International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 5, Sep-Oct 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Impact of Climate Change in India: A Review

Bhawana Kesarwani
Assistant Professor (Chemistry), Mahamaya G D C, Kaushambi
E-mail- bkesarwani1@gmail.com

Abstract:
Climate change is one of the main environmental challenges facing the world today. India also facing several problems. Climate change is associated with various adverse impacts on agriculture, water resources, forest, biodiversity, health, coastal management and increase in temperature. Decline in agricultural productivity is the main impact of climate change on India. A majority of population depends on agriculture directly or indirectly. Climate change would represent additional stress on the ecological and socio-economic systems that are already facing tremendous pressure due to rapid industrialization, urbanization and economic development. With melting glaciers, flood risks would increase in the near future. In the long-term, there can be no replacement for the water provided by glaciers that could result in water shortages on an unparalleled scale. Floods and drought are thus projected to multiply as a consequence of climate change.

Keywords: Climate Change, Greenhouse gas, Kyoto protocol, Clean Development Mechanism (CDM).

INTRODUCTION
"Climate change is now affecting every country on every continent. It is disrupting national economies and affecting lives, costing people, communities and countries early, today and even more tomorrow. People are experiencing the significant impacts of climate change, which include changing weather patterns, rising sea level and more extreme weather events. The poorest and most vulnerable people are being affected the most."[1]

India is situated below the Himalayas and lying in the sub-tropical terrain. It is adorned with a largely diverse topography, climate and biosphere. India situated in tropical region and is exposed to climatic risks hence it is vulnerable to climate change impacts on several sectors such as agriculture, forestry, health, biodiversity etc. The earlier studies have projected that the annual mean surface air temperature rise by the end of the century ranges between 3.5°C to 4.3°C.

The rate of CO_2 release into the atmosphere has increased by 30 times in the last 3-4 decades. It is estimated that a 0.5°C rise in winter temperature could reduce the wheat yield by 0.45 ton per hectare. A recent World Bank report studied two drought-prone regions in Andhra Pradesh and Maharashtra and one flood-prone region in Orissa on climate change impacts. In Andhra Pradesh, dry land farmers may see their incomes plunge by 20%. In Maharashtra, sugarcane yields may fall dramatically by 25-30%. In Orissa, flooding will rise dramatically leading to a drop in rice yields by as much as 12% in some districts.

The atmospheric concentrations of the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have all increased since 1750 due to human activity. In 2011 the concentrations of these greenhouse gases were 391 ppm (in 2019 it is 408.65 ppm-NOAA, Earth System Research Laboratory), 1803 ppb and 324 ppb and exceeded the pre industrial levels by about 40%, 150% and 20% respectively. Due to climate change for South Asia likely to increase number of hot days, cause more frequent and intense heavy precipitation days and change in rainfall pattern. The increase in temperature and change in rainfall is projected to affect the agriculture. India, with 17 percent of the world's population, contributes only 4 percent of the total global greenhouse gas emissions. In terms of per capita GHG emissions it is about 23 percent of the global average. Around 55 percent of India's population still does not have access to commercial energy.

An Overview
Global warming could have many disastrous effects on the society directly (water, food, habitat,

health, economic infrastructure such as energy, transport and industry) and also through the environment (rainfall, sea level rise, extreme events such as hurricanes and typhoons, floods and droughts). Polar ice melts as a result of the rising temperature and combined with the thermal expansion of seawater, causes oceans to slowly creep up and swallow low-lying islands. According to a panel of international experts studying climate change, entire forests may disappear and biological diversity may reduce because of the disappearance of habitat or reduced migration potential.[2]

According to the Intergovernmental Panel on Climate Change (IPCC), an international committee set up by the UN to track global warming, the average global surface temperature has already increased by 0.3-0.6°C in the last one hundred years.[2] Increase in temperatures can lead to increased eutrophication in wetlands. Increased temperatures will impact agricultural production. Higher temperatures reduce the total duration of a crop cycle by inducing early flowering, thus shortening the 'grain fill' period. The shorter the crop cycle, the lower the yield per unit area. The rise in temperature and change in humidity will adversely affect human health in India. Heat stress could result in heat cramps, heat exhaustion, heat stroke and damage physiological functions, metabolic processes and immune systems. Increased temperatures (particularly minimum temperatures) can increase the range of vector borne diseases such as malaria, particularly in regions where minimum temperatures currently limit pathogen and vector development. Water borne diseases, natural disasters, environmental migration, nutritional deficiency could be other major risk factors.

