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The AEI (Asian Energy Institute) is a network of 16 energy institutes from Asian countries. These include Bangladesh, China, India, Indonesia, Iran, Japan, Jordan, Korea, Kuwait, Malaysia, the Philippines, Pakistan, Sri Lanka, and Thailand. Besides, there are 14 associate members, both within and outside Asia. The AEI was formally established in August 1989. Its aims and objectives are to promote greater information exchange; facilitate sharing and dissemination of knowledge; undertake research and training activities that are of common interest to its members; and analyse global energy developments and their implications. TERI hosts the secretariat of the AEI at present. The secretariat publishes a biannual newsletter that informs the readers about the diverse research activities undertaken by the member institutes. Currently, the AEI is hosting the regional secretariat for REEEP (Renewable Energy and Energy Efficiency Partnership) in South Asia.

Editorial

*R K Pachauri**

Recent months have seen a rapid increase in public awareness on the subject of climate change. Much of this has taken place on account of a series of extreme weather events that have taken place in different parts of the world, such as Hurricane Katrina in the state of Louisiana and other parts of southern US, as well as unseasonal temperatures, both high and low, during specific periods in different regions of the world. Earlier, there was a severe heat wave in France during the summer of 2003, which led to a large number of deaths not only in Paris and other parts of France, but also in some other countries of Europe. All of these occurrences have created the impression that climate change is not a distant threat that scientists are pointing out through their various models and studies, but is something that is already occurring with implications that are demonstrably serious. This change in public attitudes is significant and deep, as it is based on the experiences that people and places have undergone with these recent events. The book by former Vice-president Al Gore and his movie – which has won an Oscar – have also altered public perception in favour of the belief that climate change is not only in evidence, but likely to become serious in the future. Finally, the release of parts of the Fourth Assessment Report of the IPCC (Intergovernmental Panel on Climate Change) has brought strong scientific consensus into the consciousness of the public and leaders around the world, which is likely to create action towards reducing the emissions of GHGs (greenhouse gases).

One critical element on which such actions hinge is the nature of the agreement that would come into place in the second commitment period of the Kyoto Protocol, that is, after the year 2012. It is expected that over time, major changes would take place in the use of fossil fuels, which are clearly the largest source of GHG emissions. It is interesting to note that even the US, a country that has not ratified the Kyoto Protocol, is moving in the direction of non-fossil-based energy, perhaps for reasons very different from the mitigation of GHG emissions. The dominant concern in US policy is that of ensuring energy security and minimizing the import of oil, propelled by a decline in indigenous production and a continuing increase in consumption, particularly for transportation of both passengers and freight. A small part of the measures being undertaken within the US is exemplified by the incentive being provided to ethanol production in that country, which comes essentially from agricultural crops, mainly corn. As a result, bio-ethanol production in that country increased from 4 giga litres in 1996 to 7 giga litres in 2002, and doubled again to 15 giga litres in 2005, which accounts for a growth rate of 15%–20% per year.

Since the immediate reduction in GHG emissions is committed to occur in the OECD (Organization for Economic Cooperation and Development) countries, the greatest potential for shifts towards non-fossil-based energy exists in these nations, while in emerging economies such as China and India, the consumption of fossil fuels is going up rapidly. Current infrastructure, existing technologies, and domestic access to energy resources like coal constrain any possible reduction in the near future in these countries.

In case of developed nations, the economic and technological capabilities of these countries facilitate a shift to more secure energy sources such as nuclear and renewables. The IEA (International Energy Agency) in its latest *World Energy Outlook* provides estimates of different sources of energy for electricity generation in the year 2004, with coal in a dominant position, accounting for 38% of the share of electricity generated, nuclear at 23%, hydro at 13%, and all renewables and waste accounting for a mere 3%. A shift towards sources other than fossil fuels would also enhance energy security for these countries. The IEA defines energy supply to be 'secure' if it is adequate, affordable, and reliable. Given the increase in demand, particularly for oil, which is occurring with growing dependence on a small region of the world for exportable surpluses, questions have been raised on the geopolitical dimensions of oil supply in the global market. Past experience has also shown that the oil market is very sensitive to changes in demand or quantity supplied, which result in sharp fluctuations of oil prices. Hence, a major aspect of energy security that countries worry about is the affordability of energy, particularly imported oil, under these conditions of instability.

