Article

Environmental and socio-economic impacts of global climate change: An overview on mitigation approaches

Prabhat Kumar Rai[1], **Prashant Kumar Rai**[2]

[1]Department of Forest Ecology, Biodiversity, and Environmental Sciences, School of Earth Sciences and Natural Resource Management, Mizoram Central University, Gram MZU, Tanhril, Aizawl, 796009, India

[2]Law School, Banaras Hindu University, Varanasi, India

E-mail: prabhatrai24@gmail.com

Received 17 March 2013; *Accepted 7 May 2013*; *Published online 1 December 2013*

Abstract

Climate change is expected to bring about major change in freshwater availability, the productive capacity of soils, and in patterns of human settlement. Likewise, climate change is intimately linked to human health either directly or indirectly. However, considerable uncertainties exist with regard to the extent and geographical distribution of these changes. Predicting scenarios for how climate-related environmental change may influence human societies and political systems necessarily involves an even higher degree of uncertainty. Societies have a long record of adapting to climate risks and, climate changes. Household asset portfolios and livelihood choices are shaped by the need to manage climatic risks, especially in rural areas and for low-income households. Likewise, disaggregated analysis revealed that demographic and environmental variables have a very profound effect on the risk of civil conflict and hence peace. In nutshell, we can say that there may be multifaceted impact of climate change in its totality. Further, different views, issues and mitigation measures are discussed particularly in Indian scenario. In this direction, The "National Action Plan on Climate Change" was set by Indian Prime Minister which encompasses a broad and extensive range of measures, and focuses on eight missions, which will be pursued as key components of the strategy for sustainable development. These include missions on solar energy, enhanced energy efficiency, sustainable habitat, conserving water, sustaining the Himalayan ecosystem, creating a "Green India," sustainable agriculture and, finally, establishing a strategic knowledge platform for climate change. Finally, different steps/approaches pertaining to green, eco-friendly and sustainable technology has been discussed in order to mitigate the impact of global environmental damage originating from increased industrialization and hence appropriately address this global disaster which is being the root cause of North-South debate and global environmental politics.

Keywords climate change; green house gases; Kyoto Protocol; civil conflict; sustainable; green technology.

Environmental Skeptics and Critics
ISSN 2224-4263
URL: http://www.iaees.org/publications/journals/environsc/online-version.asp
RSS: http://www.iaees.org/publications/journals/environsc/rss.xml
E-mail: environsc@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Global climate change is of prime concern at global scale in present era of science of technology (Zhang and Liu, 2012). In the present era of Science and Technology, due to the rapid pace of industrialization and urbanization, quantity of natural resources as well as quality of global environment has been altered seriously (Rai, 2008a; Rai, 2008b; Rai and Tripathi, 2009). According to Environmental Protection Agency-USA, (US-EPA), with increasing population, more and more countries are facing the problem of global environmental change originating from large expansion of industrial sector. Hand in hand, population growth will cause a rapid increase in number of industries preparing agro-chemical to sustain agriculture as well as will uplift the industrial demand for resources.

Economic globalization constitutes integration of national economies into the international economy through trade, direct foreign investment (by corporations and multinationals), short-term capital flows, international flows of workers and humanity generally, and flows of technology: phenomena defined and treated more fully below. Economic globalization is the favoured target of many of the critics of globalization. It is distinct from other aspects of globalization, such as cultural globalization (which is affected by economic globalization) and communications (which is among the factors that cause the deepening of economic globalization).

Aforesaid factors resulted in global environmental change. If the views of the Intergovernmental Panel on Climate Change (IPCC) are an accurate gauge of world scientific opinion, then the majority of scientists believe that anthropogenic global warming has either already begun or will become manifest in the very near future, with average global temperatures predicted to rise by 1.5-4.5°C by the middle of next century (IPCC, 1990). Despite an incomplete understanding of the processes at work, there is considerable agreement that this warming will be the result of increased releases and atmospheric accumulation, since the industrial revolution, of carbon dioxide (CO_2), nitrous oxide (N_20), methane (CH_4) and chlorofluorocarbons (CFCs) the primary greenhouse gases (GHGs). Anticipation in some quarters of a host of negative consequences of such warming has led to ever louder calls to initiate strong policy actions to curtail GHG emissions (Wirth and Lashof, 1990).

2 Climate Change and Its Impact

Recent evidence and predictions indicate that climate changes are accelerating and will lead to wide-ranging shifts in climate variables. There will be changes in the mean and variance of rainfall and temperature, extreme weather events, food and agriculture production and prices, water availability and access, nutrition and health status. The most adverse impacts are predicted in the developing world because of geographic exposure, reliance on climate sensitive sectors, low incomes, and weak adaptive capacity. Socio-economic impacts, though generally not well understood, are likely to be profound and will impact humans through a variety of direct and indirect pathways (Stern, 2006; IPCC, 2007; Cline, 2007; Tyler, 2010; Zhang and Liu, 2012). Climate events can result in irreversible losses of human and physical capital and may cause poverty traps.

Environmental change as a cause of violent conflict has been a contentious issue in the security discourse of the 1990s. While the concerns over the security implications of population growth and resource scarcity goes back to the late 1960s, the issue has featured more prominently in the security debate after the end of the Cold War.

The experience with managing current climatic variability does not bode well for what may happen as climate changes increase climatic variability and climatic extremes. In many parts of Africa and elsewhere, variability in rainfall and temperatures already cause variability in agricultural production and food security (Molua, 2002). Studies of the costs to poor people of coping with the climate extremes of floods, droughts, and storms make clear the enormous costs and difficulty and the limited success (Kates, 2000). Natural disasters

caused by climate extremes repeatedly wipe out the gains from development, destroying lives and livelihoods. Famines, as pointed out by Sen (1981), are manmade disasters that result from climatic risks and human failures to respond to the resulting declines in food production.

Observed responses to climate change are found across a wide range of systems as well as regions. Changes related to regional warming have been documented primarily in terrestrial biological systems, the cryosphere and hydrologic systems; significant changes related to warming have also been studied in coastal processes, marine and freshwater biological systems, and agriculture and forestry (Matthews et al., 2011; Wilby and Keenan, 2012). Climate change has adversely affected the hydrology of Indian river basins (Gosain et al., 2006)

Climate change is intimately linked with human health (Ebi and Semenza, 2008; Gage et al., 2008; Hess et al., 2008; Keim, 2008; Kinney, 2008). The World Health Organisation estimates that the warming and precipitation trends due to anthropogenic climate change of the past 30 years already claim over 150,000 lives annually. Many prevalent human diseases are linked to climate fluctuations, from cardiovascular mortality and respiratory illnesses due to heat waves, to altered transmission of infectious diseases and malnutrition from crop failures.

The most vulnerable households are those with assets and livelihoods exposed and sensitive to climatic risks and who have weak risk management capacity. While all households are exposed to risks associated with climate change and could potentially be rendered vulnerable, the poorer households are the most at risk. This is because their assets and livelihoods tend to be highly exposed and sensitive to the direct and indirect risks associated with climate change, and because they lack access to formal and informal risk management arrangements. People that depend on agriculture (especially rainfed), livestock, and fisheries would be at risk. Within households, impacts will sometimes fall disproportionately on vulnerable individuals such as children, women, elderly, and disabled. Improved management of climatic variability becomes all the more important as climate changes lower the returns to assets and livelihoods and increases volatility.

Global surface temperature increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 100 years ending in 2005. The Intergovernmental Panel on Climate Change (IPCC) concludes that most of the temperature increase since the mid-twentieth century is "very likely" due to the increase in anthropogenic greenhouse gas concentrations (Table 1). Singh (2005) also discussed the impact of climate change by mentioning the report of Oslo situated Centre for International and Environmental Research (Rahish Singh, 2005).

Natural phenomena such as solar variation and volcanoes probably had a small warming effect from pre-industrial times to 1950 and a small cooling effect from 1950 onward. These basic conclusions have been endorsed by at least 30 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries. While individual scientists have voiced disagreement with these findings, the overwhelming majority of scientists working on climate change agree with the IPCC's main conclusions.

Societies have a long record of adapting to climate risks and, climate changes. Household asset portfolios and livelihood choices are shaped by the need to manage climatic risks, especially in rural areas and for low-income households. Even so, climate events continue to bring devastation.

Table 1 Annual green house gas emission by sector.