A trend of sea level rise of 1 cm per decade has been recorded along the Indian coast. Sea level rise due to thermal expansion of seawater in the Indian Ocean is expected to be about 25-40 cm by 2050. This could inundate low lying areas, drown coastal marshes and wetlands, erode beaches, exacerbate flooding and increase the salinity of rivers, bays and aquifers. Deltas will be threatened by flooding, erosion and salt intrusion. Loss of coastal mangroves will have an impact on fisheries. The major delta area of the Ganga, Brahmaputra, and Indus rivers, which have large populations reliant on riverine resources, will be affected by changes in water regimes, salt-water intrusion and land loss. Climate systems, such as the Indian subcontinent's monsoon system, could be dramatically affected. This will have a direct impact on the economy of nations. For instance, both drought and floods caused by interference in India's climatic systems could result in crop failure, affecting both the economy and the food security in the country. Dealing with the natural disasters also imposes a huge cost on the country's economy, as is evident from the droughts and floods India has suffered over the last year.

The United Nations Framework Convention on Climate Change (UNFCCC), which provides an outline to the parties to address the causes of climate change,[1] defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."[3] Simply put, climate change or global warming is an increase in global average temperatures that will have a largely negative effect on ecosystems across the world.[4] The overexploitation of natural resources and increasing environmental pollution has already triggered the harmful effects of climate change on people's lives. A rise in global average temperatures is likely to only worsen the current condition of human health and safety.[5]

In addition, it is believed that, billions of people, over the next few decades, mainly those living in developing countries will have to face acute shortages of water, food and greater risks to health and life as a result of harmful effects of climate change.[6] Climate change includes diseased crop yields, the disappearance of glaciers, extreme weather conditions like floods, droughts and storms, increased coastal flooding and species extinctions."[7]

"Rising fossil fuel burning and land use changes have emitted and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO_2), methane (CH_4) and nitrous

oxide (N_2O) and a rise in these gases has caused a rise in the amount of heat from the sun with held in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change. The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers; reduced snow cover; increases in ocean temperatures and ocean acidity, due to sea water absorbing heat and carbon dioxide from the atmosphere.

India faces an alarming environmental and socioeconomic challenge in its effort to protect its fast-depleting natural resources. Water and air quality are worsening day by day due to increase of various pollutants in the atmosphere. In addition, the sectors that will be subjected to the highest exposure to climate change are the country's coastal eco-systems, biodiversity and agricultural productivity.[8]

India is the world's third largest greenhouse gas (GHG) emitter, however in terms of emissions per capita it has the lowest level in the G20. Emissions in the agriculture sector stem primarily from livestock's enteric fermentation and rice cultivation produces methane while from manure and residue burning produces nitrous oxide. India's largely oil-dependent transport sector accounts for about 9 percent the country's GHG emissions. India's residential sector contributes about 4 percent to the national GHG emissions. Solid biofuels (e.g., wood) remain the most common source of fuel in the sector.[9]

There is also evidence of prominent increases in the intensity and frequency of many extreme weather events such as heat waves, extended dry spells and intense rainfall. The adverse impacts of such disasters range from hunger, vulnerability to diseases, loss of income and livelihoods.[10]

As per the World Bank, an increase of 2°C in the world's average temperature in the next few decades will only make India's monsoon more unpredictable. The shift in rain patterns across India is predicted to leave a number of areas under water and others without enough water even for drinking. [11] "In India, more than 60% of the crop area is rain-fed, making it highly vulnerable to climate-induced changes in precipitation patterns. It is estimated that by the 2050s, with a temperature increase of 2°C-2.5°C compared to pre-industrial levels, water for agricultural production in the river basins of the Indus, Ganges and Brahmaputra will reduce further and may impact food adequacy for some 63 million people."[12]

Accumulation of trace gases such as carbon dioxide (CO_2) and methane (CH_4) in the atmosphere, caused mainly due to anthropogenic activities such as burning of fossil fuels is believed to be altering the earth's climate system. Climate change is the most complex issue at the global level. Carbon dioxide (CO_2) is the major pollutant that traps heat and lingers in the atmosphere for thousands of years, gradually warming the planet.[13]

The two main approaches to address this issue are 'mitigation' and 'adaptation'.

- **Mitigation:** An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.[14]
- **Adaptation:** Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities.[14]

While mitigation addresses the degradation rate of climate change, adaptation deals with weakening the adverse impacts of climate change.[15]

Although they share a common ultimate objective namely the sustainable development of human society, there are significant differences between mitigation & adaptation (M & A) in practice, including the scales of the departments and the research involved. The mitigation actions primarily focus on the energy sector and carbon emissions reduction.

