyclone, landslides, and the provisions therein are significant adaptation options to the impact of climate change.

- **Forecasting and Early Warning:** Improving early warning is a critical requirement for effective and timely response in case of disasters. Cyclone warning has now improved and the benefits have been witnessed in managing cyclone Phailin and cyclone Hudhud. India Meteorology Department is gearing up to improve its network for monitoring and forecasting.

- **Integrating Adaptation and Disaster Resilience into District Plans:** An initiative has been undertaken to showcase the development of climate resilient and disaster risk focused departmental plans at district level, at Gorakhpur district of Uttar Pradesh. The process called as "Shared Learning" utilized climate projection downscaling and led to climate resilient disaster management plan of the district.

- **State Action Plans for Climate Change and Disaster Management**: Looking to specific challenges of coastal areas and of the local communities in dealing with impact of climate change and disaster risks, lessons of the pilot projects in Tamil Nadu and Andhra Pradesh were integrated into a framework of district disaster management plan. Process outcome was integrated in fine tuning the State Action Plan for Climate Change and the State Disaster Management Plan. Climate resilient village plans were also developed through participatory process.

- **Integration of Climate Change and Disaster Risk Reduction:** Various programmes and schemes of the government, viz. Mahatma Gandhi National Employment Guarantee Scheme, Indira Aawas Yojana, Integrated Water Development Project, Jawaharlal Nehru Urban Renewable Mission, Prime Minister Irrigation Scheme, etc. have been analyzed and their customization is delineated to integrate climate change related disaster management.

There were several field interventions of the government, community, corporate and public-private partnership, with co-benefits of climate change adaptation and disaster risk management. Documentation of such practices is recommended to bring their lessons into policies and planning practices. A Delhi Declaration on Resilient Housing, released on 27 January 2014, called for a specific building code on flood resilient housing. The year 2015 marks special significance with new sustainable development goals and a new protocol on climate change. Implementation would require effective capacities, customised and tested tools, and policy planning mechanisms up to district and village level. An "environmental action plan" at district level has been much awaited since the enactment of Environmental Protection Act 1986. The time calls for improving the planning process and implementation with adequate awareness and effective governance and safety of people and their resources are crucial components of sustainable development. A "national mission" on environment and value education as part of National Action Plan for Climate Change may be incorporated to create social and professional environment for sustainable development. ❑

(E-mail: envirosafe2007@gmail.com, anil.nidm@nic.in)

India's INDC Goals-Mobilizing Finance

- To Mobilize Domestic and New & additional funds from developed countries to implement mitigation and adaptation actions in view of the resource required and the resource gap.
- USD 2.5 trillion (at 2014-15 prices) required for meeting India's climate change actions between now and 2030 as per preliminary estimates
- Ratio of emission avoided per dollar invested & economic growth attained would be relatively more favourable in case of investments made in India

India's INDC Goals - Adaptation Component

- Enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management
- Strategies and initiatives include actions in agriculture, water, health, coastal region & islands, disaster management, protecting biodiversity and Himalayan ecosystem and securing rural livelihood.
- New missions on Health and Coastal Areas. redesigning National Water Mission & National Mission on Sustainable Agriculture
- India has set up a INR 350 Crores (USD 55.6 million) National Adaptation Fund

Climate Change: Synergistic Impacts on Human and Ecosystem Health

J S Pandey

EF and CF delineate activity-specific, product-specific and process-specific environmental impacts. Thus, they (EF & CF) form the basis on which Resolute Environmental Management Plans (REMP) should be based. An REMP thus developed will have a much larger and wider bearing on overall environmental protection, which provides the basic support on which human health and development is dependent

During the last few decades, concerns have been continuously growing regarding alterations in global, regional and local climate (Pandey, 2013). This also includes heat island effect, which is due to (day by day) increasing greenhouse gases (GHGs) emanating through various anthropogenic activities such as burning of fossil fuels, waste disposal and various industrial, commercial and residential activities. These anthropogenic activities are accelerating at a rate, which far exceeds the natural (environmental) pollution-assimilative capacities.

There are substantial risks to public health and the environment from climate change. More frequent and intense heat waves increase mortality, especially among the infants, elderly and poor. There also are possibilities for enhancement and spread of some water-borne and pest-related diseases. Disease transmission dynamics is likely to alter significantly and the most vulnerable and sensitive group which is affected by climate related health effects are children, the elderly and the poor (Pandey et al. 1992 b - 1994; 2005).

International Initiatives

GHGs combined with conventional air pollutants have a synergistic impact, which changes from one region to another and is highly dependent on various local factors (Pandey et al., 1991). Many of these impacts are being tackled through various international-level harmonized attempts like the State and Territorial Air Pollution Program Administrators (STAPPA) and Association of Local Air Pollution Control Officials (ALAPCO). A Menu of Harmonized Options (MHO) has been prepared by these organizations so as to evolve strategies that simultaneously reduce conventional air pollution and GHGs. The GHGs, which are of main concern include carbon dioxide (CO_2), methane, nitrous oxide, hydro-fluorocarbons, per fluorocarbons and sulfur hexafluoride. Tropospheric Ozone is also a GHG when formed in the troposphere. Therefore, Ozone-precursors (i.e. NOx and non-methane volatile organic compounds or NMVOCs have an indirect warming potential).

Carbon and Ecological Footprints

In order to be fully equipped for tackling climate change impacts, there is an urgent need for quantifying the

The author is Chief Scientist and Professor, AcSIR, (Academy of Scientific & Innovative Research) heading the Climate Change Programme at CSIR-NEERI. He has been the recipient of the prestigious NEERI's Best Scientist Award (known an NEERI Foundation Day Award) for two consecutive years and presently working on some emerging areas like Ecological and Carbon Footprints. He has published about 100 papers in international/national journals, conferences and seminars and has written about seven chapters for national and international books. He is the Editor of NEERI's Magazine called *Paryavaran Patrika* and has written a book called *Paryavaran Evam Parivesh*, which has got him the highest Rajbhasha Honour.

carbon and ecological footprints (CF & EF) of every industrial, commercial and residential activity (Pandey et al., 2001 b; Pandey, 2010). CF and EF are some of the recently developed environmental impacts assessment (EIA) - tools. Institutions like US Environmental Protection Agency (US-EPA) and Water Utility Climate Alliance are already working on the quantification and analysis of CF and EF. Figure-1 shows one example carried out for illustration purpose.

Need for a Multi-disciplinary and Integrated Approach

World-over, there is a realization now that climate change research calls for a multi-disciplinary and integrated approach. Moreover, it becomes important that at local and regional scales, mechanisms of GHG-interactions with conventional pollutants, radiation, carbon, nitrogen, sulphur, phosphorus and hydrological cycles be investigated and the effects integrated in such a fashion that is amenable to quantifying the cumulative impacts at the global, regional and local scales (Pandey et al., 1991, 1995, 1997-98, 2001a)

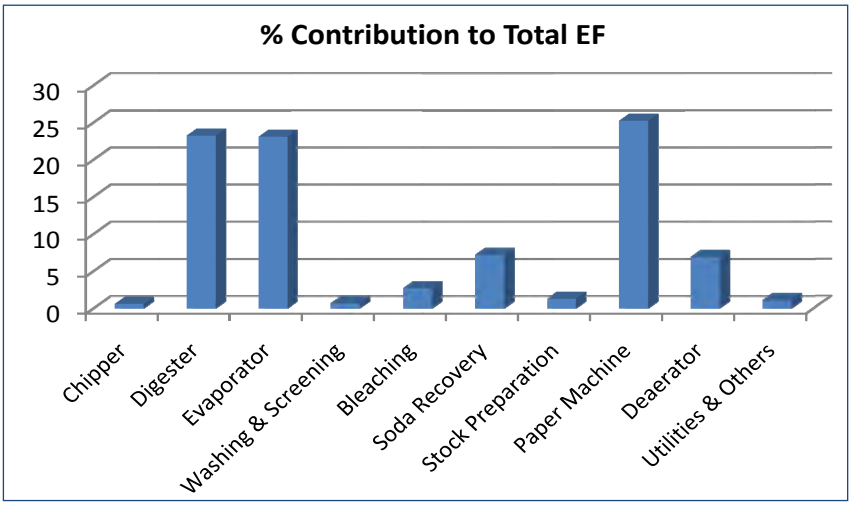
Climate Change: Impacts on Ecosystem Health

In association with air, water and soil pollution, climate change is also emerging as a significant threat to ecosystem and human health. Natural disasters like heat waves, floods and droughts are all consequences of climatic perturbations. These natural disasters subsequently culminate in various kinds of diseases and species-specific enhanced mortality. The diseases could be common vector-borne diseases such as malaria, dengue and diarrhoea. However, the magnitude of impact would be significantly different at local, regional and global levels. In view of this, the immediate research challenges before us are:

- To identify cause-effect relationships between EF, CF, ecosystem and human health impacts;
- To carry out exposure risk assessment and integrate them with dose-response characteristics;
- To evaluate population vulnerability and adaptive capacity, and;
- To assess, evaluate and adopt appropriate mitigation and intervention strategies.

Distribution and transport of pollutants through air, water and soil, human exposure to pollutants and toxicology and pharmaco-kinetics of different pollutants are some of the essential elements involved in ecosystem and health risk assessment modeling (Pandey et al., 2001a, 2005).

Figure-1: Illustration: *A Case Study of PAPER-Industry:*
Per cent Contribution by different activities towards total Ecological Footprint (EF)



Integration and Quantification of Cumulative Impacts : Not an Easy Task

However, the task of quantifying integrated impacts is not so easy. Many obstacles and uncertainties are likely to creep in to this process. Issue of "scale", specification of "exposure" and elaboration of often complex and indirect causal pathways are difficult to deal with. Notwithstanding these difficulties and limitations, one can start with empirical studies referring to the recent past and present. This process would enhance our capacity for estimating future impacts subsequently. In short, what is required immediately is to establish baseline relationship between weather and health; seek evidence of early effects of climate change; develop scenario based predictive models; evaluate several adaptation options and estimate benefits and costs of several mitigation options.

Some activities need regular pursuance, refinement, modification and application in regard to evolving site-specific, region-specific and ecosystem-specific environmental management plans aimed at combating the climate regulated environmental pollution problem (Pandey et al. 2002-2006).

Questions Which Need to be Addressed

- How do different sectors (Power, Transport, Industrial, Commercial, Residential, Agricultural, Forestry, Aquaculture) contribute to different types of GHG-emissions ?
- How to reduce these contributions ?
- What are the parameters that accelerate GHG-emissions and how can they be controlled ?
- What are the policy needs and regulations ?

Then there are issues connected with the interfacial interactions amongst the three most important components of environment, i.e. air, water and land. For example, air pollution emanating

from the cities finally becomes a water-pollution problem like the problem of acid rain, which has far wider ramifications and ultimately leads to several unexpected impacts through the entire ecological food chain (Pandey et al., 2001a).

The synergistic impacts of climate change with other environmental pollutants can now be clearly seen as perturbations in bio-geochemical cycling i.e. in terms of aberrations in carbon, water, nitrogen, sulphur and phosphorus cycles or as the undesirable accumulation of any metal or material in the land, air and water components of concerned ecosystems with serious repercussions on our livelihood and well being. Food-production is getting adversely affected day by day. Supply chains are falling too short of demands. Moreover, residential sector is also under high pollution-threat because of both indoor and outdoor air pollution.

Some burning issues related to environmental water demand (Pandey et al., 2006), nutrient modeling in wetlands (Pandey et al., 1997) and their role as pollution-remediators/ mitigators (Pandey et al., 2004a), carbon and ecological foot printing (Pandey et al., 2001 b; Pandey, 2010) and ecological risk assessment (Pandey et al., 2001a) , development of PFT's (Plant Function Types) (Pandey and Khanna, 1995) and ecological economics (Pandey et al., 2004) need immediate and urgent attention.