Sector	GHG gases (%)	CO2 (%)	Methane (%)
Power Stations	21.3	29.5	-
Industrial Processes	16.8	20.6	-
Transportation fuels	14.4	19.2	-
Agricultural bi-products	12.5	-	40
Fossil fuel retrieval, processing and distribution	11.3	8.4	29.6
Residential, commercial and other sources	10.3	12.9	4.8
Land use and bio-mass burning	10.0	9.4	6.6
Waste disposal and treatment	3.4	-	18.1

Source: IPCC Report.

Climate model projections indicate that global surface temperature will likely rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the twenty-first century. The uncertainty in this estimate arises from use of differing estimates of future greenhouse gas emissions and from use of models with differing climate sensitivity. Another uncertainty is how warming and related changes will vary from region to region around the globe. Although most studies focus on the period up to 2100, warming is expected to continue for more than a thousand years even if greenhouse gas levels are stabilized. This results from the large heat capacity of the oceans.

Increasing global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, likely including an expanse of the subtropical desert regions. Other likely effects include increases in the intensity of extreme weather events, changes in agricultural yields, modifications of trade routes, glacier retreat, species extinctions and increases in the ranges of disease vectors.

3 Regulation of Global Environmental Change

3.1 The politics of climate change and the Kyoto Protocol

Most national governments have signed and ratified the Kyoto Protocol aimed at reducing greenhouse gas emissions. Political and public debate continues regarding what, if any, action should be taken to reduce or reverse future warming or to adapt to its expected consequences.

The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro, Brazil, from 3–14 June 1992. The treaty is intended to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The Kyoto Protocol establishes legally binding commitments for the reduction of four greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride), and two groups of gases (hydro-fluorocarbons and perfluoro-carbons) produced by "Annex I" (industrialized) nations, as well as general commitments for all member countries. As of 2008, 183 parties have ratified the protocol, which was initially adopted for use on 11 December 1997 in Kyoto, Japan and which entered into force on 16 February 2005. Under Kyoto, industrialized countries agreed to reduce their collective GHG emissions by 5.2% compared to the year 1990.

National limitations range from 8% reductions for the European Union and some others to 7% for the United States, 6% for Japan, and 0% for Russia. The treaty permitted GHG emission increases of 8% for Australia and 10% for Iceland (Nature reports climate change, 2007).

Kyoto includes defined "flexible mechanisms" such as Emissions Trading, the Clean Development Mechanism and Joint Implementation to allow Annex I economies to meet their greenhouse gas (GHG) emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges, projects that reduce emissions in non-Annex I economies, from other Annex I countries, or from Annex I countries with excess allowances. In practice this means that Non-Annex I economies have no GHG emission restrictions, but have financial incentives to develop GHG emission reduction projects to receive "carbon credits" that can then be sold to Annex I buyers, encouraging sustainable development. In addition, the flexible mechanisms allow Annex I nations with efficient, low GHG-emitting industries, and high prevailing environmental standards to purchase carbon credits on the world market instead of reducing greenhouse gas emissions domestically. Annex I entities typically will want to acquire carbon credits as cheaply as possible, while Non-Annex I entities want to maximize the value of carbon credits generated from their domestic Greenhouse Gas Projects.

Among the Annex I signatories, all nations have established Designated National Authorities to manage their greenhouse gas portfolios; countries including Japan, Canada, Italy, the Netherlands, Germany, France, Spain and others are actively promoting government carbon funds, supporting multilateral carbon funds intent on purchasing Carbon Credits from Non-Annex I countries, and are working closely with their major utility, energy, oil and gas and chemicals conglomerates to acquire Greenhouse Gas Certificates as cheaply as possible. Virtually all of the non-Annex I countries have also established Designated National Authorities to manage the Kyoto process, specifically the "CDM process" that determines which GHG Projects they wish to propose for accreditation by the CDM Executive Board.

3.2 Objectives of protocol

Kyoto is intended to cut global emissions of greenhouse gases. The objective is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The Intergovernmental Panel on Climate Change (IPCC) has predicted an average global rise in temperature of 1.4°C (2.5°F) to 5.8°C (10.4°F) between 1990 and 2100.

Proponents also note that Kyoto is a first step as requirements to meet the UNFCCC will be modified until the objective is met, as required by UNFCCC Article 4.2(d).

The treaty was negotiated in Kyoto, Japan in December 1997, opened for signature on 16 March 1998, and closed on 15 March 1999. The agreement came into force on 16 February 2005 following ratification by Russia on 18 November 2004. As of May 2008, a total of 181 countries and 1 regional economic integration organization (the EEC) have ratified the agreement (representing over 61.6% of emissions from Annex I countries).

According to article 25 of the protocol, it enters into force "on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55% of the total carbon dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession." Of the two conditions, the "55 parties" clause was reached on 23 May 2002 when Iceland ratified. The ratification by Russia on 18 November 2004 satisfied the "55%" clause and brought the treaty into force, effective 16 February 2005. Australian Prime Minister Kevin Rudd ratified the Kyoto protocol on 3 December 2007. This came into effect after 90 days (the end of March 2008), as is stated in the guidelines set by the United Nations.

The five principal concepts of the Kyoto Protocol are as follows:

- *Commitments*: The heart of the Protocol lies in establishing commitments for the reduction of greenhouse gases that are legally binding for Annex I countries, as well as general commitments for all member countries.
- *Implementation*: In order to meet the objectives of the Protocol, Annex I countries are required to prepare policies and measures for the reduction of greenhouse gases in their respective countries. In addition, they are required to increase the absorption of these gases and utilize all mechanisms available, such as joint implementation, the clean development mechanism and emissions trading, in order to be rewarded with credits that would allow more greenhouse gas emissions at home.
- Minimizing Impacts on Developing Countries by establishing an adaptation fund for climate change.
- Accounting, Reporting and Review in order to ensure the integrity of the Protocol.
- Compliance. Establishing a Compliance Committee to enforce compliance with the commitments under the Protocol.

3.3 Common but differentiated responsibility

The United Nations Framework Convention on Climate Change agreed to a set of a "common but differentiated responsibilities." The parties agreed that:

1. The largest share of historical and current global emissions of greenhouse gases has originated in developed countries;
2. Per capita emissions in developing countries are still relatively low, and
3. The share of global emissions originating in developing countries will grow to meet their social and development needs.

In other words, China, India, and other developing countries were not included in any numerical limitation of the Kyoto Protocol because they were not the main contributors to the greenhouse gas emissions during the pre-treaty industrialization period. However, even without the commitment to reduce according to the Kyoto target, developing countries do share the common responsibility that all countries have in reducing emissions. There will be a mechanism of "compliance", which means a "monitoring compliance with the commitments and penalties for non compliance."

3.4 Financial commitments

The Protocol also reaffirms the principle that developed countries have to pay billions of dollars, and supply technology to other countries for climate-related studies and projects. This was originally agreed in the UNFCCC.

3.5 Emissions trading

Kyoto is a 'cap and trade' system that imposes national caps on the emissions of Annex I countries. On average, this cap requires countries to reduce their emissions 5.2% below their 1990 baseline over the 2008 to 2012 period. Although these caps are national-level commitments, in practice most countries will devolve their emissions targets to individual industrial entities, such as a power plant or paper factory. One example of a 'cap and trade' system is the 'EU ETS'. Other schemes may follow suit in time.

This means that the ultimate buyers of credits are often individual companies that expect their emissions to exceed their quota (their Assigned Allocation Units, AAUs or 'allowances' for short). Typically, they will purchase credits directly from another party with excess allowances, from a broker, from a JI/CDM developer, or on an exchange.

National governments, some of whom may not have devolved responsibility for meeting Kyoto obligations to industry, and that have a net deficit of allowances, will buy credits for their own account, mainly from JI/CDM developers. These deals are occasionally done directly through a national fund or agency, as in the

case of the Dutch government's ERUPT programme, or via collective funds such as the World Bank's Prototype Carbon Fund (PCF). The PCF, for example, represents a consortium of six governments and 17 major utility and energy companies on whose behalf it purchases credits.