Climate Change and Agriculture

The diversity of natural regions and climatic conditions in India allow for the cultivation of a wide range of crops. Agriculture is a major source of employment in India. The green revolution in cereal production (late 1960s – early 1980s) was succeeded by the white revolution in milk production (starting in the 1970s), the gene revolution in cotton production (early 2000s) and

the more recent diversification of production towards pulses, fruit and vegetables as well as meat and meat products. India is also the world's largest producer of pulses, accounting for about a quarter of global output. India is the world's second largest producer of fruit and vegetables after China.

Agriculture accounts for 18% of total greenhouse gas (GHG) emissions in India and is the second major emitter of greenhouse gases (GHGs) after the energy sector (71%). The majority of agricultural GHG emissions occur at the primary production stage and are generated through livestock rearing (enteric fermentation and manure management) (59% of agricultural GHGs), the use of chemical fertilisers and their associated impacts on soils (21%), paddy rice cultivation (18.3%), as well as residue management practices (1.7%). Botswana suggests that changes in climate that lead to an increase in temperature and a decrease in precipitation are associated with a[16] increase in diarrhoeal disease in children.

Climate Change Adaptation

India is one of the world's most vulnerable countries to climate change.[17, 18, 19] India's vulnerability to climate variability and change is shaped by a mix of non-climatic drivers, including those related to its economy, social development, governance and environmental sustainability. Poverty and inequality are two of the critical underlying socio-economic drivers that increase the vulnerability of a given society, such as India's, to climate risks.[20]

If the percentage of agricultural land is high, the flood vulnerability reduces. A significant share of the Indian economy comes from agriculture. However, in recent years, the Indian economy has witnessed a substantial shift from being predominantly rural and agriculture based to more focused on service and manufacturing.

The primary reasons for urban flooding and its reoccurrence are poor urban planning and lack of flood resilient infrastructure. The uncontrolled expansion of cities led to flood plain encroachments, reducing the previous area and increasing run off.[21]

Until recently, India's storm water drains were designed per the Central Public Health and Environmental Engineering Organisation (CPHEEO) guidelines. They are designed for rainfall intensities of once in one year to once in two years return periods. If rainfall records are unavailable, rainfall intensity is usually adopted in the range of 12 mm/hr – 20 mm/hr.

Global Warming

The Earth's temperature is maintained at a level where it can sustain life by a balance between heat from the sun and cooling from reflecting some of the heat by the Earth's warm surface and atmosphere back to space. But atmospheric gases such as carbon dioxide, methane, nitrous oxide and halocarbons absorb some of the rays reflected back from the Earth's surface. These are 'greenhouse gases' (GHGs). They act like a blanket, preventing much of the heat reflected by the earth's surface escaping directly to space. By slowing the release of cooling radiation, these gases warm the Earth's surface. While this is a natural process that is essential to life on Earth, the trouble starts when the concentration of these GHGs in the Earth's atmosphere increases. The result is an increase in the Earth's temperature or global warming. Global warming in turn interferes with the Earth's climatic systems, resulting in climate change. Of all GHGs, carbon dioxide is singly responsible for over half the effect of global warming. Though the gas is naturally present in the Earth's atmosphere and in oceanic and terrestrial 'sinks' (such as forests), the trouble starts when carbon dioxide concentrations increase beyond limits that can be absorbed by the Earth's natural cycle. Carbon dioxide concentrations have been increasing rapidly in the atmosphere since the start of the industrial revolution, when the world became heavily dependent on carbon-based fossil fuels for economic growth. Ever since then, human beings have been emitting carbon dioxide into the atmosphere in their pursuit for industrialisation, economic growth and better lifestyles.

Effects of Global Warming

Global warming could have many disastrous effects on the society directly (water, food, habitat, health, economic infrastructure such as energy, transport and industry) and also through the

environment (rainfall, sea level rise, extreme events such as hurricanes and typhoons, floods and droughts). Polar ice melts as a result of the rising temperature and combined with the thermal expansion of seawater, causes oceans to slowly creep up and swallow low-lying islands. According to a panel of international experts studying climate change, entire forests may disappear and biological diversity may reduce because of the disappearance of habitat or reduced migration potential.[2]

Climate systems, such as the Indian subcontinent's monsoon system, could be dramatically affected. This will have a direct impact on the economy of nations. For instance, both drought and floods caused by interference in India's climatic systems could result in crop failure, affecting both the economy and the food security in the country. Dealing with the natural disasters also imposes a huge cost on the country's economy, as is evident from the droughts and floods India has suffered over the last year effects of climate change already been recorded. According to the Intergovernmental Panel on Climate Change (IPCC), an international committee set up by the UN to track global warming, the average global surface temperature has already increased by 0.3-0.6°C in the last one hundred years. [2]

Scientists have recorded the 1990s as the hottest decade in the world since the industrial revolution began. Devastating hurricanes and typhoons have cost lives and destroyed entire national economies in previous years. Scientists have also recorded that spring now arrives a week earlier in the northern hemisphere, tree lines in the northern most forests of the world are moving towards the poles and ice shelves on Antarctica's northern fringe are disintegrating.