Climate Change, Ecosystem and Electronics Engineering

There is a continuous feed back (positive and negative both) between alterations in bio-geo-chemical cycling and the alterations in temperature and humidity. Bio-geo-chemical cycling and its alteration involve various physical, chemical and biological processes all of which are regulated by temperature and humidity. The wisest environmental management should, therefore, concentrate on minimizing the alterations in the bio-geochemical cycling so as to contain them within the limits of environmental elasticity.

Ecosystem health assessment is a discipline, which analyzes these environmental impacts in the same way as human health analysis does. For instance, in case there is any alteration in the normal physiological functioning of any organ in a human body, it is soon reflected in terms of changes in body-temperature. Similarly, whenever there is a change in normal bio-geo-chemical cycling (in the ecosystem under study), it is reflected as the changes in temperature and humidity of the relevant and concerned ecosystems.

If we go deep into the ecosystem-functioning, it more or less works like an electronic (integrated) circuit. Some of its components may behave like amplifiers, some like oscillators, capacitors, inductors, and resisters etc. and there are well known positive and negative feedbacks of material, energy and information.

Climate Change and Ecological Services

Then, there are issues connected with eco-hydrology and agricultural food-production and the critical challenge in future will be whether the available freshwater is sufficient to support food production as well as to generate ecosystem services, because at the moment, the pressure on ecosystems is very high mainly due to (day by day) increasing population and extensive land use changes. Sustainable use of water and land resources requires that these scarce resources be appropriately allocated among various competing human activities. It is precisely because of these reasons that sustainable river basin management should be accorded the highest priority, as it deals not only with technical, but also with ecological and socio-economic aspects, and thus calls for a multi-disciplinary and integrated approach.

Forest Ecosystem

Forest ecosystem offers the substrate on which most of the human activities survive and thrive. However, during the last few decades, there has been tremendous increase in forest damage all over the globe. By now, well known damage symptoms and empirical data on the physiological responses of plants (to pollutants including green house gases) have established the importance of the role played by forest ecosystem. In particular, secondary ozone (formed in the troposphere) in association with additional air pollutants induces long-lasting physiological and bio-chemical aberrations, which are mainly responsible for forest damage.

Suggestions for Future Studies

- There should be a prioritization process for the Climate Change Research in the area of Ecosystem Health and Environmental Impact Assessment. And, we must focus on programme/project-specific priorities.
- There could be a short-term framework followed by a long-term objective, which together would appropriately take care of societal needs and scientific excellence. These priorities should be directly linked to scientific-questions and societal problems.
- Initiatives should be sensitive to policy and practice needs as also to rapidly emerging and newer scientific dimensions. Initially, the programme should aim at working strategically so as to provide the scientific output required in the light of key policy decisions at the national/ international level.
- There is also a strong need for better understanding and communication amongst several sectors as also for coordination, dissemination (of information) and awareness-generation.
- Communication and collaboration with other National/International Scientific Institutions would help in developing useful and appropriate science priorities.
- Also, there should also be a concerted fund-raising strategy on developing research priorities and more and more policy and practice-relevant science.

Following is the list of some innovative research activities which

should be taken up in the area of environment and climate change synergies :

- Newer methodologies for Environmental Auditing based on Ecological and Carbon Footprints;
- Innovating a methodology which will make the EIA (Environmental Impact Assessment) Process much quicker;
- Evaluation of Technologies, Processes, Environmental Management Plans and Feasibility Reports with Climate-Impact Ramifications;
- Environmental Awareness linked with Environmental Management;
- Dealing with the issues of sustainability with a hololological (integrated) approach and not in fragmented ways which cannot be smoothly interfaced;
- Environmental Management of Sensitive Urban Fringe Areas (so as to solve rural and urban environmental problems in one go).

Research Management : Utility and Applicability

The above-mentioned measures would require several multidisciplinary R&D (Research and Development) efforts. Works related to Ecological Footprint (EF) and Carbon Footprint (CF) have their direct application in Environmental Management of Industries, Commercial Centers, Residential Sectors and various other activities because EF and CF delineate activity-specific, product-specific and process-specific environmental impacts. Thus, they (EF & CF) form the basis on which Resolute Environmental Management Plans (REMP) should be based. An REMP thus, developed will have a much larger and wider bearing on overall environmental protection, which provides the basic support on which human health and development is dependent.

Readings:

Pandey, J.S., Moghe, S. and Khanna, P. 1991. *Green House Gases, Environmental Stress and Ecological Analysis*. IGBP Report No. 18 : 2, 1991, p. 103-108.

Pandey, J.S. and Khanna, P. 1992a. *Speed-Dependent Modeling of Ecosystem Exposures from Vehicles in the Near-Road Environment.* Journal of Environmental Systems 21 (2) : 185-192.

Pandey, J.S., Pimparkar, S. and Khanna, P. 1992b. *Micro-Environmental Zones and Occupancy Factors in Jharia Coal-Field : PAH-Health Exposure Assessment.* Journal of Environmental Systems 21 (4) : 349-356.

Pandey, J.S., Pimparkar, S. and Khanna, P. 1993. *Health Exposure Assessment and Policy Analysis.* International Journal of Environmental Health Research 3 : 161-170.

Pandey, J.S., Mude, S. and Khanna, P. 1994. *Comparing Indoor Air Pollution Health Risks in India and United States.* Journal of Environmental Systems 23 (2): 179-194.

Pandey, J.S. and Khanna, P. 1995. *Development of Plant Function Types for Studying Impact of Green House Gases on Terrestrial Ecosystems*. Journal of Environmental Systems 23 (1) : 67-82.

Pandey, J.S., Deb, S.C. and Khanna, P. 1997. *Issues Related to Greenhouse Effect, Productivity Modelling and Nutrient Cycling : A Case Study of Indian Wetlands.* Environmental Management 21(2) : 219-224.

Pandey, J.S. and Khanna, P. 1998. *Sensitivity Analysis of a Mangrove Ecosystem Model.* Journal of Environmental Systems 26(1) : 57-72.

Pandey, J.S. and Joseph, V. 2001a. *A Scavenging-Dependent Air-Basin Ecological Risk Assessment (SABERA) - Model Applied to Acid Rain Impact around Delhi City, India.* Journal of Environmental Systems 28(3) : 193-202.

Pandey, J.S., Khan, S., Joseph, V. and Singh, R.N. 2001b. *Development of a Dynamic and Predictive Model for Ecological Footprinting (EF).* Journal of Environmental Systems 28 (4) : 279-291.

Pandey, J.S., Khan, S. and Khanna, P. 2001c. *Modeling and Quantification of Temporal Risk Gradients (TRG) for Traffic Zones of Delhi City in India.* Journal of Environmental Systems 28(1): 55-69.

Pandey, J.S., Khan, S., Joseph, V. and Kumar, R. 2002. *Aerosol Scavenging : Model Application and Sensitivity Analysis in the Indian Context.* Environmental Monitoring and Assessment 74 : 105-116.

Pandey, J.S., Joseph, V. , Shanker, R. and Singh, R.N. 2004a. *Modeling the Role of Phytoremediation in Mitigating Groundwater Contamination in India.* Journal of Environmental Systems 30 (3) : 177-189

Pandey, J.S., Joseph, V. and Kaul, S.N. 2004b. *A Zone-wise Ecological-Economic Analysis of Indian Wetlands.* Environmental Monitoring and Assessment 98 : 261-273.

Pandey, J.S., Kumar, R. and Devotta, S. 2005. *Health Risks of NO_2, SPM and SO_2 in Delhi (India).* Atmospheric Environment 39 : 6868-6874.

Pandey Jai S. and Devotta, S. 2006. *Assessment of Environmental Water Demands (EWD) of Forests for Two Distinct Indian Ecosystems.* Environmental Management 37 (1) : 141-152.

Pandey, J.S., Wate, S.R. and Devotta, S. 2007. *Development of Emission Factors for GHGs and Associated Uncertainties.* PROCEEDINGS : 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories. International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria, 27-28 September, 2007.

Pandey, J.S. 2010. Development of Ecosystem-specific Direct Emission Factors (DEF) for Estimating Carbon and Ecological Footprints (CF&EF). In "Climate Change, Global Warming and NE India : Regional Perspectives (Eds. : Borthakur, S.K., Sharma, R.K., Sharma, G.K. and Barbhuiya, A.H.), ERD Foundation, Guwahati, pp. 59-65.

Pandey, J.S. 2013. "Synergistic Impacts of Climate Change and Environmental Pollution : Studies Required for Impact Minimization and Environmental Management". "Climate Change Impacts on Water Resource Systems" (Ed. Shete, D.T.), Excel India Publishers, New Delhi, India, pp. 112-118. ❑

(E-mail: js_pandey@neeri.res.in/ jaispandey@rediffmail.com jaispandey@rediffmail.com)

NORTH EAST DIARY

HOSTEL FOR NORTH EAST STUDENTS IN JNU

A new hostel for students from North-east is set to come up in the Jawaharlal Nehru University (JNU) campus by 2017. This campus will be one of the three new hostels for Northeast students in Delhi planned by the DoNER Ministry during the last one year. The work on the construction of JNU hostel is expected to commence soon. Most of the formalities and paper-work of the hostel project in JNU Campus have been completed and the construction work will start very soon. JNU has a huge strength of students coming to Delhi from Northeast to pursue higher education and the number of students staying over here from each of North Eastern States is higher than the number of students from several other States of the Indian Union. The Northeast Study Center in JNU is also being advised to enlarge the spectrum of scholars and faculty persons associated with it in order to seek a healthy balance among all schools of thought. There is unusual enthusiasm about this project not only among the students from Northeast in the campus but also among the students of the other parts of the country.

Another proposal for another two hostels in Delhi University campus of Ramanujan College and possibly also in the Hindu College premises is also in consideration.Apart from this, the existing Northeast Working Women's Hostel at Jasola near Apollo Hospital is also being upgraded with more modern facilities. ❑

DO YOU KNOW?

Carbon Sequestration

Carbon sequestration is a process by which, the carbon dioxide is captured from atmosphere or anthropogenic sources of Co_2 (like large stationary industrial sources) and stored for a long term to be utilized for later use.These sources include large sites created by humans such as power plants , refineries, coal and gas plants , large industrial sources like that of ethanol , cement production and natural gas processing plants. This process involves mainly three steps. The first step includes the capturing of the CO_2 from these sources mentioned above. The second step involves transporting it through pipelines, trains, trucks, or ships after compressing this captured CO_2. The third step includes storing this CO_2 in deep underground rock layers in the earth's surface for long term storage.

There are mainly two types of carbon sequestrations: Geologic and Terrestrial sequestration.Terrestrial sequestration involves using plants to capture the CO_2 in their roots, stems and soil to help them utilize it for photosynthesis and when the plant withers, adding their carbon content to the soil making it more fertile.Thus, this essentially uses land management techniques to facilitate retention of more carbon in plants and soil for a longer term naturally.

Geological sequestration, on the other hand, involves storing the Captured carbon dioxide underground by injecting it into solid, porous rock formations such as sandstone, basalt, dolomite, shale, saline formations and deep coal seams .This layers lies under the impervious and solid , non porous layers of rocks so as to prevent its leakage upwards. This injection is done only after conducting proper site characterization in order to ensure its safe storage without any leakages.