Since allowances and carbon credits are tradable instruments with a transparent price, financial investors can buy them on the spot market for speculation purposes, or link them to futures contracts. A high volume of trading in this secondary market helps price discovery and liquidity, and in this way helps to keep down costs and set a clear price signal in CO_2 which helps businesses to plan investments. This market has grown substantially, with banks, brokers, funds, arbitrageurs and private traders now participating in a market valued at about $60 billion in 2007. Emissions Trading PLC, for example, was floated on the London Stock Exchange's AIM market in 2005 with the specific remit of investing in emissions instruments.

Although Kyoto created a framework and a set of rules for a global carbon market, there are in practice several distinct schemes or markets in operation today, with varying degrees of linkages among them.
Kyoto enables a group of several Annex I countries to join together to create a market-within-a-market. The EU elected to be treated as such a group, and created the EU Emissions Trading Scheme (ETS). The EU ETS uses EAUs (EU Allowance Units), each equivalent to a Kyoto AAU. The scheme went into operation on 1 January 2005, although a forward market has existed since 2003.

The UK established its own learning-by-doing voluntary scheme, the UK ETS, which ran from 2002 through 2006. This market existed alongside the EU's scheme, and participants in the UK scheme have the option of applying to opt out of the first phase of the EU ETS, which lasts through 2007.

The sources of Kyoto credits are the Clean Development Mechanism (CDM) and Joint Implementation (JI) projects. The CDM allows the creation of new carbon credits by developing emission reduction projects in Non-Annex I countries, while JI allows project-specific credits to be converted from existing credits within Annex I countries. CDM projects produce Certified Emission Reductions (CERs), and JI projects produce Emission Reduction Units (ERUs), each equivalent to one AAU. Kyoto CERs are also accepted for meeting EU ETS obligations and ERUs will become similarly valid from 2008 for meeting ETS obligations (although individual countries may choose to limit the number and source of CER/JIs they will allow for compliance purposes starting from 2008). CERs/ERUs are overwhelmingly bought from project developers by funds or individual entities, rather than being exchange-traded like allowances.

Since the creation of Kyoto instruments is subject to a lengthy process of registration and certification by the UNFCCC, and the projects themselves require several years to develop, this market is at this point largely a forward market where purchases are made at a discount to their equivalent currency, the EUA, and are almost always subject to certification and delivery (although up-front payments are sometimes made). According to IETA, the market value of CDM/JI credits transacted in 2004 was EUR 245 m; it is estimated that more than EUR 620 m worth of credits were transacted in 2005.

Several non-Kyoto carbon markets are in existence or being planned, and these are likely to grow in importance and numbers in the coming years. These include the New South Wales Greenhouse Gas Abatement Scheme, the Regional Greenhouse Gas Initiative and Western Climate Initiative in the United States, the Chicago Climate Exchange and the State of California's recent initiative to reduce emissions.

These initiatives, taken together may create a series of partly-linked markets, rather than a single carbon market. The common theme across most of them is the adoption of market-based mechanisms centered on carbon credits that represent a reduction of CO_2 emissions. The fact that some of these initiatives have similar approaches to certifying their credits make it conceivable that carbon credits in one market may in the long run be tradeable in other schemes. This would broaden the current carbon market far more than the current focus on the CDM/JI and EU ETS domains. An obvious precondition, however, is a realignment of penalties and

fines to similar levels, since these create an effective ceiling for each market.

3.6 Revisions

The protocol left several issues opens to be decided later by the sixth Conference of Parties (COP). COP6 attempted to resolve these issues at its meeting in the Hague in late 2000, but was unable to reach an agreement due to disputes between the European Union on the one hand (which favoured a tougher agreement) and the United States, Canada, Japan and Australia on the other (which wanted the agreement to be less demanding and more flexible).

In 2001, a continuation of the previous meeting (COP6bis) was held in Bonn where the required decisions were adopted. After some concessions, the supporters of the protocol (led by the European Union) managed to get Japan and Russia in as well by allowing more use of carbon dioxide sinks.

COP7 was held from 29 October 2001 through 9 November 2001 in Marrakech to establish the final details of the protocol.

The first Meeting of the Parties to the Kyoto Protocol (MOP1) was held in Montreal from 28 November to 9 December 2005, along with the 11th conference of the Parties to the UNFCCC (COP11). See United Nations Climate Change Conference.

The 3 December 2007, Australia ratified the protocol during the first day of the COP13 in Bali.

Of the signatories, 36 developed C.G. countries (plus the EU as a party in the European Union)agreed to a 10% emissions increase for Iceland; but, since the EU's member states each have individual obligations, much larger increases (up to 27%) are allowed for some of the less developed EU countries (see below #Increase in greenhouse gas emission since 1990). Reduction limitations expire in 2013.

3.7 Enforcement

If the Enforcement Branch determines that an Annex I country is not in compliance with its emissions limitation, then that country is required to make up the difference plus an additional 30%. In addition, that country will be suspended from making transfers under an emissions trading program.

4 Issues & Mitigating Steps of Climate Change: Indian Perspective on Legal as well as Related Polities

'More and more people now believe climate change to be a result of human activities'

Global warming and climate change are the most written-about topics in the journals, newspapers and magazines in the last few years. It paved the way to researches to mitigate the impact of global climate change worldwide (Desai, 2012; Zhang and Liu, 2012). The importance of this phenomenon was highlighted when Nobel Prize for peace was awarded jointly to Al Gore and R K Pachauri, Chairman of the Inter Governmental Panel on Climate Change (IPCC) in the year 2007. In Indian scenario, the Prime Minister, Dr Manmohan Singh, and leaders of four other emerging economies, China, Brazil, Mexico and South Africa, took the offensive in the debate on climate change asking the developed world first to make significant cuts in greenhouse gas emissions (K. Venugopal , 2007).

Recently, in India, Dr. Manmohan Singh unveiled action plan on climate change i.e. 'National Action Plan on Climate Change' here, ahead of the G-8 Summit to be held in Japan. The National Action Plan encompasses a broad and extensive range of measures, and focuses on eight missions, which will be pursued as key components of the strategy for sustainable development. These include missions on solar energy, enhanced energy efficiency, sustainable habitat, conserving water, sustaining the Himalayan ecosystem, creating a "Green India," sustainable agriculture and, finally, establishing a strategic knowledge platform for climate change.

The mission for sustaining the Himalayan ecosystem will include measures for sustaining and safeguarding the Himalayan glacier and mountain ecosystem as it is the source of key perennial rivers. The Green India

mission will enhance ecosystem services including carbon sinks, to be called Green India. The sustainable agriculture mission intends making agriculture more resilient to climate change by identifying and developing new varieties of crops that are thermal-resistant and capable of withstanding extreme weather.
The mission on strategic knowledge will identify challenges and develop responses to climate change. The solar mission will be launched to significantly increase the share of solar power in the total energy mix while recognising the need for expanding the scope of other renewable and non-fossil options such as nuclear energy, wind energy and biomass.

Under the national mission for enhanced energy efficiency, four new initiatives including a market-based mechanism to improve the cost-effectiveness of improvements will be put in place. With solid waste proving a major challenge, the action plan stresses recycling material and urban waste management, and developing technology to produce power from waste. The mission on sustainable habitats will include a major research and development programme, focussing on biochemical conversion, waste water use, sewage utilisation and recycling options wherever possible. The water mission will develop a framework to optimise water use through regulatory mechanisms.

Dr. Singh said further that "India is prepared to play its role as a responsible member of the international community and make its own contribution. We are already doing so in the multilateral negotiations taking place under the United Nations Framework Convention on Climate Change (UNFCCC) and the outcome we are looking for must be effective, fair and equitable,". Further, he added that every citizen on the planet must have an equal share of the planetary atmospheric space. Long-term convergence of per capita emission was, therefore, the only equitable basis for a global compact on climate change. Pointing out the need for rapid economic growth to overcome widespread poverty in the country, the Prime Minister said ecologically sustainable development need not be at odds with achieving the growth objectives. "In fact, we must have a broader perspective on development. It must include the quality of life, not merely the quantitative accretion of goods and services but a better standard of living." (Aarti Dhar, The Hindu, 2008).

Before this India has criticised the U.S. for voicing concerns over the provisions of the deal fixing a 2009 deadline for signing a new treaty to tackle global warming. Science and Technology Minister and leader of the Indian delegation to the Bali conference on climate change, Kapil Sibal, made this known to *The Hindu (17 December 2007).*

Similarly, Union Water Resources Minister Saifuddin Soz recently called for immediate action to make a realistic assessment of climate change on water resources. "The effect of climate change on water is bound to have an impact on agriculture, ecology, as well as on health-related issues", he said while addressing "Kshitij 2008," an annual techno-management festival organised at the Indian Institute of Technology, Kharagpur.