Responsibility for Global warming

Due to industrialisation developed countries have been emitting carbon dioxide in the Earth's atmosphere for years before developing countries, at the time when the harmful effects of these emissions were not known and hence there were no restrictions on emissions. Since carbon dioxide accumulates in the atmosphere for hundreds of years, the emissions by developed countries are still present in the Earth's atmosphere and are still causing global warming. Therefore, developed countries are responsible for increasing the carbon dioxide concentrations in the atmosphere through their historical emissions.

Carbon dioxide emissions of developing countries like India have now grown as they follow the fossil fuel-intensive economic growth model set out by the rich countries and try to achieve better standards to living. But even to this day, many industrialised countries emit more carbon dioxide than many developing countries. The differences in developed and developing country emission are even more apparent when per capita emissions of carbon dioxide are concerned. This is because of the energy intensive lifestyles of industrialised countries. Many of the uses of energy in the richer countries are for purposes of luxury and the emissions caused from such uses may be termed luxury emissions. But the lower per capita emissions of developing countries are because a large number of poor people do not even have access to basic amenities such as electricity. They will need their share of ecological space to increase what could be termed survival emissions. Citizens of richer countries will have to decrease their per capita emissions in order to allow these poor people to increase theirs and to allow them to improve their living standards.

Carbon dioxide emissions are essential for economic growth so long as economic growth is dependent on fossil fuel use. But the Earth's capacity to absorb carbon dioxide is limited. If the Earth's capacity to absorb these emissions is exceeded, the ill effects of global warming will be unleashed. In other words, one could say that the 'ecological space' available to human beings to pursue their economic goals is limited. Life on Earth will be threatened if this ecological space is exceeded.

Indian perspective as a developing country

A team of scientists sponsored by the UN have reported that developing countries are, on an average, twice as vulnerable as industrialised countries and small island developing countries are three times as vulnerable.

India's economy is largely dependent on agriculture and is already under stress due to its increasing population, and the resulting increase in demand for energy, fresh water and food. This situation will worsen with the effects of global warming. India, as a developing country has reasons to be concerned about the adverse impact of climate change on its economy. A large part of its population depends on climate sensitive sectors for livelihoods which makes it highly vulnerable to climate change. Climate change can have serious impact on its crops, forests, coastal regions etc. which can in turn affect the achievement of its important national development goals. The issue of climate change cannot however be taken up without linking it to developmental needs such as poverty, health, energy access and education. Higher energy production and consumption is a major driving force of economic development and poverty reduction. Most economic activities depend on energy. Economic growth may not be associated with proportionate GHG emissions, though its emissions are bound to grow in short as well as medium term with the upsurge of the manufacturing sector and need for industrialisation to meet the growing demands of its huge population.

Other initiatives may include increase in the usage of LED lighting, use of compressed natural gas as fuel, providing for stringent vehicle emission norms and usage of renewable sources of energy. There needs to be a strong national environmental policy which should include clear cut rules with regard to environmental pollution and waste management, while giving licenses to industrial houses. Since vehicles contribute to air pollution in a significant manner, a practical solution needs to be developed to curb this issue.[22] The State must take initiative to encourage community participation in monitoring pollutions.

Increased temperature

Scientists from the Indian Institute of Technology (IIT), New Delhi, already report that surface air temperatures over India are going up at the rate of 0.4°C per hundred years, particularly during the post-monsoon and winter season.[23] Using models, they predict that mean winter temperatures will increase by as much as 3.2°C in the 2050s, and 4.5°C by the 2080s, due to GHGs. Summer temperatures will increase by 2.2°C in the 2050s and 3.2°C in the 2080s.[12]

Extreme temperatures and heat spells have already become common over Northern India, often causing loss of human life. In 1998 alone, 650 deaths occurred in Orissa due to heat waves.

Effect on monsoon

India is heavily dependent on the monsoon to meet its agricultural and water needs and also for protecting and propagating its rich biodiversity. Subtle changes have already been noted in the monsoon rain patterns by the IIT, Delhi, despite the 11 near-normal monsoons in a row. IIT scientists warn that India will experience a decline in summer rainfall by the 2050s. Since summer rainfall accounts for almost 70 percent of the total annual rainfall over India and is crucial for Indian agriculture, this could have a devastating effect on the Indian economy, and on food security.