For example, if we take the case of US, the electric power generation produces more than 40 per cent of Co_2 emissions. If this Technology can be applied to a 500MW coal-fired plant, the GHG emission avoided can be equal to planting 62million trees and avoiding annual electricity emissions from roughly 300,000 homes clearly showing this technique to be environment friendly. The captured and stored CO_2 finds its various uses in beverage industry, food manufacturing, paper and pulp industries, fabrication of metals and oil recovery. The concept of carbon sequestration is assuming great importance ,particularly at present and will continue to hold even more siginificance in the times to come, as it can help in reducing the greenhouse gas emissions from cement production and natural gas processing facilities to a great extent.Thus, the importance of this technique certainly can not be overlooked if we have to make efforts to combat an alarmimg global phenomenon like climate change. ❑

(Compiled by Vatica Chandra, Sub Editor)
(E-mail: vchandra.iis2014@gmail.com)

Corrigendum

It is informed that in the article by Dr. Isher Judge Ahluwalia "Cities as Engines of Growth" in the October 2015 issue of Yojana,, in the last page 3rd last paragraph on 'Housing for All Mission', the figure should read as 2 crore houses. instead of "2 lakh crore houses"
The error is regretted

Air Pollution, Climate Change and Public Health: Dangerous Link

Anumita Roychowdhury

It has estimated that currently the health cost from particulate pollution is as high as 3 per cent of India's GDP. But its mitigation will cost less than 1 per cent of GDP and provide annual savings from health benefits that can be more than USD 100 billion. At the same time the efforts to clean up the air will reduce the heat trapping CO_2 emissions from our fossil fuel burning by upto 60 per cent. Thus, India will get more health and climate benefits

In this climate and pollution challenged world, public health is at serious risk from the ominous trends in toxic air pollutants and warming gases. Air pollutants are under scientific scrutiny not only for what they do to our lungs and health, but also how they enhance climate impacts and associated health risks. Science does not allow us to keep the local public health impacts of air pollution and the global warming impacts of green house gases in silos anymore. The emerging science has given us more reasons to be worried about air pollution. This demands an integrated framework for mitigation to minimize public health risk.

Air Pollution and Public Health Challenge

The speed with which urban air pollution is growing across India is alarming. Close to half of cities are reeling under severe particulate pollution while newer pollutants like nitrogen oxides, ozone and- air toxics are worsening the public health challenge. As many as 95 per cent of Indians across the country breathe air quality that is worse than the WHO's recommended standards. The worrying trend is the proliferation of new hot spots every year. Smaller and more obscure cities are amongst the most polluted in the country.

Some mega cities that have initiated some pollution control action in the recent years, have witnessed either stabilization or some lessening of the high levels. But several cities like Delhi, even after the initial stabilization are finding it difficult to sustain their air quality gains and are in the pincer grip of serious multi-pollutant crisis.

It is worrying that even after decades of air quality management, particulate air pollution has remained among the top 10 killers globally with disproportionately high health impacts in the developing world. The recent global burden of disease (GBD) estimates shows that in India alone, more than 627,000 people die prematurely and 18 million healthy life years are lost every year due to ill health connected especially with the tiny particles.

There are now myriad studies across the world and also in India to prove that outdoor urban air pollution is a serious environmental risk factor that causes or aggravates acute and chronic diseases. Also, given the latency period of toxic risk, Indian cities are likely to see more cancers due to increase

The author is the Executive Director, Research and Advocacy, Centre for Science and Environment, New Delhi, India. She is in charge of research and advocacy programme on Sustainable Urbanisation that encompasses clean air and sustainable mobility and sustainable habitat. Over the years she has participated and played active role in many important national policy forums as well global environmental platforms. She has published numerous articles, policy research papers.

in environmental health risk. This makes a strong case for control of air pollution. Health criteria need to be built into the air pollution control policies more clearly.

According to the GBD, toxic air worsens symptoms of ischemic heart disease, stroke, chronic obstructive pulmonary disease, asthma, lung cancer and acute lower respiratory tract infection. This causes premature deaths and loss of healthy life years due to illness. India specific GBD shows ischemic heart disease causes half of the total air pollution related premature deaths in India with strokes causing more than a quarter. The rest is dominated by respiratory conditions and cancer.

Most vulnerable are the children, elderly and those with respiratory and cardiac conditions. Even healthy people are vulnerable from prolonged exposure. According to the recent estimates of the World Bank, South Asia's urban population is poised to grow by almost 250 million people by 2030. Most of this growth will take place in India. This will bring significant number of children within toxic urban environment. Because their lungs are still developing, children are most vulnerable to the impact of air pollution.

Polluted air has also compromised the health of our future generations in cities like Delhi. Considerable evidence has come from the epidemiological study on children in Delhi carried out by CPCB and Chittaranjan National Cancer Institute in Kolkata and published in 2012. This study had covered 11,628 school-going children from 36 schools in different parts of Delhi and in different seasons. Every third child had reduced lung function. There is a marked increase in the number of bio-markers like alveolar macrophages (the first line of cellular defense against inhaled pollutants) in the sputum of children. This shows greater exposure to particulate pollution. Sputum of children in Delhi contains four times more iron-laden macrophages than those from cleaner environs, indicating pulmonary haemorrhage. The study found the level of these bio markers higher in children from areas with high particulate levels.

Studies are dominated by the focus on respiratory symptoms. But in the recent years, they have begun to include more diverse health end points – cardiac cases, cancer, mutagenic effects, etc. Though this investigation in India is still very nascent, global studies have made more robust linkages with a wide range of health endpoints – diabetes, stroke, hyper tension, effects on brain, effects on foetus etc. Given the fact that endpoint of all toxic risk is cancer, all environmental risk factors should be minimized. This is particularly serious in India that reports overall over 700,000 new cancer cases and National Cancer Control Programme (NCCP) forecast that by 2026, more than 1.4 million people will be falling in the grip of the disease. NCCP has listed greater exposure to environmental carcinogens as one of the most important reasons. The mitigation strategy must reduce environmental risk from all factors – and air pollution is an important factor. Numerous studies in the West assessed the causes such as genetic susceptibility, environment factors and lifestyle.

Given the fact that endpoint of all toxic risk is cancer, all environmental risk factors should be minimized. This is particularly serious in India that reports overall over 700,000 new cancer cases and National Cancer Control Programme (NCCP) forecast that by 2026, more than 1.4 million people will be falling in the grip of the disease.

This trend in public health risk is expected to get worse if the pollution trends remain business as usual and the global warming impacts get further enhanced.

Air Pollution and Climate Impacts: Demystifying Link

While both rural and urban environments are getting increasingly toxic, the planet is also getting warmer. The climate scientists have warned that planet cannot afford to warm up beyond 2 degree C. But the link between public health impacts of air pollution in a warmer climate is often not well understood; nor, the impact of air pollution on warming of the climate and further enhancement of health risk.

Air Pollution and Public Health Impact of Warming: A range of toxic pollutants and the warming gases are co-emitted from vehicles, industry, power plants and cooking stoves, in urban and rural environment. The toxic pollutants including tiny particles, nitrogen oxides, ozone, sulphur dioxide, carbon monoxide also contribute through secondary transformation in the atmosphere to the load of warming gases like carbon dioxide, methane, black carbon etc. This transformation is subtle but significant. For example, hydrocarbons and nitrogen oxides react to create regional ozone and also contribute to hemispheric ozone that warms. The tiny particles of less than 10 and 2.5 micrometer size that are health damaging also have black carbon that absorbs heat and warms the atmosphere.

There are already evidences to suggest that increased frequencies in extreme weather events especially heat waves and heat island conditions further enhance air pollution and public health risks. Studies have shown that each increase of 1 degree Celsius caused by carbon dioxide concentration can enhance particulate and ozone build up. This can lead to thousands of additional deaths and many more illness. Some of the key indicators of this change are ozone build up and formation of secondary particulates. Warmer temperatures and the extreme heat waves are threatening to increase the frequency of days with unhealthy levels of ozone, with serious public health consequences.

These pollutants are rarely monitored in Indian cities. But Delhi has begun to monitor ozone. Delhi witnesses significant ozone build-up during summer. A study of the real-time air quality data available from the key monitoring locations of the Delhi Pollution Control Committee (DPCC) for the period January to June in any year shows rapid build-up of ozone and more frequent violation of standards this summer. Ground-level ozone is not directly emitted by any source. This is formed when oxides of nitrogen (NO_x) and a range of volatile gases - primarily from vehicles and other sources - are exposed to each other in sunlight. Warm and stagnant air increases the formation of ozone, which is known to be extremely hazardous for human health.

During the summer of 2014 when heat wave lashed Delhi, ozone pollution worsened. It doubled up very quickly as soon as the heat wave hit Delhi in the first week of June. The average temperature increased rapidly from 35 degree C on June 1, to more than 44 degree C on June 6, 2014. As a result, the ozone level shot up by 87 per cent to 315 per cent in different locations of the city. This is of serious concern as even short duration exposure to high ozone levels can cause great harm. This is one of the reasons why ozone standards are set for eight hours average as well as one hour average.

Climate Change Impact of Air Pollution: In the public mind, it is the carbon-dioxide (CO2) that comes primarily from fossil fuel burning that is the main warming agent and that is rightly so. CO2 is a long lived gas and stays on in the atmosphere for hundreds of years and its rising concentration is trapping heat. This demands urgent action across the world to reduce consumption of fossil fuels and modify life style. However, science has also changed our understanding about the role that some of the short lived gases and particles like black carbon, methane and ozone play in the warming, snow melt and rains.

It is now understood that, for best results the short lived air pollutants like particulate matter must also be curbed to reduce the warming spikes while taking stringent action to curb CO2 for the overall impact.

The particulate matter consists of black carbon that is largely a product of incomplete combustion and comes from all combustion processes, all dust generating activities and secondary particulates. These last up to minutes, hours and even one week or little more in the atmosphere depending on the combustion process and size. But as long as they exist, they can absorb heat and warm up the surrounding atmosphere; accelerate snow melt and disturb rain patterns.

But this does not mean that this science of warming impact of local air pollution shifts the blame of causing global warming and climate change now from the developed world who have cleaned up their to the developing world that are still much lower on the technology ladder and responsible for high local pollution. The magnitude of CO2 emissions from fossil fuel burning in the developed world still remains the most important reason for climate change.

The latest IPCC report AR5 has taken note of the recent research and is more explicit in its discussion on black carbon than it was ever before. For instance, AR5 has doubled the estimate of warming of black carbon from its previous report. For instance, if global warming potential of CO2 over 100 years is 1, that of black carbon is estimated to be 900. Though this comparison has limitations due to their different residence life in the air, there are impacts.

Black carbon can also accelerate ice-melt when they settle on snow. The bright snow surfaces reflect a high amount of solar energy back into space. But black carbon absorbs substantial fraction of this energy and re-emits it as heat. The Arctic and the Himalayas are therefore vulnerable. Black carbon is also known to interfere with cloud formation and the rainfall pattern. It also reduces sunlight that reaches the surface and that is reflected back to the space. Black carbon may change precipitation and surface visibility.

According to the climate science, there are good and bad particles depending on their cooling and warming impacts. All particles do not warm. Some have cooling effect as well. The organic carbon and sulphate that come largely from open biomass burning and cook stoves of the poor have cooling effect as they are light reflecting. These have much higher proportion of cooling particles. But black carbon that comes mostly from diesel vehicles, brick kilns etc is light absorbing. Share of cooling and warming particle determines the net positive or net negative impact of different pollution sources.

But this does not mean that this science of warming impact of local air pollution shifts the blame of causing global warming and climate change now from the developed world who have cleaned up their to the developing world that are still much lower on the technology ladder and responsible for high local pollution. The magnitude of CO2 emissions from fossil fuel burning in the developed world still remains the most important reason for climate change. In fact, the cooling particles from the poor people's technology and cooking stoves in developing countries are masking a lot the committed warming in the developed world.

However, from public health perspective, both cooling and warming particles must be eliminated as they harm our health. This demands aggressive action on air pollution. These pieces of scientific evidence only show that the rising trend in air pollution and also the worsening of warming impacts has insidious links

and this complex web can have serious implications for growing public health risk in India.

Capture the Win-Win Agenda of Co-Benefits

Our cities face the challenge of the balance – curb local air pollution as well as climate impacts to save lives. This can provide significant co-benefits. India's National Climate Action Plan has already adopted the principle of co-benefit. That means the same policy intervention should provide a range of benefits and welfare that includes public health and climate impacts.