5 There Are Different Reports on Impact of Climate Change in India

Rising temperature is changing the climate and the lives of the people in the villages of Tehri Garhwal (Dionne Bunsha, 2007, Frontline). In Jardhargaon, a village on the slopes of the Tehri Garhwal Himalayas (1,500 metres), the rising temperatures are changing the climate and the lives of people who live off the land.

6 Class Injustice in Climate Change Policies

R. Ramachandran added that "Rich Indians are eating into the carbon space the poor need for economic growth, and recent national policies have helped such disparities grow".

"Hiding behind the Poor", a recent report by Greenpeace India, provides a quantitative perspective to this internal "climate injustice". Even such a quantitative perspective is not new. In 1997, N.S. Murthy and associates from the Indira Gandhi Institute of Development Research (IGIDR), Mumbai, highlighted the high

degree of distortion in energy consumption prevalent in the country. Using 1989-90 data, they showed that the richest top 10 per cent of urban people emitted 12 times as much carbon a person a year as the bottom poor. They showed that the extreme disparity ratio (EDR), defined as the ratio of the energy (direct and indirect) consumed by the urban top and the rural bottom, was 10.3 for coal, 14.8 for oil and 9.0 for electricity and 12 in terms of the total carbon equivalent. The Greenpeace report only serves as a reminder – if one was required – that it is high time the government put in place appropriate policy measures to reverse this trend, which has been allowed to continue unbridled.

7 Strategies to Combat Global Environmental Change

The "Bali Road Map" for the future fight against climate change in the period after 2012, when the first commitment period of the Kyoto protocol ends, has an agenda for the developing countries also to adapt to the impact of climate change. As has been rightly emphasised by environmentalist Mr R.K. Pachauri, who heads the Nobel Prize-winning Inter-Governmental Panel on Climate Change, India has to gear itself for a path of development that is sustainable and get ready for a low-carbon society. Developing countries, seeing the writing on the wall, have agreed to take action to mitigate climate change, though they have not been mandated to do so under the UN Framework convention on climate change. India, which has played a major role through an amendment for the road-map, has the added responsibility to ensure that it emerges a winner in a scenario of low-carbon society through innovative strategy for energy alternatives.

Reduction of greenhouse gas emissions is an accepted goal with a definite commitment from industrialised countries to cut the emissions by 5 per cent below 1990 levels. Attempts are afoot to replace the fossil fuels in the transport sector, which is considered to be a major culprit in this regard.

Hydrogen as an energy source has found favour with many countries, ostensibly for the advantages it offers.

It is environmentally clean, particularly in transport applications, as it does not release greenhouse gases at the end-use. Transition to hydrogen economy is much easier, as production is possible through a variety of processes such as thermal, photolysis, biochemical routes to name only a few. It can be stored in all the three states of matter, namely gas, liquid and solid. Its distribution is also easily possible.

Developing countries are normally taken in by the euphoria generated by the industrialised West and try to imitate the technology adopted by them unmindful of the differing conditions and environment. There is also a tendency to accept their conclusions without subjecting them to rigorous proof. There is a belief that hydrogen being the most abundant element in the nature should be exploited and transition to hydrogen-based fuel cell as the west, could be a solution for sustainable energy economy even for countries such as India. The proponents overlook the fact that even after three decades of research (the hydrogen movement started in 1974), the hydrogen option has not made the kind of impact that was expected to. For a secured energy future we have to look for a new energy source.

It is also important to note that production, packaging, storage, transfer and delivery of hydrogen are energy guzzlers. Is there an alternative to hydrogen economy?

Hydrogen or methanol as alternative energy source to mitigate climate change concerns has not made the impact expected and with the rising energy demand, it is vital to find cost-effective options. Methanol alternative recent developments in this regard point to the emergence of a methanol economy. Prof George A Olah, a Nobel laureate, proposed this concept as an alternative in 2005. The supporters of methanol economy claim that methanol can be directly used as a fuel and can be produced in a greenhouse-neutral process.

Methanol which has higher hydrogen content per litre than liquid hydrogen can be blended with gasoline. Yet another positive aspect is that methanol can be distributed through the existing gasoline infrastructure.

In a country such as India where even switchover to LNG for vehicles is beset with numerous distribution problems, the cost of infrastructure required for hydrogen distribution will be prohibitively high and cannot be ignored.

Methanol too has its limitations. Synthesis of methanol is not a clean process and requires carbon monoxide and hydrogen which are presently produced from fossil fuels. Methanol's corrosive action on some metals can have adverse effects. It can even cause contamination to the groundwater.

A road map for energy conversion no doubt has to take into account energy efficiency and environmental impact, more so because of the global awareness on the impact of climate change.

But any changeover should not only be easy to implement, but also capable of being sustained over a period by the economy.

We are in a market economy driven by profit motive and expensive energy options are likely to be discarded in favour of better ones.

As the demand for fuel from the expanding transport sector, is likely to shoot up with the projected 9-10 per cent growth of the economy, there is an imperative need to look for better alternatives which can be smoothly implemented.

A roadmap for the introduction of the most appropriate alternative based on a critical and careful analysis is a must and thus a priority research area for the country (Vijayalakshmi Viswanathan, 2007, Business Line). Further, B S Bhavanishankar, 2007 in The Hindu mentioned that: "*India must put in place water management plans to counter climate change*".

Sewerage generation from habitation in rural as well as urban areas should be reduced to the least by adopting zero water toilets for which technologies are available. Wastage of water must be prevented at all cost at both individual and community level. There must also be ways of recycling waste water. Efficiency in agriculture (which uses nearly 80 per cent of water for irrigation), that is currently at 30 per cent, should be gradually increased to 60 per cent, so that a large amount of water could be made available for municipal and industrial requirements. Water literacy should be introduced at primary and university levels to create awareness about water conservation. Integrated water resource management should be adopted in right earnest at all levels in various sectors where water is used. This should be done by all stake holders, including the governments and corporate agencies. These measures coupled with the measures taken by countries around the world to counter climate change, that involves all the stakeholders, are important to ensure sustainability of water and are necessary to take on the challenges posed by climate change.

Appropriate change in policies and practices relevant to electricity industry alone can go a long way in reducing the total GHG emission of the country. What is required is a paradigm shift in our energy policy (Shankar Sharma).

Further, climate change originating from rapid industrialization and globalization is a matter of serious concern. The member of British Antarctic Survey Dr. John Turner mentioned in his research paper that temperature of Antarctica is increasing day by day which is an alarming signal for global climate and environment (Anonymous, 2006).

N. Gopal Raj (2007) alarmed that melting of glaciers which feed important rivers such as the Ganga, the Indus, and the Brahmaputra that provide water for millions of people as well as for irrigation and industry. The accelerated melting of these glaciers are experiencing as a result of the earth's warming will have profound effect on future water availability. A sharp rise in sea level could have a considerable impact as about a quarter of the population lives within 50 km of the coastline. Further, balancing greenhouse gas emissions and economic growth is another worry. Similarly, changes in temperature and rainfall associated with global warming could result in about 80% of the existing forests in the country undergoing a change in the vegetation

type, according to R. Sukumar, an environmental Scientist at Indian Institute of Science. Such changes were bound to have a very significant impact on the forests and wildlife they supported (N. Gopal Raj, 2007).

Similarly, coral reefs which are considered to be the rain forests of oceans and ecologically play an important role have declined particularly one recent report in *Science* stated that there was a 14% drop in coral growth of Great Barrier Reef from 1990-2005 due to effect of global warming (R. Prasad 2009. The Hindu dt. 7-1-09)

William D. Dar, President of ICRISAT, Andhra Pradesh emphasized that a combined effort to deal with climate uncertainty, land degradation and water scarcity is needed. Further, he emphasized that dry-land farmers will be severely affected with the process of climate change. Similarly, in its recent report entitled *"Climate Change and Food Security in Pacific Island Countries"* Food and Agricultural Organization (FAO) reported that climate change may threaten the food security (The Hindu dt. 2-12-08)

Based on scale, magnitude, and irreversible, global climate change constitutes a critical security issue. There is a need for action by all and a need for action now. Delay in acting on climate change now will mean that the costs of addressing it later, according to stern report, will be significantly greater. The technical challenges will also mount with growing complexity. An intermediate grouping between the G8 and the U.N., which includes China and India, is best suited to deal with the challenges of climate change and energy security (Thakur and Bradford, 2007).