Effects on water resources

Relatively small climatic changes can cause large water resource problems, particularly in arid and semi-arid regions such as northwest India. This will have an impact on agriculture, drinking water and on generation of hydroelectric power, resulting in limited water supply and land degradation.

Effect on agriculture

Increased temperatures will impact agricultural production. Higher temperatures reduce the total duration of a crop cycle by inducing early flowering, thus shortening the 'grain fill' period. The shorter the crop cycle, the lower the yield per unit area.

Human health

Modelling suggests that the rise in temperature and change in humidity will adversely affect human health in India. Heat stress could result in heat cramps, heat exhaustion, heat stroke and damage physiological functions, metabolic processes and immune systems.

Increased temperatures (particularly minimum temperatures) can increase the range of vector borne diseases such as malaria, particularly in regions where minimum temperatures currently limit pathogen and vector development. Stress on food supply, water availability, sea level rise and changes in ecosystems is likely to have additional effects on human health in India. Water borne diseases, natural disasters, environmental migration, nutritional deficiency could be other major risk factors.

Effect on forests

Increase in temperatures will result in shifts of lower altitude tropical and subtropical forests to higher altitude temperate forest regions, resulting in the extinction of some temperate vegetation types. Decrease in rainfall and the resultant soil moisture stress could result in drier teak dominated forests replacing Sal trees in central India. "In any case an increased turnover of forest species is indicated," says M Lal from IIT Delhi. This could potentially result in species extinction and decline in biodiversity. Increased dry spells could also place dry and moist deciduous forests at increased risk from forest fires.

Responsibility for global warming

Developed countries have had a head start on developing countries in the industrialisation process. They have been emitting carbon dioxide in the Earth's atmosphere for years before developing countries, at the time when the harmful effects of these emissions were not known, and hence there were no restrictions on emissions. Since carbon dioxide accumulates in the atmosphere for hundreds of years, the emissions by developed countries are still present in the Earth's atmosphere and are still causing global warming. Therefore, developed countries are responsible for increasing the carbon dioxide concentrations in the atmosphere through their historical emissions. Carbon dioxide emissions of developing countries like India have now grown as they follow the fossil fuel-intensive economic growth model set out by the rich countries and try to achieve better standards to living. But even to this day many industrialised countries emit more carbon dioxide than many developing countries.

Way to stop global warming

The only way to stop global warming is for the world to reduce GHG emissions by 50-70 percent below 1990 levels, by reducing or even altogether abandoning, the use of carbon-based fuels. This is a difficult task, because the world's economy depends on fossil fuels and because GDP growth in all countries in the world is currently linked with the growth in carbon dioxide emissions. Under these circumstances, any limit on carbon emissions amounts to a limit on economy growth.

To deal with the climate change problem by reducing GHG emissions, a global Framework Convention on Climate Change (FCCC) was signed under the auspices of the UN in 1992. This convention recognised that the problem of global warming was caused mostly by industrialised countries and hence they should take the first step to limit emissions. The Kyoto Protocol, adopted under the FCCC in 1997, laid down a timetable for industrialised countries to reduce their GHG emissions. According to the protocol, industrialised countries have to decrease their emissions by at least 5.2 percent compared to 1990 emission levels, by the 2008-2012 period. The Kyoto Protocol has not yet come into effect, and the finer details of some of its articles still have to be negotiated. This is expected to happen at the sixth conference of parties (CoP-6) to the FCCC, to be held in The Hague from November 13-24, 2000.

The protocol will come into effect only after it has been ratified by 55 countries who are parties to the FCCC, with emissions adding up to at least 55 percent of the total 1990 carbon dioxide emissions of industrialised countries. This means the US and Russia, which together account for almost 54 percent of these emissions, have to ratify the protocol for it to come into force. Also, the protocol would be meaningless without the ratification of the US, which accounts for a fourth of the world's carbon dioxide emissions.

Unfortunately, the international negotiations have turned acrimonious as the US has made its ratification of the protocol conditional to 'meaningful participation' of key developing countries (mainly China, India and Brazil), in clear contravention of the FCCC agreement. This is because the US Senate wants to protect the US economy. They are afraid that industries and hence jobs will move from the US to these developing countries, if the US has limitations of greenhouse gas emissions and these countries do not. But asking developing countries to reduce their carbon dioxide emission levels amounts to asking them to freeze at their current level of development. This amounts to freezing global inequality, by accepting that some countries will always be more developed than others in the world. Also, the US is looking for new ways to meet their commitments under the Kyoto Protocol in the cheapest possible way, without compromising its economy. Therefore, it is pushing for the acceptance of the so-called 'flexibility mechanisms' of the protocol. With these mechanisms, the cost of meeting the Kyoto commitments could come down by over 95 per cent for the US.