A study carried out by the World Bank in 2013 has helped to establish the potential of co-benefit approach from air pollution mitigation in India. It has estimated that currently the health cost from particulate pollution is as high as 3 per cent of India's GDP. But its mitigation will cost less than 1 per cent of GDP and provide annual savings from health benefits that can be more than USD 100 billion. At the same time, the efforts to clean up the air will reduce the heat trapping CO2 emissions from our fossil fuel burning by upto 60 per cent. Thus, India will get more health and climate benefits.

Such an approach can help India to maximize the larger welfare. This will help to take early and effective action in all sectors of pollution, enable leapfrogging to clean technology and to the alternatives. This would also have to be enabled by local and global support for action to improve access to clean technologies and disseminate knowledge on best practices. Clearly, the magnitude of impact of air pollution on health and climate do not allow any room for uncertain and delayed action. ❑

(E-mail: anumita@cseindia.org)

YOJANA WEB- EXCLUSIVES

Yojana publishes articles on various topics in its 'Web-Exclusives' column for the benefit of its readers on the website of Yojana : www.yojana.gov.in. Announcements about the articles under the Web-Exclusives section are carried in the Yojana magazine of the month.

We are carrying the following articles under the Web-Exclusives section of Yojana for December 2015

1. Sustainable Indicators of Food, Nutritional and Health Outcomes in India - A Amarender Reddy
2. India Pledges for Non-fossil Fuel-based Energy - R.C. Sundriyal, S.K. Nandi & P.P. Dhyani
3. Stock Market Volatility in India - .V.Pankunni

Please send in your comments and suggestions to us on ***yojanace@gmail.com***

Climate Change Mitigation : Proactive Approach

Subhash Sharma

India should always emphasise on 'Common but differentiated responsibility' for mitigation and adaptation of climate change at global level because of 'historical wrongs' committed by many developed countries as colonial powers in the last 300 years, yet we should also make all voluntary genuine efforts at national and State levels to reduce carbon emissions and practice adaptation through technological innovations in view of substantial absolute emissions in India

Climate change is a change in the space and time distribution of weather patterns or conditions or properties of a region or some regions or the entire earth. It is caused by natural processes like biotic processes, variation in Earth's orbit, variation in *albedo* or reflexivity of the oceans and continents, continental drift and mountain-building, variation in solar mediation on earth, glacier melting, floods, volcanic eruptions and plate tectonics or anthropogenic activities like deforestation, burning of crop residues, use of fossil fuel and high energy consumption through electronic gadgets (use of air conditioners, aeroplanes, refrigerators, vacuum cleaners, industrial machines etc). While the term "global warming" means specific increase in surface temperature due to human activities, the term "climate change" is very comprehensive and includes global warming as well as other changes in weather patterns/ conditions resulting into more emissions of greenhouse gases due to both human activities and natural processes. Many natural scientists have found in their researches that there are internal and external forcing mechanisms for climate change – internal forcing mechanisms are natural processes within the climate system (e.g. thermohaline circulation) while external forcing mechanisms may be either natural (e.g., changes in solar output) or anthropogenic (human activities leading to more emission of green house gases). The year 2014 was the hottest year in recorded history of climate and July 2015 was the hottest month in past 1627 months since January, 1880 (since then, monthly record is available). There are three categories of nations in terms of per capita carbon emission in the world: a) there are 60 countries with average per capita GDP of $1768 that emit up to 2.3 tons carbon per capita; b) 74 countries with average per capita GDP of $ 3058 emit up to 4.5 tons carbon per capita; and c) 13 countries with average per capita GDP of $ 33700 emit above 10 tons carbon per capita (as per World Bank, 2014).

At present, we have two major global ecological crises: first, the climate change; and second, the extinction of species of flora and fauna. Since the Industrial Revolution in Western Europe, there has been a substantial increase in earth's surface temperature and if no proactive mitigation steps are taken in time, we may experience up to 4°C increase in temperature by the end of twenty first century. There have been many extreme weather events (in both mean and spread) as, in 2015, 2/3^{rds} of India faced droughts and at global level glacier melting, shrinkage of lakes, rise in sea level, floods, droughts, cyclones, global warming, acid rains,

The author is Addl Secretary and Financial Advisor, Ministry of I&B. He has also authored a number of books and articles on environmental issues in national and international journals.

longer and colder winter and so on are pronounced. A glimpse of such major extreme weather events at global level may be perused in Table 1 below:

These and other extreme weather events have caused massive losses to humans, animals, plants and properties. In 1995, United Nations Leipzig Conference on Plant Genetic Resources pointed out that 75 per cent of world's biodiversity disappeared in agriculture due to Green Revolution and industrial farming. On the other hand, another UN agency, Food and Agriculture Organization (FAO), has estimated that 70 to 90 per cent of global deforestation is caused by industrial agriculture which has promoted monoculture into forests to grow commodities for export, not for food. Further, according to grain. org report, transnational food industry contributes to 44 to 57 per cent of all anthropogenic greenhouse gas emissions. Furthermore, fossil fuel consumption is also largely responsible for increase in emissions. It is a bitter truth that 68 per cent of India's energy comes from thermal plants - mostly coal and to some extent gas and oil. Thermal plants are largely responsible for carbon emission besides transport vehicles, use of fuelwood etc. These thermal plants are owned by State Governments., Central Govt. and private companies (some being joint ventures), Maharashtra (28294 MW) leads in thermal power capacity, followed by Gujarat (23160 MW), Chhattisgarh (13234 MW), U.P. (12228 MW), Tamil Nadu (11513 MW), M.P. (11411 MW), and Rajasthan (10226 MW).

In this regard, Inter-Governmental Panel on Climate Change (IPCC) has published many comprehensive reports (in 1990, 1995, 2001, 2007 and 2014). Its Synthesis Report of AR5 found the following major trends:

a) Anthropogenic emissions of GHGs are highest in history; climate changes have widespread impacts on both human and natural systems.

b) Oceanic uptake of carbon dioxide (CO_2) resulted in acidification of oceans; warming of 0.85˚C increased during 1882-2012 and sea level rose by 0.19 m during 1901-2010.

c) Due to continued emission of GHGs, there is likelihood of severe, pervasive and irreversible impacts for humans and ecosystems.

d) Limiting total human-induced warming to less than 2° C relative to the period 1861-1880 with a probability of more than 66 per cent would require cumulative CO_2 emissions from all anthropogenic sources since 1870 to remain below 2900 $GtCO_2$, about 1900 $GtCO_2$ had already been emitted by 2011.

e) Risks are unevenly distributed and are generally greater for disadvantaged people and communities in all countries at all levels of development.

f) Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change.

g) Without additional mitigation efforts beyond those in place today, warming by the end of 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally.

h) Multiple mitigation pathways would require substantial emission reductions over next few decades and near zero emissions of CO_2 and other GHGs by the end of 21st century; to implement these would pose technological, economic, social and institutional challenges.

i) During 2001-2100 relative to 1986-2005, the rise in sea level ranges from 0.26 to 0.55 m for RCP 2.6, and from 0.45 to 0.82 m for RCP 8.5; by the end of 21st century sea level will rise in more than 95 per cent of the ocean area.

(j) Emission scenarios leading to GHG concentrations in 2010 of about 450 PPM CO_2 or lower are likely to maintain warming below 2°C over 21st century relative to pre-industrial levels. These scenarios are characterised by 40 per cent to 70 per cent global anthropogenic GHG emissions reductions by 2050 compared to 2100, and emission levels near zero or below in 2100.

Thus many credible researches have confirmed that climate is changing over the last few decades and humans are realising and experiencing such changes in their everyday life. Now this phenomenon cannot be brushed aside by the utilitarians, developmentalists and political leaders of different hue. Hence, mitigation and adaptation measures are to be taken well in time.

Recently, Government of India prepared Intended Nationally Determined Contribution (INDC) on Climate Change on 2nd October 2015. This is an official document as to what and how India intends to address the challenges of climate change, especially in urbanisation, transport, agriculture, health, water and coasts. Needless to say that in 2007 at Bali Convention on Climate Change, it was by and large agreed by most of the nations that there should be a 'paradigm shift' in curving carbon emission from 'top-down' international decision-making to 'bottom-up' agreement (to be agreed in Paris in December, 2015). That is, instead of global decision to reduce carbon emission everywhere in one stroke, every nation has freedom to decide its roadmap to mitigate and adapt climate change. It is believed by many scientists and eco-democrats that bottom-up approach of mitigation and adaption will have larger co-benefits like lower air pollution, prudent use of energy, less potential of extreme weather events etc. India has invoked Mahatma Gandhi who had once rightly remarked: 'Earth has everything to fulfill everybody's need but not anybody's greed'. Need versus greed paradigm is very relevant today, as it has moral voice in addition to socio-economic and ecological

upper hand. But some scholars (like N.K. Dubash, Radhika Khosla) have opined that in reality, India's 'nature-friendly lifestyle' proposition does not hold good – almost 60 per cent people defecate in open, Delhi is the world's most polluted city (air pollution – mix of ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and fine particulates - 6 times more than permissible PM2.5 limit), 13 out of 20 most polluted cities in the world with worst PM2.5 counts are in India (including Gwalior, Raipur and Patna), Mumbai's 60 per cent population lives in unhygienic slums, two-thirds of rural Indians use fuel wood for cooking, 75 per cent of India's energy supply is provided by non-renewable sources, about 30 crores of population live in poverty (implying unequal distribution of natural resources) and so on. India has pledged for 2030 three things: to reduce carbon emissions intensity by 33 per cent to 35 per cent from 2005 baseline; second, it also promises to share of non-fossil fuel based electricity to 40 per cent of total capacity through transfer of technology and low cost finance; third, creation of an additional carbon sink of 2.5 to 3 billion tons of CO_2 equivalent (including methane, GHGs, nitrous oxide) through forest cover. However, India's INDC does not commit to any sector-specific mitigation obligation and its actual implementation of such pledges will, in the ultimate analysis, be guided by global agreement in Paris.

However, it is a well-known fact that per capita emission in India (1.6 tons) is less than the global average of 6.6 (some estimate it to 4.5 tons) tons per capita emission of carbons, and far lower than that in developed countries like U.S. (with varying estimates of 16 to 20 tons per capita) or even China (6 tons) in 2012. In fact, per capita emission in India equals only 36 per

Table 1 : Major Global Events of Climate Change

S. No.	Major extreme climate events	Country / Continent	Time	Climate Effects
1.	Shrinkage of Lake Chad	Chad, Africa	1960-2002	Persistent drought has shrunk Lake Chad (once world's sixth largest Lake) to 1/20th of its size in 1960 – now wetland in place of open water
2.	Shrinkage of Lake Toshka	Egypt	1984-2001	From Lake Nasser reservoir (on Nile river) water passed to Toshka Depression in Western Desert, but flow to Toshka ceased in 2001 – so many lakes almost lost
3.	Flood in Mississippi river	U.S.	28th Jan 2011- 3 May, 2011	Due to snowiest winters and violent early spring rainstorms, Mississippi and its tributaries overflowed their banks inundating lakhs of homes, crops, woodland with muddy water.
4.	Flood in Indus river	Pakistan	Aug 2010	More than a million acres of land were flooded destroying crops, devastating towns (Sukkar, Dadu and Mehar) 1800 persons were killed and one crore persons lost their shelters.
5.	Yellow river's course change	China	2001-2009	Yellow river was the cradle of Chinese civilisation but frequent devastating floods have changed its course – now it is known as ''China's sorrow".
6.	Shrinkage of Lake Mead, Nevada/ Arizona	U.S.	2000-2010	Lake Mead supplies water to California, Arizona, Nevada, Las Vegas & Mexico; since 2000 water level is dropping due to lower snowfall – by July, 2010 it is at 38 per cent of its capacity; between 2001-2004 it dropped 18 mtrs.
7.	Global warming	World over	1880-2009	Earth's surface temperature increased by 0.7° C since 1880; 2/3rd of warming since 1975 @ 0.15 degree Celsius to 0.20° C per decade.
8.	Helheim Glacier melt	Greenland	2001-2005	Helheim Glacier is crumbling into icebergs, glacier's flow to the sea has sped up.
9.	Inja Glacier melt	Himalayas		Major retreat and collapse of the lower tongue of the glacier and formation of new melt ponds.
10.	Ice melt, Mount Kilimanjaro	Tanzania (Africa)	1993-2000	Kilimanjaro is the tallest free-standing mountain, is made up of three volcanic cones, there is major decline in its ice cap during 1993-200.
11.	Flood in Kedar Nath	Uttarakhand, India	June, 2013	Cloudburst led to death of 10,000 persons and huge property loss.