United Nations Industrial Development Organisation (UNIDO) made an alarming note that climate change will impact India more due to heavy dependence on fossil fuel and it will cause severe health hazards particularly more spread of vector borne diseases as well as shortage of fresh water will aggravate. UNIDO also predicted that green house emission will soar if India sustains 8% growth rate (The Hindu: Climate change will imact India more says UNIDO dt. 4-09-08).

Prior to this India should maintain sustainability in energy, industrial and environmental law sector to address the challenge of industrialization, urbanization and climate change.

Srinivasan (2007), who is former chairman and presently a member of Atomic Energy Commission, mentioned that there are many initiatives that India can take to reduce carbon emission without sacrificing its priority of economic development.

1. All new coal generators should use super-critical boilers in the size range of about 800 MW, which can achieve an efficiency of about 40%.
2. A further gain in efficiency is possible when the integrated coal gasification technology is available.
3. India should collaborate with foreign countries in removal of carbon dioxide (carbon sequestration) from the flue gases of coal power station.
4. India must give maximum emphasis to developing the still fairly large untapped hydrogen potential in the north-west, north and north east.
5. Avery important non-carbon energy is nuclear power which can be given more emphasis. Indo-US nuclear deal may be an important step in this regard.
6. Solar energy in India provides immense option as energy source which should be given emphasis. R.K. Pachauri, (2008) also gave impetus that India can emerge as a leader in solar energy within the next 10 years and show the world a way out of global warming.
7. Energy efficiency will have to be achieved in Industry, transport, domestic appliances and agriculture. CFL and other electric appliances should be used by the society.
8. India must adopt, as a matter of deliberate choice, decentralised and regional development, which would minimise long distance transport of food articles, consumer goods, minerals, and industry items.

9. Responsible lifestyle of society is extremely essential.

10. *Environmental Impact Assessment: Judicial Activism*

In the countries where the mandatory model EIA exists it is found that judicial review makes a significant contribution in involving procedural standards and developing EIA as a strong weapons in maintaining the balance between development and environmental.

Better strategy and curriculum preparation or Environmental Impact Assessment is a weapon which can be followed in the state of Orissa. This Environmental Impact Assessment should reach to the remote area where we can make them aware of EIA system. Any proposed project by our Orissa Govt. or policies this EIA will change the quality of environment. It is the duty of the State Board, other agencies and most important to the political parties to see the EIA not to be misused but be handled properly. According to my opinion EIA is a multi disciplinary process which involves resolution of disputes among conflicting and diverse interest in society'. Therefore I appeal to the people of Orissa that please take proper care of EIA in order to function it smoothly in the state of Orissa.

11. Environmental Education may play a pivotal role in environmental management because self-analysis is a great way to learn. The Centre for Science and Environment's green schools audit their consumption of water, land, air, and energy. This appreciable step promises to instil mindfulness in human relations with nature.

12. Other developing countries should also ratify the Kyoto protocol.

Gupta emphasized the need of developed countries to ratify the Kyoto protocol because they are the prime industrialized countries and hence contributing to global environmental change. USA and China are two top ranker producers of green house gases. However, they have not ratified the Kyoto Protocol.

Kyoto protocol should be enforced effectively in order to have uniform regulation of industrial emission. The world is on track to meet its Kyoto targets for green house gases. But unfortunately the drop has little to do with climate policies (David Adam, The Hindu dt. 8-12-08). The Kyoto Protocol ends on 2012 and there is an urgent need to decide on a new agreement in Copenhagen in 2012 for more effective emission control policies (Mary Robinson et al. 2008 The Hindu dt. 11-12-08).

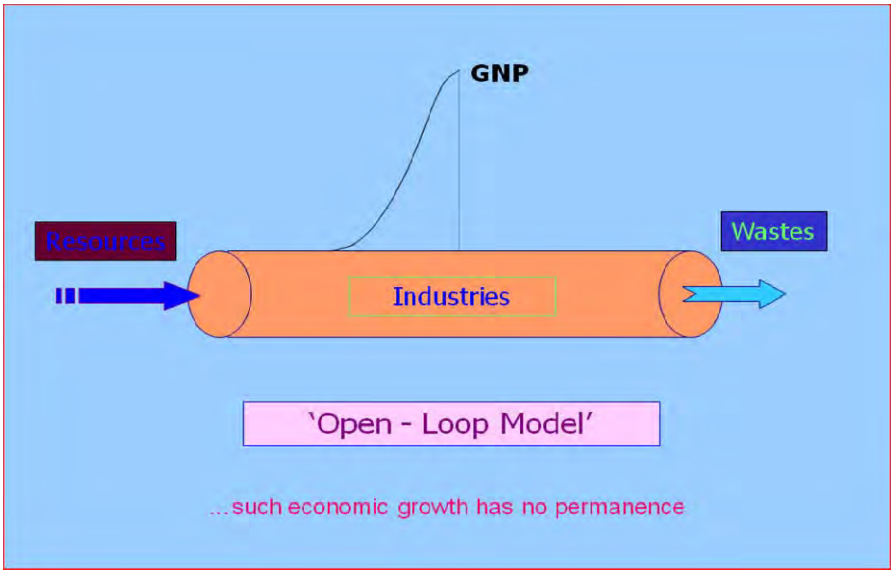
13. Although climate change is something which affects us all and which we need to address together inspite of debate between developed and developing countries (Richard Stagg, Managing climate change The Hindu dt. 12-3-08), however, India should stand tough on its stand for implementing environmental protection policies in its own climatic conditions. Because costly pollution control devices operating in developed countries may not be successful in India therefore, focus should be on indigenous technologies. There was also a view that Kyoto has failed and we must rethink climate change policy because the global economy is not decarbonising-it is carbonizing therefore, there must be a much larger commitment to fundamental energy technology R&D (Gwyn Prins, The Hindu dt. 6-04-08). After tough time in Bali a paper published by Oxford University, places India at the very bottom of the list of countries assessed to be morally responsible for climate change supported the India's stand (Promode Kant, 2007).

Very recently (Special Correspondent, The Hindu dt. 21-10-08), 193rd report of Parliamentary Standing Committee on "Global Warming and its Impact on India" recommended inclusion of several measures such as identification of key areas of energy technologies, such as renewable energy, energy efficiency, setting up technology missions to focus on development of cutting edge renewable technologies and attracting investment. Further, the committee suggested the initiation of national research agenda on climate change to address the impact of climate change and the setting up of a national institute on climate change to cater to the concerns pertaining to climate change mitigation. Similarly, the committee felt that the Mass Rapid Transit transport system should be introduced in major cities for integration of public transport services and encouraging the use of energy efficient fluorescent lamps (CFL) and light emitting diode (LED).

14. Industries should also take initiatives in the direction of climate change however, the generally failed to take concrete action. While a number of industries expect to contribute to mitigating their impact on climate change, only few seem to be approaching it in a structured and measurable manner (V. Jayanth, 2008 The Hindu dt. 10-08-08).

Industries should follow the B model (Closed Loop Model) instead of A (Open Loop Model) for sustainable and healthy environment Fig. 1 (A & B).

A.



B.