Flexibility mechanisms of Kyoto Protocol's

The 3 flexibility mechanisms of the Kyoto Protocol are based on the notion that reductions of GHGs can be achieved at lower costs in many developing countries as well as in Central and Eastern Europe (CEE) than in industrialised countries. Joint Implementation (JI) and Emissions Trading allow for emissions trading programmes between only industrialised countries. But the Clean Development Mechanism, or CDM, is a form of joint implementation between industrialised and developing countries. Under this mechanism, industrialised countries pay the extra cost of upgrading technology in developing countries. In turn, they get credits for the amount of GHG emissions mitigated by the technology upgrade. The primary purpose of CDM mechanism is to allow industrialised countries to buy cheap reductions from developing countries.

CDM (Clean Development Mechanism)

The Clean Development Mechanism, or CDM, is a form of joint implementation between industrialised and developing countries. Under this mechanism, industrialised countries pay the extra cost of upgrading technology in developing countries. In turn, they get credits for the amount of GHG emissions mitigated by the technology upgrade.

The primary purpose of CDM mechanism is to allow industrialised countries to buy cheap reductions from developing countries. Let us say that India decided to invest in a new power station, and has decided on a particular technology at the cost of X crore. An entity from an industrialised country (which could even be a company) offers to provide India with slightly better technology, which costs more (say Y crore), but will result in lower emissions. The industrialised country will only pay the incremental cost of the project – viz. Y minus X. In return, the 'investing' country will get 'certified emission reductions' (CERs), or credits, which it can use to meet its Kyoto commitments. This is a very good deal indeed – but for the investing country. Not only do they sell developing countries their technology, but they also meet their Kyoto commitments without lifting a finger to reduce their domestic emissions. Countries like the US can continue to pollute at home, so long as it makes the reductions elsewhere.

Developing countries and CDM

Not the way the CDM is currently designed. In fact, developing countries stand to lose a lot if they do not insist on equal per capita GHG emission entitlements for all countries before this mechanism comes into effect. There are several fundamental errors in the mechanism from the point of view of developing countries.

The mechanism recognises and institutionalises the right of countries like the US to emit more GHGs, and hence their right to a higher standard of living than people in poor countries. This goes against the tenets of global democracy and social justice. To be a fair and just regime, the climate negotiations must decide the per capita rights of every citizen on the Earth before allowing trade in these rights. As the Indian delegation has often asked at the climate

negotiations, *how can we be expected to trade what we do not own?* Therefore, it is important that developing countries demand the recognition and allotment of equal per capita entitlements before they agree to CDM.

Possibly, the worst aspect of CDM is that while it helps industrialised countries to buy up the cheap emissions reduction options available today, it leaves developing countries to pay a heavy price tomorrow. Economists predict that the many carbon saving options that currently cost as little as US $10-25 per tonne of carbon could cost up to US $200-300 per tonne in the long term. This is the cost that developing countries will be expected to bear. When developing countries themselves have reached high levels of energy efficiency and therefore its cost of curtailing emissions is high, the North will have no economic incentive to buy emissions credits from it. And if global warming is still a threat – as it definitely will be because industrialised countries would have taken little action domestically - then pressure will mount on developing countries to take expensive emissions reductions themselves. In other words, CDM encourages the current generations of developing countries to sell off their cheaper emissions control options today, leaving options. It is, literally, a scheme that offers cash-strapped developing country governments an opportunity to discount the future.

Several studies show that a rapid shift towards a zero-carbon energy transition is not only the best but also possibly the only option to combat climate change in the next century.

Therefore, developing countries should insist that only renewable technologies should be eligible under CDM. There is no point in their investing in carbon-based technologies, when they will have to reduce their emissions sometime soon in the future.

As long as the world remains within a carbon-based energy economy, equitable sharing of 'atmospheric space' becomes a critical issue, especially for poor developing countries who need the maximum space for their future economic growth.

The Kyoto Protocol and CDM be made more democratic.

As long as the world remains within a carbon-based energy economy, equitable sharing of 'atmospheric space' becomes a critical issue, especially for poor developing countries who need the maximum space for their future economic growth. To make the protocol and CDM more democratic and just, developing countries have to push for recognition of their per capita entitlements to the atmosphere. Developing countries should demand "space to grow" while refusing to take on emission cuts at their current stage of development. The atmosphere is a common property resource, to which every human being has an equal right. The people of industrialised countries have more than used up their share of the absorptive capacity of this atmosphere, through high emission levels in the past and in the present. So, they have to cut their emissions, and allow developing countries space to increase theirs. Once this principle is accepted, then the sale of the unused annual share of the entitlements of a country could be done bilaterally – between India and USA for instance – or through an intermediary like the UN or World Bank.