Mitigation options assessed by the IPCC highlight co-benefits, which include energy security, local environmental benefits, and other effects that are of a

* Director-General, TERI, New Delhi, and Chairman, Intergovernmental Panel on Climate Change

positive nature. Now that the IPCC has put forward much stronger evidence in the AR4 (Fourth Assessment Report) on the extent of climate change with projections for the future, global policy is likely to move faster towards measures that would also reduce the threat to energy security. Another factor that is likely to influence policies and measures is the greater detail now available in the IPCC Working Group II Report of the impacts of climate change, which elaborate on the threats to millions of people as a result, for instance, of coastal flooding, rapid melting of glaciers in different parts of the world, likely negative impacts on agricultural productivity, particularly in the subtropical and tropical regions of the world, as well as the harmful impacts of extreme events attendant with climate change. Also in evidence is the range of options that is available for the mitigation of GHG emissions, many of which can be implemented at negative costs if co-benefits are taken into account.

All of this suggests that there is a need for analysis of policy options, which would enable the implementation of measures not only to mitigate GHG emissions to a substantial extent, but also to ensure greater energy security. There is, therefore, a need for those dealing with energy security to also collaborate with those involved in climate change studies to identify common ground on which policies can be articulated in the future.

The climate change dimension of engineering a new energy future for the world has become extremely important with the findings of the IPCC as part of the AR4. Some of the major findings, which go beyond the TAR (Third Assessment Report), are relevant in this context. First, the report of the Working Group I of the IPCC clearly states that 'global atmospheric concentration of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed the pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are primarily due to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.'

This finding clearly highlights the fact that, having interfered with the long-term stability of the earth's atmosphere, the human race now needs to bring the situation into balance with a sense of purpose and determination. Projections for the future indicate that for the low scenario of the IPCC, the best estimate of temperature increase by the end of this century is 1.8 °C from a range of 1.1 °C to 2.9 °C and the best estimate for the high scenario is 4 °C from a range of 2.4 °C to 6.4 °C. Also, human actions are likely to create impacts spread over a long period of time, which means that not only are the impacts of climate change likely to be serious in the immediate future, but would have major implications for life on this planet for several centuries as expressed in the following findings of the AR4.

'Anthropogenic warming and sea-level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if GHG concentration were to be stabilized.'

As far as the impacts of climate change are concerned, there is now considerable evidence that the impacts in several parts of the world would have adverse implications for food security and malnutrition, for instance, and also the availability of water. In several regions of the world, the melting of glaciers could have serious implications—about 500 million people in the Indian subcontinent and 250 million people in China would be affected.

Overall, therefore, it can be concluded that there is a remarkable convergence in policy imperatives for ensuring energy security and for those that would mitigate climate change through the reduction of GHG emissions. Common solutions and the estimates of economic ranking of different options can be assisted greatly by collective work between those responsible for energy policies and those dealing with initiatives related to climate change. This author had raised this issue in 1988 in the presidential address delivered at the annual Conference of the International Association for Energy Economics, held in Luxemburg. The statement made during the address which would be relevant to recall stated the following.

> *One area where our profession needs to make a much stronger entry than it has thus far is in the field of energy–environment interface issues. Not only are direct environmental effects of energy, such as air and water pollution and acid rain, serious enough to merit attention, but there is also now a definite basis for concern over the effects of energy use and production on the global climate. We can postpone a deeper interest in the subject only at the risk of a continuing insularity and myopia. Climate changes are already resulting in serious problems between the tropics in the form of frequent droughts and floods.*

Climate security: issues and options for Asia

Ligia Noronha and Mitali Das Gupta[1]

Introduction

Climate change is a serious global issue. There is sufficient evidence that the rising levels of GHGs (greenhouse gases) will have a warming effect on the climate through increasing the amount of infra-red radiation (heat energy) trapped by the atmosphere, the so-called greenhouse effect. Over the past 30 years, global temperatures have risen continuously by around 0.2 °C per decade, thereby causing the earth's climate to change. Most climate models show that a doubling of pre-industrial levels of GHGs is very likely to increase the global mean temperature by 2–5°C. This level of warming will probably be reached between 2030 and 2060. High temperature poses a serious risk to the earth's ecosystem. The recent Stern Review (Stern 2006) on climate change predicts that by 2100, in South Asia and Sub-Saharan Africa, 145–220 million additional people could fall below the $2/day poverty line, and every year, an additional 165 000–250 000 children could die.