Source: Based on NASA data

cent of global average and 8 per cent to 10 per cent of US per capita emission. That is, the intensity of energy consumption due to mechanisation of household and industrial – agricultural tasks in developed countries is much more than that in developing countries like India. On the other hand, due to huge population of 125 crores, India's absolute carbon emission is quite high – 2 billion tons (5.2 per cent of global total emissions) – and its energy consumption is 5.9 per cent of global total. Hence, Nagraj Adve and Ashish Kothari criticise that India's INDC wrongly justifies the projected rise in its emission by emphasizing its development imperatives because this obscures the fact that well-off will stamp their ecological footprint. INDC does not state about inequality between the rich and the poor within India itself e.g., in India 175,000 households have assets of one million dollars or more whose per capita emission matches the rich in US and Europe. Thus, ecological footprint of the richest 1 per cent of Indians is over 17 times that of the poorest 40 per cent. So Nagraj Adve & Ashish Kothari rightly remark, "Readventing risk and improving the capacity of people to adapt to climate change is linked to effective poverty eradication, improving food security through sustainable farming, promoting greater biodiversity, improving public health, and strengthening community resilience. These linkages have simply not been made explicit". In addition, it is also observed by critics that INDC uses the term ' non-fossil fuels' in place of 'renewable', targeting 63 gigawatts (10 GWs at present) by 2032 and it calls nuclear power as 'safe, environmentally benign and economically viable source' but incidents of Chernobyl (USSR) and Fukishima Daiichi power plants (in 2011 in Japan) have proved otherwise. Further, in India, reactor construction has the history of cost over-runs and importing of foreign reactors would be very costly. Moreover, a huge displacement of local people for various electricity generation projects has been over-looked in INDC. India's INDC wrongly calls coal energy as 'clean energy' because coal emissions are 50 per cent higher than those for oil and 80 per cent higher than those for natural gas. In fact, India is the world's third largest coal producer and has the fifth largest coal reserves in the world; even then in 2011 India's coal import reached 11 per cent of total demand. This has huge implications on climate change.

As far as the proposal for afforestation in new areas is concerned, this too is not very realistic because on one hand, we have not been able to substantially check deforestation and, on the other hand, the process of urbanisation, industrialisation, power generation, irrigation etc. is taking away new agricultural lands or forest lands. According to a study by Centre for Science and Environment, six lakh hectares of forest lands were diverted during 1992-2012 for the so-called development projects in India.

In view of the facts and figures mentioned above, we are of the view that India should opt for following options for both mitigation and adaptation:

a) Actual renewable sources of energy like wind, solar, hydro, geothermal, bio-energy and natural gas etc. should be given topmost priority – solar energy is cheaper than wind energy – to fossil fuels like coal, oil, fuel wood etc.

b) Nuclear power is not environmentally safe (rather very hazardous) in the long run, though it may appear cheaper for the time being; hence it may be avoided.

c) There should be promotion for public and private investments to raise energy efficiency levels (e.g. LED bulbs/ tubes in place of conventional bulbs), and Bureau of Energy Efficiency at national level and state renewable Energy Development Authority should be more proactive.

d) There should also be public and private investments to expand capacity in clean renewable energy; public–private partnership (PPP) mode should be encouraged in letter and spirit. New investments in renewable sources of energy will bring huge employment.

e) All States should prepare fool-proof and comprehensive State Action Plans on climate change; so far 31 States/ UTs have prepared these and only four States have not prepared these. But out of 31, only 20 State Action Plans on Climate Change were found in order and endorsed by National Steering Committee on Climate Change. The proposed budget for implementing State Action Plans on Climate Change by all States is Rs. 11,33,691.75 crores. Again there should be transparent mechanisms for their implementation at every stage.

f) As per Article 12 of Kyoto Protocol, there is carbon market for global reduction of carbon/ GHG emissions through sale and purchase of carbon credits – this is called 'Clean Development Mechanism' (CDM). During 2003-14 out of total 7589 CDM projects, 1541 were from India (second highest in the world). Certified Emission Reductions issued to Indian Projects is 19.10 crore (13.27 per cent) – mostly in sectors of energy efficiency, fuel switching, industrial processes, municipal solid waste, renewable energy and forestry. But in the second commitment period, the number of CDM projects declined – only 307 projects from India were submitted out of total 3227 projects. Hence, Indian public and private sectors should be proactive, and new and effective market mechanisms should be created to cover all countries of the world.

g) A National Adaptation Fund with a corpus of Rs.100 crores has been set up by Govt. of India (Ministry of Environment and Forests and Climate Change)

to support adaptation actions to combat the major challenges of climate change in agriculture, water, forestry etc. but it has not materialised so far on the ground. Further, this corpus fund is quite meagre in view of the huge problems of climate change to be adapted in letter and spirit in India in different sectors.

In conclusion, we may observe that India should always emphasise on 'Common but differentiated responsibility' for mitigation and adaptation of climate change at global level because of 'historical wrongs' committed by many developed countries as colonial powers in the last 300 years, yet we should also make all voluntary genuine efforts at national and State levels to reduce carbon emissions and practice adaptation through technological innovations in view of substantial absolute emissions in India. India's eight Missions should be more proactive and should show visible and concrete results in a time-bound manner. ❑

(E-mail: sush84br@yahoo.com)

FROM OUR READERS ...

I express my gratitude and happiness for learning knowledge about various subjects. Being from teaching profession "Yojana" gives knowledge in various subject thus exclusively covering each subject every month - one can't simply imagine the your work and efforts of your staff which is highly commendable, simple to say that, if students of higher secondary school continuously read Yojana no doubt will became excellent (complete)professional, It's my humble request can you bring the more detail about the (HSRT) Hunar Se Rozar Tak Government Skill Development Program and with regards to NPS (National Pension Scheme) to know more such scheme ?

Manicklal Chakraborty, Chennai

I am a student of class10 who aspire to become a civil servant .I started reading Yojana from july'15. Yojana's contents are always appreciable. I appreciate the team and the writers for putting their best . But I have a small suggestion. If possible then please put a interview column of various civil services toppers .

Akanksha Pathak

It has been great to Yojana with very information content and prospective studies on various important issues especially those related to challenges faced by India. Most of articles in Yojana are enriched with knowledge and thought provoking. Providing such a good magazine at economical pricing is boon for unemployed youths who wish to appear for various competitive exams. My best wishes to Yojana Team for their hardwork.

Pankaj Sharma, Punjab

I am a regular reader of Yojana magazine and its content is really applausible and appreciable this magazine gives us wide variety of knowledege and perspective and detailed analysis on current ongoing goverment scenarios. This is very benefecial for the people of all aspects civil servant aspirants and common. please keep the innovation and hardwork up.

Atikarsh Singh

Yojana is one of the authentic sources for understanding the nuances of Government's policies and programmes and is doing extremely well in that sphere. My humble suggestion is that the magazine should give more relevance to social indicators of development like healthcare, education and science and technology without which India cant be a 'jagat guru' or super power. Nevertheless, topics can be included related to imparting quality in education and healthcare.

Monish KM, Kerala
Saurabh Kumar

Response from Yojana Team

Yojana team is overwhelmed by the appreciative responses received from its readers. It will go a long way in encouraging us to give better content to you.

Yes, we will definitely try to cover education and health care in future issues. Our June 215 issue was on alternative health care.

Thanks once again!

Your feedback is valuable to us in planning our issues.

For our Readers

No publication is perfect and complete without the suggestions and feedback from its readers. Now you can mail us your valuable suggestions and feedback at yojanafeedback@gmail.com.

Ancient Wisdom for a Contemporary Problem

Viva Kermani

The climate crisis and the current state of our planet demands responses that go beyond technology and finance. A reorientation and a renewed consciousness is required, in every Indian household, which rest upon our ancient values and also employ the tools of the present

World leaders would gather in Paris, France, on 30 November, 2015 for the fortnight-long deliberations on climate change. This is the COP-21, the Conference of Parties summit, called by the UN Framework Convention on Climate Change (UNFCCC) whose responsibility is to find ways that can contain temperature rise.

The science is clear. For the first time in recorded history, climate change has been caused by human actions largely due to the increased level of greenhouse gases in the atmosphere from the burning of fossil fuel whose origin coincided with the start of the industrial revolution around 1750. The advent of large scale industrialisation, deforestation, intensive commercial agriculture, changing food habits, increasing consumption patterns which are the characterists of developed countries, all have contribute to the deteriorating health of our planet.

This is what is now called the anthropogenic impact (and one of the popular terms for this era of climate change caused by human activities is 'anthropocene'). The terms describe planetary effects of collective action or behaviour. Such scales are often difficult to convey to households or even city and town wards. Yet, at the local level, it is individuals, households, communities and village panchayats which must also act responsibly so that environmental degradation is halted and for climate change to be addressed.

The problem appears too large and too daunting, more so for India, as it strives to meet its development challenges. Yet our government has announced an ambitious climate change action plan which will work only when citizens collaborate fully with government, at all levels. And if we want our government to be successful in its endeavour, citizens must find solutions because these exist. One of the strengths of our Indian society (in its many forms) is its ability to be sustainable, to use and re-use wisely, where values are placed on recycling, on conserving and protecting our trees and forests and existing in harmony with nature.

Earth science tells us (indeed earth systems scientists have been making this warning for at least a decade) that we must respond quickly to the climate crisis. While there are national and state-level responses and plans, there is equally a need for awareness and action at the most basic of local units: the household. It is here that following traditional values and

The author manages a non-profit organisation, the Centre for Social Markets, which works in the public interest to bring about societies that are self-reliant and sustainable. Focusing on forest biodiversity and small farmers, she has guided for several years a continuing project on demonstrating the important role of small coffee farmers, in hill and forest districts of Karnataka state, in protecting forest biodiversity and also writes regularly in online media portals on issues of climate change and on GM crops.

tapping into our collective memory can make that difference - the lived stories and accounts of our grand-parents' generation are often enough to point out the way.

Consider the sacred botany of India, for such trees and plants are a part of our environmental heritage and of our cultural consciousness. Evidence worship goes back to the Indus-Saraswati civilisation - these are seen on ancient seals with the peepal *(Ficus religiosa)* being the most frequent. In the Vedas, trees are referred to as Vanaspati (lord of the forest) and invoked as deities, just as rivers are invoked. The Vedas, the most ancient of all Hindu texts, pay tribute to nature and consider the earth as mother. Within the precincts of the home, however humble or grand, a tulsi plant is often present, cared for by the household.

Choice of food, not only what is consumed everyday by the household but also what is cultivated has a direct impact on the health of our local ecosystem and on the planet. In making food choices, our traditional and locally grown food has proved to be the most ecologically sound and such food habits play a positive role in the mitigation of the effects of climate change

Even so, it is not enough to have an evening walk in the park nearby (if there is still one that the builders and property developers have spared) or a weekend with the family at a forest reserve. Everyday mindfulness is needed, for as many actions that can be recognised as helping re-green India. The difference is made at the level of the household - reducing and finally halting altogether the use of plastics, being sparing (whether it is monsoon season or not) with the use of water, consuming only what is needed and not making purchases based on the household's ability to store or its ability to pay in instalments. These are the ways in which every household can contribute.