India's position be at the climate negotiations- India has already led the G77, the bloc of developing countries, in the demand for per capita entitlements under the climate convention. However, India is coming under a lot of political pressure from the US, in particular, to agree to CDM without any such principles.

Ozone Cell

As per its commitment to implement the Montreal Protocol and its Ozone Depleting Substances (ODS) phase out programme in India, the Ministry of Environment and Forests has set up the Ozone Cell as a national unit to look after and to render necessary service. The Ministry provides custom/excise duty exemption for ODS phase-out projects and grants duty exemption for new investments with non-ODS technologies. The Reserve Bank of India has issued directions to all financial institutions and commercial banks not to finance new establishments with ODS technology. Licensing system is there to regulate import and export of ODS.

Prime Minister on June 30th, 2008 released India's National Action Plan on Climate Change**.** The National Action Plan (see GOI, 2008) has been prepared under the guidance and direction of Prime

Minister's Council on Climate Change. The National Action Plan reflects the importance the Government attaches to mobilizing our national energies to meet the challenge of climate change. The National Action Plan focuses attention on 8 priority National Missions. These are:

1. Solar Energy
2. Enhanced Energy Efficiency
3. Sustainable Habitat
4. Conserving Water
5. Sustaining the Himalayan Ecosystem
6. A "Green India"
7. Sustainable agriculture
8. Strategic Knowledge Platform for Climate Change

Bio fuels and Climate Change

There are a wide range of different types of bio-fuels, but the most common products are bio ethanol and biodiesel, made from crops including corn, sugar-cane and rapeseed. Bio-ethanol is made by using yeast fermentation to produce ethanol from crops such as sugar-cane and corn, while biodiesel is made by chemically processing oilseeds. Both products can be used either neat or mixed with petrol / diesel.[24]

Climate Change and Intellectual Property Rights

Another challenge is to ensure that low-carbon technology is transferred from industrial countries to India and other developing countries. Restrictive intellectual property rights (IPR) arrangements can prevent the transfer of low-carbon technologies. So, there is a need to seek a regime that permits access to available low carbon technologies and IPRs on concessional terms. Collaborative research could also help in this respect

Future Works to solve the problem

a. Recognise that global warming will have economic, as well as health and environmental impacts on your constituency.

b. Initiate a parliamentary debate on the impacts of global warming on the country's economy and also on the impacts of the current international negotiations.

c. Ensure that India accepts no less than per capita entitlements, and the best and most effective renewable energy technology under the Kyoto Protocol.

d. Insist that Indian scientific institutions generate detailed studies listing these impacts, and that this information is made available to the people.

Conclusion

India is one of the most vulnerable countries to climate hazards worldwide. The literature has shown that the frequency and intensity of these extreme weather events will continue to rise in future. The cities are expanding by reducing the natural vegetation and encroaching on the natural water bodies. Under such dire circumstances, extreme rainfall events lead to increased runoff and cities get inundated. Although mitigation efforts from the Indian government receive greater attention, extreme weather events are inevitable. Therefore, the cities should have strong climate change adaptation strategies to overcome these issues.

Some extreme flooding events across various states in India are highlighted with economic and human losses. Further, the flood-vulnerable district hotspots are presented, and the crucial indicators to evaluate the flood vulnerability are compiled. This study has shown that mitigation and adaptation are two pillars in the fight against climate change. Although there are significant differences in their functionality and impact, they act together against climate change, and their benefits/consequences are deeply interlocked.

However, the multi-dimensionality of climate impacts makes it vital that India adopts an interdisciplinary approach, breaks traditional ministerial boundaries, and learns rapidly from the ongoing warming effects and our successes and failures in dealing with it them. Efforts should be made to mainstream adaptation strategies into sustainable planning processes to increase the effectiveness of reducing climate change impacts.

References

1. 'Goal 13: Take urgent action to combat climate change and its impacts' (United Nations Sustainable Development Goals) <http://www.un.org/sustainabledevelopment/climate-change-2/> accessed 18 November 2016.

2. Anon 1996, Climate Change 1995: Adaptation and Mitigation of climate change - Scientific Technica Analysis, Cambridge University Press, Cambridge, pp 21-24.