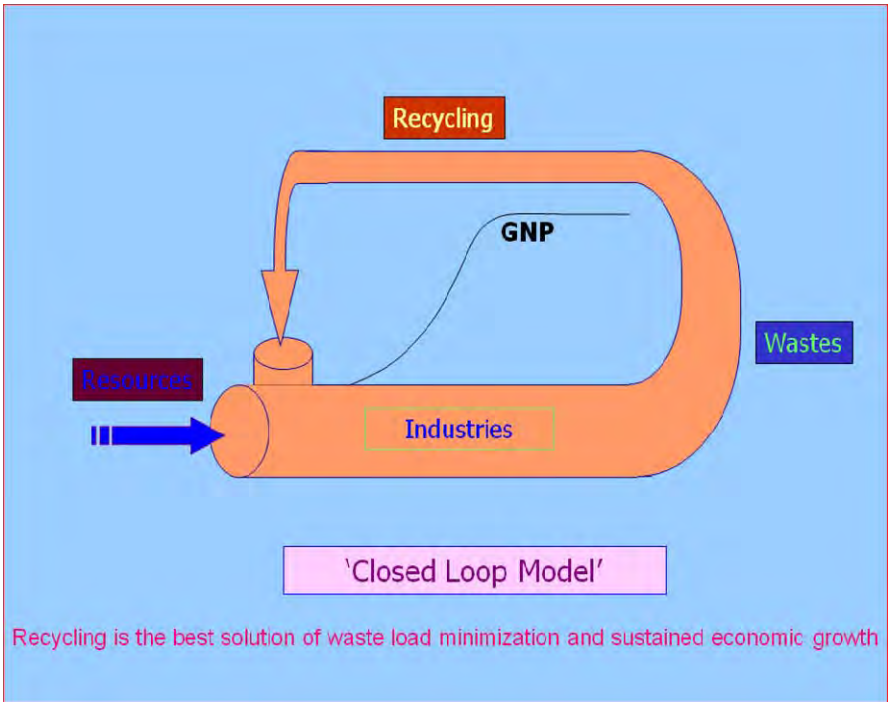


Fig. 1 Model for industrial growth.

15. R.K. Pachauri, Nobel laureate and Chairman, I.P.C.C. emphasized that role of Youngsters to spread climate change message while honouring the 60 Indian and 5 Srilankan youngsters (Smriti K. Ramchandran, The Hindu dated 3-12-08).

16. Also media may play an important role to spread the message of climate change among wide masses of people e.g. very successful film Al Gore's An Inconvenient Truth and the other film Age os Stupid which attacks consumerism, exploitation and human tendency to ignore unpleasant realities (Priscilla Jebaraj, 2008. Artists document disasters of climate change. The Hindu dt. 11-12-08).

17. One recent UN report emphasized that fighting global warming is a moral imperative and the urgency of the global financial crisis is no excuse for global climate change (Ban Ki-moon et al. 2008: The Hindu dated 12-11-08). Further, Ban Ki-moon has observed that a well thought-out fiscal stimulus can address both the problems through green growth. New President Of US Barack Obama promised of opening a "new chapter" in country's response to climate change has raised great hopes. At the recent UN Climate Change Conference in Poland a great deal of attention was devoted to implementing a much-needed adaptation fund for vulnerable countries (Anonymous 2008. Looking beyond Kyoto. The Hindu dt. 19-12-08).

18. Four Pillars of Environmental Management in Industries are:

- ✓ *Efficiency (Increase)*
- ✓ *Resource use (Optimize)*
- ✓ *Education (Awareness)*
- ✓ *Cybernetics (Control)*

Long term energy and resource security are increasingly becoming the focus of political and economic debate worldwide. Conflicts over energy and water will shape the decades to come and an efficient use of resources will become one of the dominant issues and an important strategy of green growth (Sigmar Gabriel 2008. Strategies for green growth. The Hindu dt. 16-11-08).

Cybernetics (Communication and Control) includes

- *Legal Provisions*
  - Command and Control Legislation: Discussed already in detail in Chapter III
  - Market based Instruments (MBIs)
- *Ethical Approach* : Realizing the people's responsibility to protect the environment.

19. Plant based technologies or phyto-technologies should be promoted e.g. green belt development for air & vehicular pollution control (Phytoremediation technology).

These technologies are particularly effective in abatement of aquatic industrial pollution.

The figure comprises two broad categories of effluents. First category comprises effluents of thermal power plants, acidic mine effluent (from energy intensive industrial region) and chlor-alkali effluent while, second includes primarily treated municipal effluent. The first category of effluents is generally more intense in relation to heavy metal pollution level particularly in comparison to primary/secondary treated municipal effluent. Therefore, after harvesting of wetland macrophytes the only option for reuse lies in the production of biogas. Due to high metal retention in biomass they cannot be used as bio-fertilizer or animal feed whereas, in partially treated municipal effluent after bio-filtration of heavy metals from wetland plants provide an additional reuse option in agriculture thus, aiding in water resource conservation. Also, like first category biomass may be used for biogas production. Wetland plants like *Azolla pinnata* provide reuse opportunities as a biofertilizer after metal release through mild chemical treatment thus assisting in eco-friendly agriculture. The overall integrated process thus follows an eco-sustainable approach and provides an eco-technological innovation (Fig. 2).

20. Adoption of Industrial Ecology Concept

Industrial ecology (IE) is an interdisciplinary field that focuses on the sustainable combination of environment, economy and technology. The central idea is the analogy between natural and socio-technical systems. The word 'industrial' does not only refer to industrial complexes but more generally to how humans use natural resources in the production of goods and services. Ecology refers to the concept that our industrial systems should incorporate principles exhibited within natural ecosystems.

Industrial ecology is the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes become inputs for new processes.

Much of the research focuses on the following areas:

- material and energy flow studies ("industrial metabolism")
- dematerialization and decarbonization
- technological change and the environment
- life-cycle planning, design and assessment
- design for the environment ("eco-design")
- extended producer responsibility ("product stewardship")
- eco-industrial parks ("industrial symbiosis")
- product-oriented environmental policy
- eco-efficiency

Industrial ecology proposes not to see industrial systems (for example a factory, an eco-region, or national or global economy) as being separate from the biosphere, but to consider it as a particular case of an ecosystem - but based on infrastructural capital rather than on natural capital. It is the idea that as natural systems do not have waste in them, we should model our systems after natural ones if we want them to be sustainable.

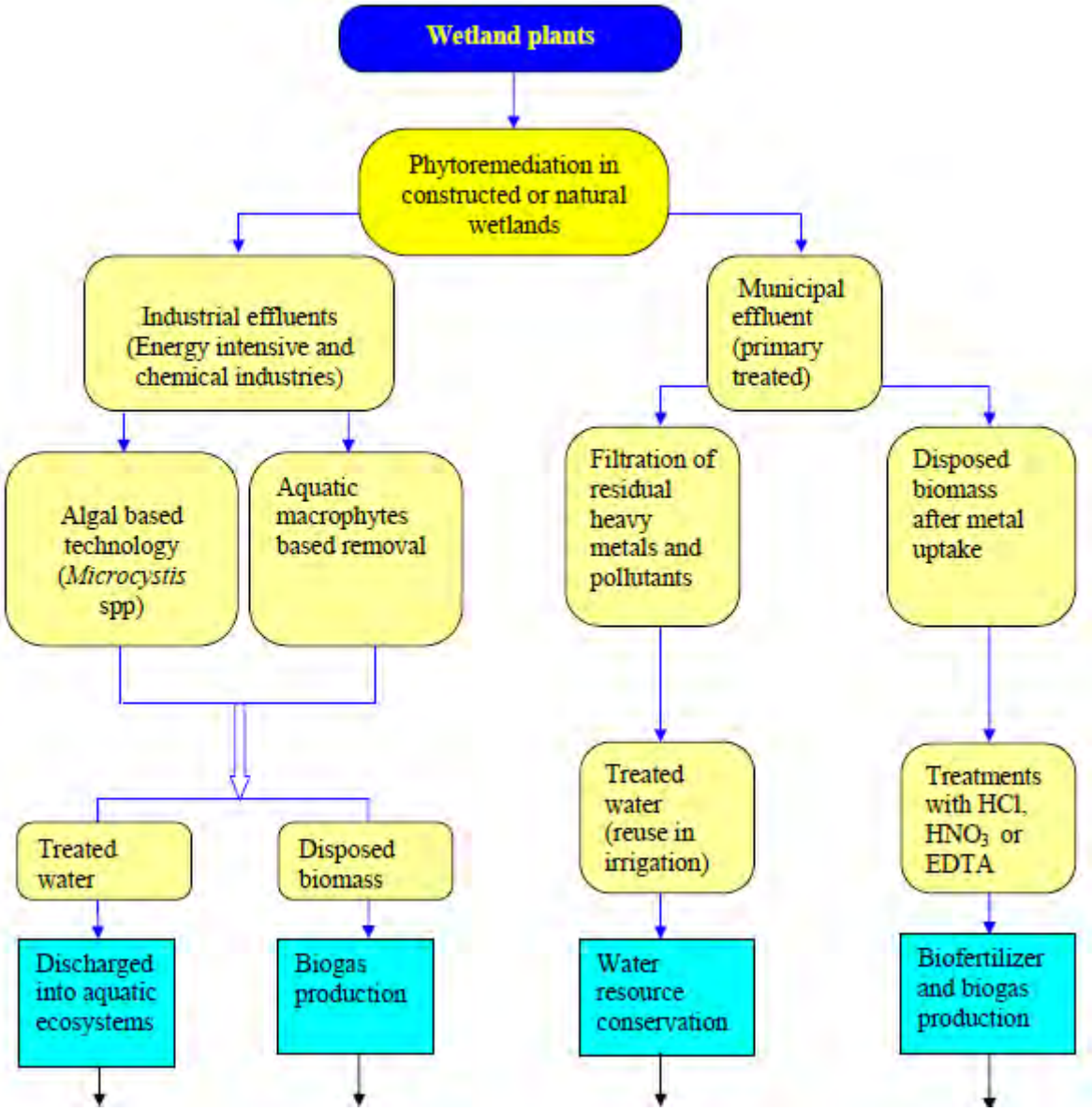


Fig. 2 Model developed for treatment of industrial effluents, municipal wastewater and eco-sustainable utilization of biomass using macrophytes (Source: Rai, 2008a; 2008b; 2008c; Rai and Tripathi, 2009).