While today we are to connect such behaviours and practices with relatively recent concepts and ideas that we have come to accept, such as sustainable development, the substance of such ideas was being considered and discussed in the decades preceding our Independence. In 1909, Sri Aurobindo wrote, "The mould is broken; we must remould in larger outlines and with a richer content". He was writing in the context of the need for an intellectual and cultural reawakening (this was over a century ago, and is needed as much now as it was then). Aurobindo

The difference is made at the level of the household - reducing and finally halting altogether the use of plastics, being sparing (whether it is monsoon season or not) with the use of water, consuming only what is needed and not making purchases based on the household's ability to store or its ability to pay in instalments. These are the ways in which every household can contribute.

was describing how the spirit and ideals of India have become confined to the old mould (imposed by colonialism) which had to be broken.

In the same way, it is useful to see that there are 'moulds' which India must protect and defend as a part of the inter-government and multi-lateral structures now concerned about climate change and the environment. But this does not mean we are not free to create larger and richer moulds that are better suited to describing the needs and imperatives of our polity. For this reason, while being cognisant of the measures used by inter-governmental political and scientific fora (such as the UNFCCC), we need also to step beyond the 'per capita', the 'energy intensity' and the 'emissions' group of concepts. This is especially important when considering what the average household, whether rural or urban, can contribute through its behaviour and practice.

We are not unused to dealing with several frames of reference at the same time. During the first efforts at central planning in India, in 1939, the sub-committee on Cottage Industries met at Wardha, Maharashtra. As documented by the historian Dharampal, Mohandas Gandhi is said to have consented to a programme of industrialisation, provided it was accompanied by an equal effort given to the promotion and extension of the cottage industry. It is of interest that at that time too, the question of what standard of living this was to help achieve was being discussed.

And so today, we continue to speak, in the context of climate change and of our responsibilities, of what is an acceptable standard of living and what is not. We know that the primary sources of energy in India are what we call traditional (fuelwood, agricultural residue and animal dung) and commercial (fossil fuels and renewable - biogas, solar, wind and off-grid micro and mini hydroelectric). The per centage of poor households has been decreasing, but their number continues to rise and therefore the use of non-commercial biomass has also continued to rise - according to the 2011 Census, 67 per cent of households still cook using firewood, crop residues, cow dung cakes or coal.

This is among the truths about which we acknowledge that India is part of the problem. What has been somewhat obscured is that India has also been an active and constructive participant in the search for solutions, which the Intended Nationally Determined Contribution (INDC) document submitted to the UNFCCC states unequivocally. Thus overall, when the per capita emissions of many developed countries vary between 7 to 15 metric tons, in India it is about 1.56 metric tons (in 2010). Likewise, the average annual energy consumption in India in 2011 was 0.6 tons of oil equivalent per capita as compared to global average of 1.88 tons per capita, while per capita annual electricity consumption stands at 917 kWh, which is about a third of the world's average. These ratios have been, in

contemporary analysis of economics and energy, been linked to where on the Human Development Index our country lies, and where it must travel to.

Just as there are simple, everyday actions based on traditional values possible (and practiced) at the household level, so too there are community and ward-level activities that contribute to lowering our collective harmful impacts on the environment and thereby lowering our carbon footprint. Our cities and towns are struggling with refuse, garbage and household waste. For large cities (with populations of 4 million and above) the daily waste produced is recorded as being upwards of 1,000 tons (for large metros the quantities are more than 4,000 tons). When such quantities are consigned to landfills, apart from endangering the health of those in nearby settlements, the methane adds to the greenhouse gases in the atmosphere (and methane is more potent than carbon).

Once again, the easy and time-tested solution lies in our memory of what was common practice. What is today called wet waste (the cut and inedible portions of vegetables and fruit), when supplemented with leaf litter and garden trimmings, with only a little care and attention transforms over time into rich and nourishing dark compost that when added to soil rejuvenates the fertility of land (or potted plants), dramatically increases the amount of water the soil can retain, and is indispensible for organic cultivation.

It is with such a holistic view that the Swachh Bharat Abhiyan (clean India Campaign) and the Paramparagat Krishi Vikas Yojana (organic farming campaign) have been conceived. By themselves, these (and other initiatives that promote renewable energy at the community and household level) are effective but it is together that they become powerfully transformative. The climate crisis and the current state of our planet demands responses that go beyond technology and finance. A reorientation and a renewed consciousness is required, in every Indian household, which rest upon our ancient values and also employ the tools of the present. ❑

(E-mail: Vivakermani@gmail.com)

App for Public Grievances Portal

A Mobile Application for the Centralized Public Grievances Redress & Monitoring System (CPGRAMS) portal of the Department of Administrative Reforms and Public Grievances has been launched. This will provide M-access to citizens through mobile phones. A Quick Response (QR) code has been provided on the pg-portal which can be scanned on to the smart phone after which grievances can be sent from the smart phone directly on to CPGRAMS, as the mobile phone has emerged as the easiest way of communication from anywhere across the country. This app will allow lodging of grievances and people can track the status of the redress of their grievances.

Climate Change: Biodiversity at Stake

I bow my head in reverence to our ancestors for their sense of the beautiful in Nature and for their foresight in investing beautiful manifestations of Nature with a religious significance - ***Mahatma Gandhi***

Vinitaa Apte

Biodiversity can support efforts to reduce the negative effects of climate change. Conserved or restored habitats can remove carbon dioxide from the atmosphere, thus helping to address climate change by storing carbon (for example restriction deforestation). Moreover, conserving intact ecosystems, such as mangroves, for example, can help reduce the disastrous impacts of climate change such as flooding and storm surges

No culture has perhaps emphasised so much on environmental ethics as Indian culture. It believes in Ecological responsibility and says that the 'Earth is our Mother'. The Vedic hymn to the earth in Atharv Veda 'Mata Bhumih Putroham Prithivya' means 'Earth is my Mother, I am her Son'. Her blessings are sought for prosperity in all endeavours and fulfilment of all righteous aspirations". Panchmahabhutas (the five elements) Space, Air, Fire, Water and Earth are the foundations of an interconnected web of life.

Someone has rightly described the Rigveda is a celebration of nature, it's hero, the God of Rain.

Nature has been beautifully described in Rigveda as:

Nature's beauty is an art of God

Let us feel the touch of God's invisible hands is everything beautiful.

By the first touch of his hand rivers throb and ripple, When she smiles the sun shines

The moon glimmers

The stars twinkle, the flowers bloom

By the first rays of the rising sun, the universe is stirred,

The shining gold is sprinkled on the smiling buds of Rose,

The fragrant air is filled with sweet melodies of singing birds,

The Dawn is the dream of God' creative fancy. (Rigveda 1.6.3)

All these beautiful things are known as biodiversity. In other words, Biodiversity is defined as the sum variation of all living organisms (animal, plant, fungal and microbial) on Earth, including their genetic diversity, species diversity and the diversity in the ecosystems they help build and regulate. Biodiversity is the variety and differences among living organisms from all sources , including terrestrial, marine, and other aquatic ecosystems and the ecological complexes if which they are a part. In essence, biodiversity represents all life. India is one of the mega biodiversity centres in the world and has two of the world's 18 "biodiversity hotspots" located in Western Ghats and the eastern Himalayas. The forest cover in these areas is very dense and diverse and of pristine beauty and incredible diversity.

The presence of this biodiversity is extremely important to human welfare in the sense that it is the basic foundation of the food chain where in, every organism is dependent on one other. It provides immense direct benefits to humans, with at least 40 per cent of the world's economy being derived from biological resources. Maintaining biodiversity provides greater food security, opportunities for economic development, and provides a foundation for new pharmaceuticals

The author is President, TERRE (Technology, Education, Research and Rehabilitation for the Environment) Policy Centre. She has been a Consultant at UN Safe Planet campaign, Geneva, UNEP Ozone Action, Paris. She has also received UNEP award on 20th Anniversary Montreal Protocol for the 'Outstanding Contribution' to the out reaching of the Montreal Protocol (2007).

and other medical advances. Ironically, maintaining biodiversity levels and functioning ecosystems is critical to ameliorating climate change.

Biodiversity and climate change both are issues of concern worldwide and both directly or indirectly affect the livings things on earth. It is now widely recognized that climate change and biodiversity are interconnected.

Although throughout Earth's history, the climate has always changed with ecosystems and species coming and going, rapid climate change affects ecosystems and species ability to adapt so biodiversity loss increases. Biodiversity is affected by climate change, with negative consequences for human well-being, but biodiversity, through the ecosystem services it supports, also makes an important contribution to both climate-change mitigation and adaptation. The earth is full of astonishing things including vast diversity of flora and fauna.

There are 17 countries in the world which have rich floral and faunal diversity. Most of the plant and animal species are endemic to that region only. The particular species is found in that region on the basis of climatic, geographical, habitat and prey availability. For example, cheetah, the fastest animal on land is normally found in Savannah grassland which is truly suitable for its existence. Also, Polar bear in Arctic Resions.

Each year, IUCN (International Union of Conservation of Nature) publishes the current status of flora and fauna species across the world differentiating them into categories such as Extinct, Near to extinct, Threatened, and Vulnerable, etc. Each year almost 140 species become extinct from the earth. Habitat loss and hunting mainly by humans are the main reasons. In the red list i.e. extinct species list, the number of species is increasing.

India is also one of those 17 countries rich in biodiversity. There are mainly 3 biodiversity hotspots, where species richness is more compared to other places in India. North East Himalaya, Andaman & Nicobar islands and Western Ghats. India is also facing the exploitation of these hotspots in the form of deforestation and climate change. In deforestation, hundreds hectares of standing forest vanishes in very short time. That directly affects regional floral and faunal population. Climate change is also the main issue due to deforestation.

Consequently, conserving and sustainably managing biodiversity is critical to addressing climate change. Climate change is the change in climate, weather pattern due to atmospheric temperature with rising activities by humans and nature. It can also be connected with global warming due to rapid increase in the greenhouse gases emissions. Industrialization, pollution, deforestation are the main causes of increasing global temperature. That is called climate change. Because of greenhouse gases released into the atmosphere, the desired amount of the gases exceed on the earth surface, also due to heaviness, the gases remain on the surface. As the sun rays come on the earth surface, these gases trap the heat from the sun. So the phenomenon of Global warming is takes place. Since last 150 years, the average annual temperature rise is 0.85^0 C. Sea level is continuously increasing. Glaciers have started melting with faster rate.

Biodiversity on Impacts of Climate Change

The present global biota has been affected by fluctuating Pleistocene (last 1.8 million years) concentrations of atmospheric carbon dioxide, temperature, precipitation, and has coped through evolutionary changes, and the adoption of natural adaptive strategies. Habitat fragmentation has confined many species to relatively small areas within their previous ranges, resulting in reduced genetic variability. Warming beyond the ceiling of temperatures reached during the Pleistocene will stress ecosystems and their biodiversity far beyond the levels imposed by the global climatic change that occurred in the recent evolutionary past. Current rates and magnitude of species extinction far exceed normal background rates.