3. United Nations Framework Convention on Climate Change 1992, art 1.

4. 'Report of the Office of the United Nations High Commissioner for Human Rights on the relationship between climate change and human rights' (Human Rights Council, 15 January 2009) <https://documents ddsny.un.org/doc/UNDOC/GEN/G09/103/44/PDF/G0910344.pdf?OpenElement> p. 2 accessed 18 November 2016.

5. Shibani Ghosh, Demystifying the Environmental Clearance Process in India (2013) 6 (3) NUJS Law Review 433, 433.

6. 'Climate Change: Impacts, Vulnerabilities and Adaption in Developing Countries' (United Nations Framework Convention on Climate Change, 2007) <https://unfccc.int/resource/docs/publications/impacts.pdf> p. 5 accessed 18 November 2016.

7. Autri Saha and Karan Talwar, India's Response to Climate Change: The 2009 Copenhagen Summit and Beyond (2010) 3 NUJS Law Review 159, 160. See also, ibid 8.

8. 'Climate Change: Impacts, Vulnerabilities and Adaption in Developing Countries' (n 9) 20.

9. https://unfccc.int/sites/default/files/resource/INDIA_%20BUR3_20.02.2021_High.pdf, pg 42

10. Shreerupa Mitra Jha, 'Natural disasters cost India $3.30bn in 2015: Here's why we should be very worried' (Firstpost, 2016) <http://www.firstpost.com/india/natural-disasters-cost-india-3-30bn-in-2015-heres-why-weshould-be-very-worried-2622940.html> accessed 18 November 2016.

11. 'Warming Climate in India to Pose Significant Risk to Agriculture, Water Resources, Health, says World Bank Report' (The World Bank, 19 June 2013) <http://www.worldbank.org/en/news/pressrelease/2013/06/19/warming-climate-india-pose-significant-risk-agriculture-water-resources-health-says-worldbank-report> accessed 19 November 2016.

12. ibid. - "Possible Impacts for India: 1. An extreme wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. 2. Kolkata and Mumbai are 'potential impact hotspots' threatened by extreme river floods, more intense tropical cyclones, rising sea levels and very high temperatures. 3. Significant reduction in crop yields predicted. Some 63 million people may no longer be able to meet their caloric demand. 4. Decreasing food availability can also lead to significant health problems. 5. Substantial reduction in the flow of the Indus and Brahmaputra in late spring and summer."

13. https://climate.nasa.gov/solutions/adaptation-mitigation

14. IPCC, 2001a: Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, R.T.Watson and the Core Team, Eds., Cambridge University Press, Cambridge and New York, 398 pp.

15. Laukkonen, J., P. K. Blanco, J. Lenhart, M. Keiner, B. Cavric, and C. Kinuthia-Njenga. 2009. "Combining Climate Change Adaptation and

Mitigation Measures at the Local Level." Habitat International 33 (3): 287–292. doi:10.1016/j.habitatint.2008.10.003.

16. Alexander KA et al., "Climate change is likely to worsen the public health threat of diarrheal disease in Botswana", Int. J. Environ. Res. Public Health,10(2013): 1202, http://www.ncbi.nlm.nih.gov/ PubMed/23531489.

17. Intergovernmental Panel on Climate Change (IPCC), in: C.B. Field, 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, et al. (Eds.), 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, Cambridge University Press, Cambridge, UK; New York, NY, USA, 2014.

18. D. Eckstein, V. Kunzel, L. Sch€afer, Global Climate Risk Index 2018, 2017, p. 36. Bonn, German watch e. V., Germany, http://germanwatch.org/sites/germanwatch.org/files/publication/20432.pdf.

19. NAPCC, National Action Plan on Climate Change, 2008. www.mma.gob.cl/1304 /w3-article-49744.html.

20. Rao, N.D., Riahi K., & Grubler, A. (2014). Climate impacts of poverty eradication. Nature Climate Change. 4, 749–751 doi:10.1038/climate 2340.

21. Singh (2022). Causes, impacts, risk and mitigation of Urban Flood Management in India – Compendium report. International Centre for Environment Audit and Sustainable Development (iCED). Available at: http://iced.cag.gov.in/wpcontent/uploads/Urban%20Flood%20Management%20in%20Inda.pdf.

22. Saha and Talwar (n 10) 187, 188; Kasturi Das and Kaushik Bandyopadhyay, Climate Change Adaptation in the Framework of Regional Cooperation in South Asia (2015) 1 CCLR 40, 50.

23. M Lal 1999, Changes, Vulnerability and Impacts: Indian sub-continent, Indian Institute of Technology, New Delhi, mimeo.

24. Climate Change and India - Some Major Issues and Policy Implications, March 2009 Department of Economic Affairs, Ministry of Finance, Government of India.