Along with more general energy conservation and material conservation goals, and redefining commodity markets and product stewardship relations strictly as a service economy, industrial ecology is one of the four objectives of Natural Capitalism. This strategy discourages forms of amoral purchasing arising from ignorance of what goes on at a distance and implies a political economy that values natural capital highly and relies on more instructional capital to design and maintain each unique industrial ecology.

Industrial Ecology approaches problems with the hypothesis that by using similar principles as *natural systems*, *industrial systems* can be improved to reduce their impact on the natural environment as well. Moreover, *life cycle thinking* is also a very important principle in industrial ecology. It implies that all

environmental impacts caused by a product, system, or project during its life cycle are taken into account. In this context life cycle includes

- Raw material extraction
- Material processing
- Manufacture
- Use
- Maintenance
- Disposal

The transport necessary between these stages is also taken into account as well as, if relevant, extra stages such as reuse, remanufacture, and recycle. Adopting a life cycle approach is essential to avoid shifting environmental impacts from one life cycle stage to another. This is commonly referred to as problem shifting. For instance, during the re-design of a product, one can choose to reduce its weight, thereby decreasing use of resources. However, it is possible that the lighter materials used in the new product will be more difficult to dispose of. The environmental impacts of the product gained during the extraction phase are shifted to the disposal phase. Overall environmental improvements are thus null.

A final and important principle of IE is its *integrated approach* or *multidisciplinary*. IE takes into account three different disciplines: social sciences (including economics), technical sciences and environmental sciences.

21. Cleaner production

Cleaner production is a preventive, company-specific environmental protection initiative. It is intended to minimize waste and emissions and maximize product output. By analysing the flow of materials and energy in a company, one tries to identify options to minimize waste and emissions out of industrial processes through source reduction strategies. Improvements of organisation and technology help to reduce or suggest better choices in use of materials and energy, and to avoid waste, waste water generation, and gaseous emissions, and also waste heat and noise.

Examples for cleaner production options are:

- Documentation of consumption (as a basic analysis of material and energy flows, e. g. with a Sankey diagram)
- Use of indicators and controlling (to identify losses from poor planning, poor education and training, mistakes)
- Substitution of raw materials and auxiliary materials (especially renewable materials and energy)
- Increase of useful life of auxiliary materials and process liquids (by avoiding drag in, drag out, contamination)
- Improved control and automatisation
- Reuse of waste (internal or external)
- New, low waste processes and technologies

22. Pollution prevention

Pollution prevention describes activities that reduce the amount of pollution generated by a process, whether it is consumer consumption, driving, or industrial production. In contrast to most pollution control strategies, which seek to manage a pollutant after it is formed and reduce its impact upon the environment, the pollution prevention approach seeks to increase the efficiency of a process, thereby reducing the amount of pollution generated at its source. Although there is wide agreement that source reduction is the preferred strategy, some professionals also use the term pollution prevention to include recycling or reuse.

As an environmental management strategy, pollution prevention shares many attributes with cleaner production, a term used more commonly outside the United States. Pollution prevention encompasses more specialized sub-disciplines including green chemistry and green design (also known as environmentally conscious design).

23. Ministry of Environment & Forest (Government of India) Initiative

The Ministry of Environment & Forests is implementing the National Plan for pollution control in the country. Abatement of industrial pollution is one of the major thrust areas of this plan. According to the latest data collected by the Central Pollution Control Board (CPCB), out of the 1551 large and medium industries in 17 categories of highly polluting industries, 1266 industries have installed the requisite pollution control facilities for complying with stipulated environmental standards. 130 industries have closed down and 155 industries are in the process of installing pollution control facilities. All these 155 defaulting units in various states have been subjected to legal action by the CPCB under Section 5 of the Environment Protection Act. The CPCB and SPCBs are monitoring status of pollution control in these industries and they are being persuaded to use cleaner production technologies for reducing the ultimate pollution load. Fiscal incentives, in the form of reduced customs and excise duty, are also being given to industries for installing pollution control equipment. The Government is catalysing industry in forming waste minimization circles and industries are being encouraged to adopt waste minimization and cleaner technologies. A total of 847 grossly polluting industries discharging their effluents into rivers and lakes have been identified in 15 States/UTs. Out of these, as per the latest status, 176 units have provided requisite effluent treatment facilities, 136 are closed and 535 are defaulters. The defaulters include industries, which are either in the process of installing the requisite treatment facilities or facing legal action. Preparation of zoning atlas for setting up of industries based on environmental consideration has been taken up.

24. Attaining Eco-efficiency in Industrial Sector

The term eco-efficiency was coined by the World Business Council for Sustainable Development (WBCSD) in its 1992 publication "Changing Course". It is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution.

The 1992 Earth Summit endorsed eco-efficiency as a means for companies to implement Agenda 21 in the private sector, and the term has become synonymous with a management philosophy geared towards sustainability.

According to the WBCSD definition, eco-efficiency is achieved through the delivery of "competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity."

This concept describes a vision for the production of economically valuable goods and services while reducing the ecological impacts of production. In other words eco-efficiency means producing more with less.

According to the WBCSD, critical aspects of eco-efficiency are:

- A reduction in the material intensity of goods or services;
- A reduction in the energy intensity of goods or services;
- Reduced dispersion of toxic materials;
- Improved recyclability;
- Maximum use of renewable resources;
- Greater durability of products;
- Increased service intensity of goods and services.

The reduction in ecological impacts translates into an increase in resource productivity, which in turn can

create a competitive advantage.

25. Implementation of Eco-industrial park concept

An eco-industrial park (EIP) is an industrial park in which businesses cooperate with each other and with the local community in an attempt to reduce waste and pollution, efficiently share resources (such as information, materials, water, energy, infrastructure, and natural resources), and help achieve sustainable development, with the intention of increasing economic gains and improving environmental quality.

The Eco-industrial Park Handbook defines EIPs as "An Eco-Industrial Park is a community of manufacturing and service businesses located together on a common property. Members seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues."

"Industrial symbiosis" is a related but more limited concept in which companies in a region collaborate to utilize each other's by-products and otherwise share resources. In Kalundborg, Denmark a symbiosis network links a 1500MW coal fired power plant with the community and other companies. Surplus heat from this power plant is used to heat 3500 local homes in addition to a nearby fish farm, whose sludge is then sold as a fertilizer. Steam from the power plant is sold to Novo Nordisk, a pharmaceutical and enzyme manufacturer, in addition to a Statoil plant. This reuse of heat reduces the amount thermal pollution discharged to a nearby fjord. Additionally, a by-product from the power plant's sulfur dioxide scrubber contains gypsum, which is sold to a wallboard manufacturer. Almost all of the manufacturer's gypsum needs are met this way, which reduces the amount of open-pit mining needed. Furthermore, fly ash and clinker from the power plant is utilized for road building and cement production.

The industrial symbiosis at Kalundborg was not created as a top-down initiative, but instead evolved gradually. As environmental regulations became stricter, firms were motivated reduce the cost of compliance, and turn their by-products into economic products.

26. Industrial symbiosis

Industrial symbiosis is a type of eco-industrial development which is an application of the concept of industrial ecology. Industrial ecology is a relatively new field that is based on the ideology of nature. It claims that industrial ecosystem may behave similar to the natural ecosystem where everything gets recycled.