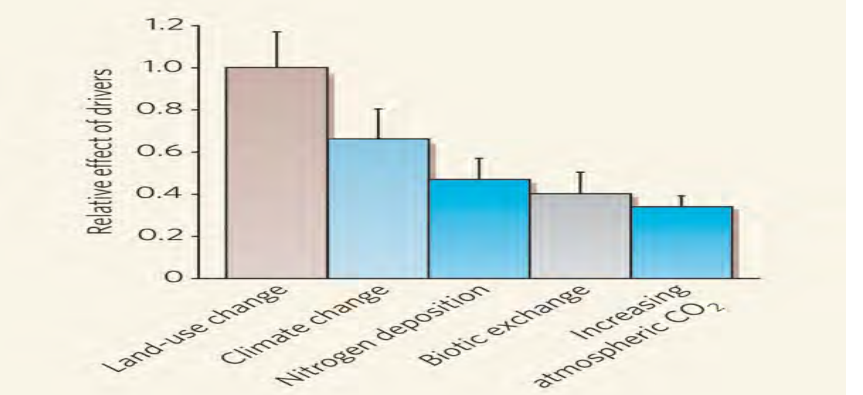
Human activities have already resulted in the loss of biodiversity and thus, may have affected goods and services crucial for human well-being. The rate and magnitude of climate change induced by increased greenhouse gases emissions has and will continue to affect biodiversity either directly or in combination with other drivers of change.

Links between Biodiversity and Climate Change:

There is ample evidence that climate change affects biodiversity. According to the Millennium Ecosystem Assessment, climate change is likely to become one of the most significant drivers of biodiversity loss by the end of the century. Climate change is already forcing biodiversity to adapt either through shifting habitat, changing life cycles, or the development of new physical traits.

As per the Convention on Biological Diversity goals, conserving natural terrestrial, freshwater and marine ecosystems and restoring degraded ecosystems (including their genetic and

Figure-2



species diversity) is essential for the overall Convention on Climate Change because ecosystems play a key role in the global carbon cycle and in adapting to climate change, while also providing a wide range of ecosystem services that are essential for human well-being and the achievement of the Millennium Development Goals.

Biodiversity can support efforts to reduce the negative effects of climate change. Conserved or restored habitats can remove carbon dioxide from the atmosphere, thus helping to address climate change by storing carbon (for example restriction on deforestation). Moreover, conserving intact ecosystems, such as mangroves, for example can help reduce the disastrous impacts of climate change such as flooding and storm surges.

Indian Scenario

These are the impacts of climate change on the biodiversity of India.

- Adverse effect on agriculture, health, forestry and infrastructure.
- Temperature rise by 3° C to 4°C towards the end of 21st century.
- Reduction in wheat and rice yields. Rainfall patterns and quantities in periods of drought in some regions, more rainfall in central India and reduced rain in the north-east, leading to changes in forestry and vegetation. Rain spells in the Ganga, Krishna and Godavari more intense.
- Number of rainy days may be reduced in the western parts of the Gangetic basin.
- 70 per cent of vegetation vulnerable to change.
- Adverse impact on wildlife and other biological species.

Impact on Forests of India:

- Shift in vegetation type boundaries i.e in Western Ghats the moist forest species are shifting eastward.
- Species of lower altitude migrating to higher altitude.
- Mountain forests of Western Ghats would change into grasslands.
- Increase in dry season length would increase the risk of forest fires in moist and dry deciduous forests.

Shows Figure-2 the relative effect of different drivers on the biodiversity, in which climate change comes on the second top.

Overall, the development rate and the changing habits of man are really scary. In my school days, we always learn to save water, save energy and save nature. This should be the Mantra of living. But I am afraid that if we forget the other living things on earth and try to destroy them, they will definitely destroy the human life in near future. ❑

(E-mail: aptevh@gmail.com)

Tackling Climate Change

Sharad Gupta

The disparity in average emissions per person has dominated India's position on global climate talks for two decades. Since the 1992 Rio Earth Summit, India has been the strongest voice for "common but differentiated" responsibilities. Those were enshrined in the famous 1997 Kyoto Protocol where developing countries avoided binding agreements to reduce their emissions until developed economies first dramatically slashed their own

Frequent droughts, sudden bursts of heavy downpour and unseasonal snowfall cannot be dismissed merely as vagaries of weather. We know that these are a result of climate change - which in simple terms, is warming of the atmosphere due to excessive industrial and auto emission. Rising temperatures have led to a nearly 10 per cent reduction in the duration and rainfall levels of the annual monsoon that is vital for our agriculture. Himalayan glaciers are melting fast threatening river ecosystems - lifeline of our agriculture. Melting of glaciers are contributing to rising sea levels putting hundreds of millions of Indians at risk in low-lying areas in Mumbai, Kolkata and Chennai areas.

Unchecked climate change and rising global temperatures will mean that monsoon rainfall, the crucial input for food production here, will fail more often over the next 150 years. This could mean a rain shortfall of anywhere between 40 per cent to 70 per cent. It could also mean untimely excess rainfall, which would disrupt life, wreck havoc with food production and push up food prices. A study by Jacob Schewe and Anders Levermann of the Potsdam Institute for Climate Impact Research predicts that the monsoons could fail every fifth year between the year 2150 and 2200 unless governments act decisively to counter climate change.

India has enormous reserves of coal and other fossil fuels. But, so far we have not been able to exploit its full potential, which has come as a boon for the environment as that would have contributed to increasing greenhouse gas emissions. We already are the world's third-largest national emitter. At 2 gigatons in 2012, its carbon emissions ranked far behind those of the United States (5.2 gigatons) and China (9.9 gigatons). On per capita basis, an Indian emits four times less than a Chinese and ten times less than an American. This is because we are still lagging behind them in industrial development.

The disparity in average emissions per person has dominated India's position on global climate talks for two decades. Since the 1992 Rio Earth Summit, India has been the strongest voice for "common but differentiated" responsibilities. Those were enshrined in the famous 1997 Kyoto Protocol where developing countries avoided binding agreements to reduce their emissions until developed economies first dramatically slashed their own.

For over a decade after Kyoto, India refused to discuss any binding limits. Indians would only discuss binding targets when other countries had reduced their own emissions to the per-person level of the average Indian – which at current rates would not happen until sometime in the 2030-2040 range.

The author is is a senior journalist with over 27 years experience of working in several national newspapers including The Times of India, The Indian Express, India Today and Hindustan. Presently he is Editor, Political Affairs with Dainik Bhaskar in New Delhi.

Emissions by Countries in 2012

Country	CO_2 Emissions per year (billion tons)	%age Share in Global Annual Emissions	CO_2 Emissions per capita (tons/ person)
World	34.5	100	4.9
China	9.86	28.6	7.1
United States	5.19	15.1	16.4
European Union	3.74	10.9	7.4
India	1.97	5.7	1.6
Russia	1.77	5.1	12.4
Japan	1.32	3.8	10.4

Analysts suggest that given the current levels of carbon emission, implementing all the measures that would limit emissions would still mean a "40 per cent chance of warming exceeding 4 degrees by 2100 and a 10 per cent chance of it exceeding 5 degrees in the same period." The best case is a warming of 3.8 degrees. All of it is way above the 2 degrees safe-limit that science has identified, and which all governments have accepted as a goal as part of the UN-sponsored climate change negotiations.

The Indian argument is simple. China and America have already taken lead in development whereas in India, several areas are still stranger to electricity, basic need for development. Most countries have given an undertaking for self-imposed reduction in emissions and set targets for themselves for 2039. This undertaking submitted to United Nations Framework Convention on Climate Change (UNFCCC) is called Intended Nationally Determined Contributions (INDC).

India has submitted its Intended Nationally Determined Contributions (INDCs) at midnight on 1st October to The United Nations Framework Convention on Climate Change (UNFCCC) – Conference of Parties (COP21)—that will be held in Paris in December this year. A total of 146 countries, representing 87 per cent of global greenhouse gas emissions have submitted their INDCs to UNFCCC before the deadline.

India has historically not been responsible for the emissions, has per capita emissions of 1.6 tons/person and ranks 135th – standing along with most of the least developed countries. But with total CO_2 emissions of 1.97 billion tons, it is currently the 3rd biggest emitter after U.S. and China.

The IEA meanwhile, has put forward a set of policy measures, which if adopted could help contain global temperature rise to 2 degrees at no net economic cost. These efforts include adopting specific energy efficiency measures, limiting construction and use of least efficient or sub critical coal fired power plants, minimizing methane production from upstream oil and gas production and accelerating the phasing out of subsidies to fossil fuel consumption. This would buy precious time while international climate negotiations continue towards the important Conference of Parties meeting in Paris in 2015 and the national policies necessary to implement an expected international agreement are put in place, the IEA report states.The report suggested that India could avoid up to 279 million tonnes of emission based on energy efficiency measures and more efficient power plants.

India's INDC Goals

India's INDC builds on its goal of installing 175 gigawatts (GW) of renewable power capacity by 2022 by setting a new target to increase its share of non-fossil-based power capacity from 30 per cent today to about 40 per cent by 2030 (with the help of international support). The country also commits to reduce its emissions intensity per unit GDP by 33 to 35 per cent below 2005 by 2030 and create an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide through additional tree cover. The plan also prioritizes efforts to build resilience to climate change impacts, and gives a broad indication of the amount of financing necessary to reach its goals.

Besides, India has also been working on reducing its auto-emissions by constantly improving emission standards. As a result, India's emissions intensity (carbon dioxide emissions per unit of GDP) declined by approximately 18 per cent between 1990 and 2005, and the country has already committed to reduce it by another 20-25 per cent from 2005 levels by 2020. The new INDC target commits India to go further – 33-35 per cent from 2005 by 2030.

In the course of meeting its renewable energy and non-fossil targets, and by tapping the substantial potential of energy efficiency improvements, India should be able to easily exceed its intensity target.

India's INDC recognizes the importance of increasing forest cover. Creating an additional carbon sink of 2.5 to 3 billion tonnes of CO2 through this would require average annual carbon sequestration to increase by at least 14 per cent over the next 15 years relative to the 2008-2013. India has put forward a well-balanced climate plan that, alongside its renewable energy goals, will generate transformational changes. These actions are also being proposed alongside an aggressive development agenda.

India had in the past declared a voluntary goal of reducing the emissions intensity of its GDP by 20–25 per cent, over 2005 levels, by 2020, despite having no binding mitigation obligations. A slew of policy measures were launched to achieve this goal. As a result, the emission intensity of India's GDP has decreased by 12 per cent between 2005 and 2010. India has further pledged in its INDC that it will increase its target to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level.

National Acton Plan on Climate Change

India has also committed to increase its share in renewable energy to 40 per cent in installed capacity by 2030. Its current share of renewable energy is around 13 per cent (36 GW) making it a very ambitious goal. India says that the ambitious goal will be attained by the following.

Solar and Wind energy will increase from current 4060 MW and 23.76 GW in 2015 to 100 GW and 60 GW by 2022 respectively and an increase even after that.It is envisaged to increase biomass installed capacity to 10 GW by 2022 from current capacity of 4.4 GW.Special programmes will be launched to promote small and mini hydel projects, new and efficient designs of water mills have been introduced for electrification of remote villages and will continue to be promoted.

Nuclear energy will be promoted from the current capacity of 5780 MW to 63 GW installed capacity by the year 2032, if supply of fuel is ensured.

Clean coal will be promoted by increasing the efficiency standards and old inefficient thermal stations will be assigned mandatory targets for improving energy efficiency.

India has also agreed to enhance its forest cover from 24 per cent of the geographical area in 2013 to 33 per cent of its geographical area in long term. And it also mentions that its forest cover will absorb 2.5 to 3 billion tonnes of carbon dioxide by 2030 making it a major sink for absorbing Carbon Dioxide. We have also decided to build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Steps already taken

BEE ratings have been introduced for electrical appliances like tubelites, so that people know how much their electricity bill is going to increase and buy less energy consuming appliances.

Bharat IV emmission norms for all 4 wheelers will be introduced in the country from 2010. India is the 4th largest producer of electricity by wind energy in the world and the government offers concessions to companies who establish wind farms.

India has set up the Ministry of New and Renewable Energy, which provides funds for developing new sources of energy in India. Asia's largest solar pond has been set up at Bhuj in Rajasthan. Also, an experimental Ocean Thermal Energy Conversion (OTEC) plant is being set up in Kerala.