Eco-industrial development is one of the ways in which industrial ecology contributes to the integration of economic growth and environmental protection. Some of the examples of eco-industrial development are:

- Recycling Clusters
- Green Companies' Clusters
- Redevelopment of industrial parks
- New development of eco-friendly industrial parks
- Eco-friendly resource exchange networks (not confined in the same area)

Industrial symbiosis can be defined as sharing of information, services, utility, and by-product resources among one or more industrial actors in order to add value, reduce costs and improve environment. Industrial symbiosis is a subset of industrial ecology, with a particular focus on material and energy exchange.

Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity". Such a system collectively optimizes material and energy use at efficiencies beyond those achievable by any individual process alone. IS systems such as the web of materials and energy exchanges among companies in Kalundborg, Denmark have spontaneously evolved from a series of micro innovations over a long time scale; however, the engineered design and implementation of such systems from a macro planner's perspective, on a relatively

short time scale, proves challenging. Often, access to information on available by-products is non-existent. These by-products are considered waste and typically not traded or listed on any type of exchange.

8 Conclusion

A complete policy on anthropogenic climate change would require addressing at least four major issues in their totality and also following an integrated approach

(1) *Greenhouse gas levels*: what proportion of the current global greenhouse gas (GHG) content in the atmosphere should be removed and by what dates should that reduction be accomplished?

(2) *Burden sharing*: for what share of the desired global GHG reduction should each nation or region be accountable?

(3) *Actions*: what is the best set of actions to undertake to achieve the reductions, who (eg which sectors) should take which ones, and where (e.g. which nations) and when should they be done?

(4) *Institutions*: how should the specified actions be carried out that is, in what institutional context and through what kind of administrative processes or mechanisms (e.g. market based, command and control, taxation, voluntary compliance, or some combination of these)?

Acknowledgement

I thank Vice Chancellor, Mizoram University for his kind cooperation and support extended. I thank Dr. J. Pandey, Department of Environmental Science, BHU for his kind cooperation and support during his coordinatorship in Refresher course of Environmental Science.

References

Aarti Dhar, 2008. Manmohan unveils action plan on climate change. The Hindu, 1st July 2008

Anonymous 2006. Garam ho raha hai Antarctica. Nature watch. Dainik Jagaran, dt. 29-04-06

Anonymous, 2008. Looking beyond Kyoto. The Hindu, dt. 19-12-08

Ban Ki-moon et al. 2008: The Hindu, dated 12-11-08

Bhavanishankar BS. 2007. Climate change: Conserve water. Deccan Herald, January 2007

Cline WR. 2007. Global Warming and Agriculture: Impact Estimates by Country. Center for Global Development, Peterson Institute for International Economics, Washington DC, USA

David A. 2008. Has the Kyoto protocol worked? The Hindu, dated 08-12-08

Desai A. 2012. Formulating an FM strategy for climate change mitigation and adaptation of commercial built assets. PhD thesis, University of Greenwich, UK

Dionne B. 2007. Climate Change: Vanishing snow Frontline, Volume 24 - Issue 24, Dec. 08-21, 2007

Ebi KL, Semenza JC. 2008. Community-based adaptation to the health impacts of climate change. American Journal of Preventive Medicine, 35: 501-507

Gage KL, Burkot TR, Eisen RJ, et al. 2008. Climate change and vectorborne diseases. American Journal of Preventive Medicine, 35: 436-450

Gosain AK, Rao S, Basuray D. 2006. Climate change impact assessment on hydrology of Indian river basins. Current Science, 90(3): 346-353

Gwyn P. 2008. The Hindu, dt. 6-04-08

Hess JJ, Malilay J, Parkinson A. 2008. Climate change: the importance of place. American Journal of Preventive Medicine, 35: 468-478

Internet source: Google Search; Wikipedia free encyclopedia

IPCC (Intergovernmental Panel on Climate Change). 1990. Climate Change: Tile IPCC Scientific Assessment Cambridge University Press, Cambridge, USA

IPCC. 2007. Climate Change 2007. http://www.ipcc.ch. Accessed 12 December 2008

Keim ME. 2008. Building human resilience: the role of public health preparedness and response as an adaptation to climate change. American Journal of Preventive Medicine, 35: 508-516

Kinney PL. 2008. Climate change, air quality, and human health. American Journal of Preventive Medicine, 35: 459-467

K. Venugopal. 2007. Who is to act on climate change? Business Line, June 7th 2008

Kates RW. 2000. Cautionary tales: adaptation and the global poor. Climatic Change, 45(1): 5-17

Mary Robinson et al. 2008. A new climate deal based on human progress and Justice. The Hindu dt. 11-12-08

Matthews JH, Wickel BAJ, Freeman S. 2011. Converging currents in climate-relevant conservation: Water, infrastructure, and institutions. PLOS Biology, 9(9): e1001159.

Molua EL. 2002. Climate variability vulnerability and effectiveness of farm-level adaptation options: the challenges and implications for food security in Southwestern Cameroon. Environment and Development Economics; 7: 529-545

N. Gopal Raj 2007. India and challenge of global warming. The Hindu, dt.4-02-07

Nature reports climate change. 2007. www.nature.com/reports/climatechange Vol. 1

Pachauri RK. 2008. We can emerge as a leader in solar energy within the next 10 years and show the world a way out of global warming. India Today, Special Issue: 124-126

Priscilla J. 2008. Artists document disasters of climate change. The Hindu, dt. 11-12-08

Promode K. 2007. Global warming & India's responsibility. The Hindu, dt. 17-12-07

R. Prasad, 2009. The Hindu, dt. 7-1-09

Rahish Singh, 2005. Sankat ke saye me bhavishya. Dainik Jagran

Rai PK. 2008a. Heavy-metal pollution in aquatic ecosystems and its phytoremediation using wetland plants: An eco-sustainable approach. International Journal of Phytoremediation, 10(2): 133-160

Rai PK. 2008b. Heavy metal phytoremediation from aquatic ecosystems with special reference to macrophytes. Critical Reviews in Environmental Science and Technology, 39(9): 697-753.

Rai PK. 2008c. Mercury pollution from chlor-alkali industry in a tropical lake and its bio-magnification in aquatic biota: Link between chemical pollution, biomarkers and human health concern. Human and Ecological Risk Assessment, 14(6): 1318 -1329

Rai PK, Tripathi BD. 2009. Comparative assessment of *Azolla pinnata* and *Vallisneria spiralis* in Hg removal from G.B. Pant Sagar of Singrauli Industrial region, India. Environmental Monitoring and Assessment, 148: 75-84

Richard S. 2008. Managing climate change. The Hindu, dt. 12-3-08

Sen A. 1981. Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford University Press, UK

Shankar S. 2009. Consultant to Electricity Industry, Inefficient Electricity Industry and Global Warming. Accessed 12 February 2009

Sigmar G. 2008. Strategies for green growth. The Hindu, dt. 16-11-08

Smriti KR. 2008. Youth to spread climate change message. The Hindu, dated 3-12-08

Special Correspondent U.S. concern on climate change deal not warranted: Sibal. The Hindu, 17 December 2007

Srinivasan MR. 2007. Climate change and India's option. The Hindu, dt. 29-06-07

Stern N. 2006. Stern Review on the Economics of Climate Change. HM Treasury

Thakur R, Bradford C. 2007. Climate change & global leadership. The Hindu, dt.9-02-07

Tyler E. 2010. Aligning South African energy and climate change mitigation policy. Climate Policy, 10(5): 575-588

V. Jayanth. 2008. Climate change: industry's lukewarm response. The Hindu, dt. 10-08-08

Vijayalakshmi V. 2007 Climate change compulsions Business Line, 27 December 2007

Wirth D, Lashof D 1990. Beyond Vienna and Montreal: muhilateral agreements on greenhouse gases. Ambio 19(6-7): 305-310

V. Jayanth. 2008. Climate change: industry's lukewarm response. The Hindu, 10th August 2008

Vijayalakshmi V. 2007. Climate change compulsions. Business Line, 27th December 2007

Wilby RL, Keenan R. 2012. Adapting to flood risk under climate change. Progress in Physical Geography 36(3): 348-378

Zhang WJ, Liu CH. 2012. Some thoughts on global climate change: will it get warmer and warmer? Environmental Skeptics and Critics, 1(1): 1-7