India has announced a National Biofuel Policy, by which, biofuels will be grown on non-agricultural land, using the plant Jatropha, so that the agricultural production is not harmed in any way. ❑

(E-mail:sharad.editor@gmail.com)

India's INDC Goals-Enhancing Forests Carbon Sink

- To create additional carbon sink of 2.5 -3 billion tonnes of CO2 equivalent through additional forest and tree cover (increase of about 680 - 817 million tonne of carbon stock)
- Full implementation of Green India Mission
- Launched Green Highways Policy: 140,000 km long "tree-line" along both sides of national highways. 1% of project cost to be earmarked for plantation
- Plantation along Rivers: part of the Namami Gange Mission
- Finance Commission (FC) Incentive for creation of carbon sink: devolution of funds to states from federal pool (attaches 7.5 % weight to area under forest).
- Reduction in consumption of wood/ biomass as fuel
- Funds from Compensatory Afforestation Fund Management and Planning Authority (CAMPA): USD 6 billion proposed to be given to States
- Other Policies: REDD-plus; National Agro-forestry Policy (NAP); Joint Forest Management; National Afforestation Programme

India's INDC Goals-Increase the Share of Non Fossil Fuel Based Electricity

- To achieve 40% of electric power installed capacity from non-fossil fuel by 2030
- A jump of 33% over non-fossil fuel capacity of 2015
- India running one of the largest renewable capacity expansion programs in world
- The 175 GW target by 2022 will result in abatement of 326 million tons of CO2 equivalent/year. More progress after 2022.
- To include wind power, solar, hydropower, biomass, waste to energy and nuclear power.
- Solarization of all petrol pumps, toll plazas across country
- Ongoing scheme for development of
  25 Solar Parks
  Ultra Mega Solar Power Projects
  Canal top solar projects
  One hundred thousand solar pumps for farmers
  India to anchor a global solar alliance
  New missions on wind energy and waste to energy
  Green Energy Corridor projects being rolled out to ensure evacuation from renewable energy plants

Science Express-Unique Initiative on Climate Change

The prestigious "Science Express", redesigned on the theme 'Climate Change' is now running as 'Science Express – Climate Action Special (SECAS)' from October 15th, 2015 . The state-of-the-art exhibition aboard the 'Science Express – Climate Action Special (SECAS)' aims to create awareness among various sections of society, especially students, as to how Climate Change can be combated through mitigation and adaptation. Of the 16 coaches of SECAS, exhibition in 8 coaches developed by Centre for Environment Education (CEE) on behalf of MoEFCC, Government of India is exclusively devoted to information, case studies and material related to various aspect of Climate change, the underlying science, impacts, adaptation activities, mitigation solutions and policy approaches in a manner that is easy to understand and interesting for not just school students but also the masses. SECAS will travel across the country for about 7 months, halting at 64 locations in 20 States, covering about 19,800 km. The exhibition will convey a strong message about Climate Change and will also be a good opportunity to generate dialogue and discussion. A unique collaborative initiative of Department of Science & Technology, Ministry of Environment, Forest & Climate Change (MoEFCC), and Ministry of Railway, Government of India, the Science Express has successfully completed 7 tours across India

Science Express is a unique initiative of the government of India to create awareness on scientific issues. The science exhibition, mounted on a 16-coach AC train has been travelling across India successfully for the past seven years covered over 1,22,000 km across the country, receiving more than 1.33 crore visitors at its 391 halts, in 1404 days. Science Express has thus become the largest, the longest running and the most visited mobile science exhibition in India and has created six Limca Book of Records in its journey so far.

New Website on Climate Change Launched

A new website on climate change– www.justclimateaction.org was launched recently by the Ministry of Environment & Forests & Climate Change . The website, created especially for the purpose of putting up India's stands and efforts till Paris Summit includes India's Intended Nationally Determined Contributions (INDCs). The website focuses on bringing transparency to the entire effort. As each stakeholder brings his activity to the fore to take a billion-strong people into confidence, the website and associated social media infrastructure ensures that each citizen in the country becomes a votary for a better future. The website brings most of its content in the form of videos that can be shared on personal social media channels. Built on a 'break away and play' architecture, each page, story or section can be posted/shared by viewers anywhere in the world. It contains over 300 GB of data in films, reports and pictures. The thrust is to provide rich content in the form of short films to engage the audience and retain their interest in going through all the material presented.

Green India Mission Plans of Four States Approved

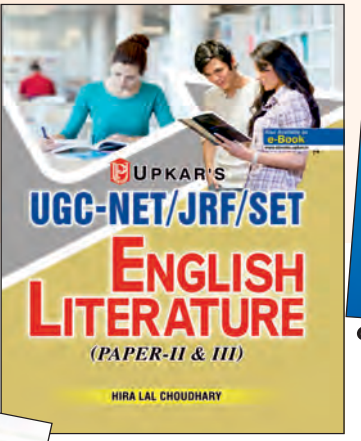
Perspective Plans & Annual Plan of Operations (APOs) submitted by four States - Mizoram, Manipur, Jharkhand and Kerala have been approved by the National Executive Council (NEC) of the National Mission for a Green India (GIM). The Perspective Plans of all four States, with a total financial outlay of Rs. 90, 202.68 lakh for a Plan period of 5 to 10 years were approved, along with APOs of Rs.11, 195.32 lakh for this financial year. The total forest and non-forest area taken up in these four States under GIM during the total plan period will be 1, 08, 335 hectares (ha) out of which 81, 939 ha will be improving the density of existing forests and 16, 396 ha will be new areas. For the current financial year, it will be 28, 250 ha and 7, 827 ha respectively. Approval has been granted for alternative energy devices such as biogas, solar devices, LPG, biomass-based systems and improved stoves for 27, 032 households for the current financial year and 81, 233 households for the total plan period. This will help in reducing pressure on forests, gaining carbon benefits, along with health and other associated benefits.

Regd. No. RNI 949/57
Licenced U(DN)-56/2015-17 to post without pre-payment at RMS, Delhi (Delhi Post
Postal Regd. DL(S)-05/3230/2015-17
No. Pages 80

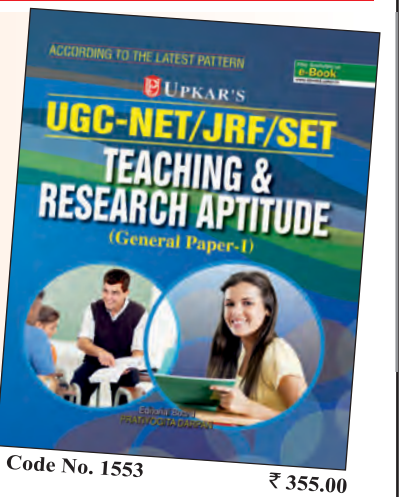
Published on 23 November 2015
Posted on 25-26 November 2015

CSIR-UGC NET/JRF/SET

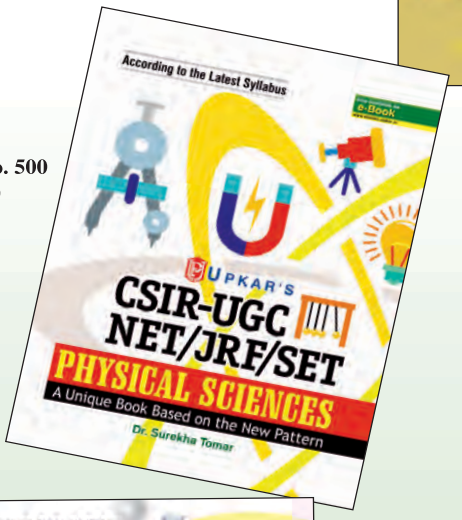
Examination-oriented study material catering to the various needs of the examination encompassing the wide spectrum of syllabi



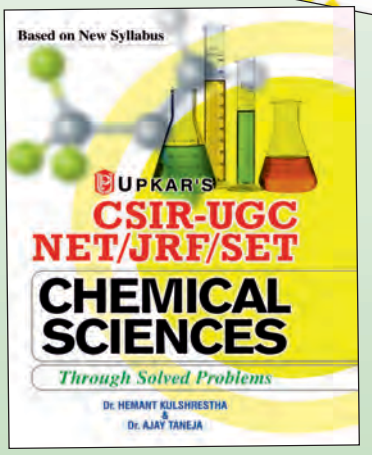
Code No. 1736
₹ 475.00



Code No. 1553 ₹ 355.00



Code No. 500
₹ 850.00



Code No. 1588 ₹ 835.00

Useful Books	Code No.	Price
CSIR-UGC NET Chemical Sciences	1588	835.00
CSIR-UGC NET Mathematical Sciences	1587	660.00
CSIR-UGC NET Life Sciences	317	680.00
CSIR-UGC NET Physical Sciences	452	410.00
CSIR-UGC NET Physical Sciences	1551	499.00
UGC-NET General Paper-I	420	315.00
UGC-NET General Paper-I	1761	345.00
UGC-NET PWB General Paper-I	1781	180.00
UGC-NET Geography	336	225.00
UGC-NET Objective Geography (Paper-II)	320	215.00
UGC-NET Geography (Paper-II & III)	1735	599.00
UGC-NET English Literature (Paper-II)	940	115.00
UGC-NET English (Paper-III)	1544	190.00
UGC-NET English (Paper-II & III)	1549	310.00
UGC-NET English Literature (Paper-II & III)	1736	475.00
UGC-NET English Literature (Paper-II & III)	1723	330.00
UGC-NET PWB English (Paper-II & III)	1809	235.00
UGC-NET 'Hindi' (Paper-II& III)	2258	395.00
UGC-NET 'Hindi' (Paper-II & III)	567	415.00
UGC-NET 'Sanskrit' (Paper-II & III)	2328	560.00
UGC-NET Psychology (Paper-II)	322	175.00
UGC-NET Psychology (Paper-II)	1765	390.00
UGC-NET Psychology (Paper-III)	1770	350.00
UGC-NET Commerce (Paper-II)	968	199.00
UGC-NET Commerce (Paper-II)	888	445.00
UGC-NET Commerce (Paper-II & III)	1861	515.00
UGC-NET Computer Science (Paper-II & III)	894	750.00
UGC-NET Physical Education (Paper-II & III)	931	445.00
UGC-NET Management (Paper-II)	1653	455.00
UGC-NET Management (Paper-III)	1701	450.00
UGC-NET Management (Paper II & III)	1813	499.00
UGC-NET Education (Paper-II)	1522	325.00
UGC-NET Education (Paper-III)	1860	275.00
UGC-NET Education (Paper-II& III)	1815	399.00
UGC-NET PWB Education (Paper-II & III)	1803	235.00
UGC-NET Sociology (Paper-II)	1755	330.00
UGC-NET Sociology (Paper-III)	1772	460.00
UGC-NET Economics (Paper-II & III)	1775	635.00
UGC-NET Visual Art (Paper-II)	1752	180.00
UGC-NET Mass Communication and Journalism (Paper-II & III)	1764	510.00
UGC-NET History (Paper-II & III)	1769	540.00
UGC-NET History (Paper-II & III) Facts At a Glance (With Multiple Choice Questions)	1773	390.00
UGC-NET Home Science (Paper-II & III)	1771	525.00
UGC-NET Political Science (Paper-II & III)	1777	670.00
UGC-NET Library & Information Science (Paper-II & III)	1785	355.00
UGC-NET Social Work (Paper-II & III)	1791	325.00
UGC-NET PWB Human Resource Management (Paper-II & III)	1810	255.00

Printed & Published by Dr. Sadhana Rout, Additional Director General and Head on behalf of Publications Division, Soochna Bhawan, C.G.O. Complex, Lodhi Road, New Delhi - 110 003. Printed at Chandu Press, D-97, Shakarpur, Delhi-110 092 Phone: 22424396, 22526936.