The growing concerns about climate change prompted a debate in the UN Security Council on 17 April 2007, led by the UK government. UN Secretary General Mr Ban Ki-Moon said that, *Projected changes in the earth's climate are thus not only an environmental concern…issues of energy and climate change can have implications for peace and security* (The Financial Times 2007). In this article, we would like to discuss these security risks and suggest that in general, we see the climate security issue as more of a non-traditional security risk – linked to impacts on human health, livelihoods, displacement, and reduced well-being – which, if unattended, could well lead to intra-state conflict, failed states, and general breakdown of law and order. Despite all this, we would suggest that the issue, as of now, is best dealt with as a foreign–domestic policy problem centred around equity issues, in order to avoid the route of threats to peace and security of the more traditional kind.

Impacts on Asia

Despite the extensive interest in assessing the economic impacts of climate change in Asia, in general, there is limited empirical research on the subject. However, more recently, the IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report, the Stern Review, and a few other studies have provided us with some useful information on the potential impacts of climate change in Asia.

Studies suggest that there will be serious risks and increasing pressures on coastal cities in South and East Asia, especially in Vietnam, Bangladesh, and parts of China (Shanghai) and India, because of their large coastal populations in low-lying areas. It is also predicted that the region could lose 15% of its land area. On the other hand, events like the El Niño, with strong warming in the central Pacific, could cause the Indian monsoon to switch into a 'dry mode', characterized by significant reductions in rainfall leading to severe droughts. Thus, as warming intensifies, on one hand, it will reinforce scarcity of water supply, thereby increasing the risk of droughts, and on the other hand, it could increase water availability, for example, a 10%–20% increase for a 2 °C temperature rise and slightly greater increases for a 4 °C rise, according to several climate models. The Stern Review suggests that the cost of climate change in India and South-East Asia could be as high as a 9%–13% loss in GDP (gross domestic product) by 2100, compared with what could have been achieved in a world without climate change. The report also suggests that under the high climate change scenario[2], an additional 60 000 to 250 000 child deaths per year could take place by 2100 in South Asia.

Any change in the rainfall pattern of the Asian monsoon would severely affect the lives of millions of people across the region. For instance, over 1000 people died in Mumbai when the city was devastated by flash floods from extremely heavy rainfall in August 2005. The Stern Review mentions that in South Asia in

[1] Ligia Noronha is the Director of the Resources and Global Security Division, TERI, and Mitali Das Gupta is Associate Fellow working in the same division.

[2] In the high-climate-change scenario, global mean temperature increases to 4.3°C in 2100. The high-climate change scenario is designed to explore the impacts that may be seen if the level of temperature change is pushed to higher levels through positive feedbacks in the climate system.

particular, climate change will increase the intensity of extreme events. Water tables have already started falling in some drought-affected districts of Pakistan, with water now available only at depths of 200–300 metres. Several climate models also predict a decrease in the agricultural output and food security in this region. For instance, the report clearly mentions that in India, with an increased risk of critical temperatures being exceeded more frequently, crop yields could significantly change. For example, mean yields for some crops in northern India could be reduced by up to 70% by 2100.

India and China

The study by Mendelsohn (2005) analyses results from India and selected experiments from the rest of South-East Asia in order to measure the impact of climate change on agriculture in this region. He estimates that the economic damages in India and China taken together owing to agricultural loss could be over half of the economic loss in the entire South-East Asian region. Lin and Zou (2006) mention that China faces a number of major challenges, including pressure on water resources, pressure on arable land from urbanization, soil erosion and desertification, and urban air pollution. China could be hit hard through impacts on water resources, agriculture, ecosystems and coastal zones, as well as direct impacts of natural disasters on human life and infrastructure. Floods are of high frequency and have already become one of the main natural disasters in the country. Tropical cyclones such as typhoons have also become frequent in the rainy season in coastal regions.

In India, Roy (2006) suggests that a sea-level rise of 100 cm can lead to welfare loss of $1259 million, equivalent to 0.36% of the GNP (gross national product). Frequencies and intensities of tropical cyclones in the Bay of Bengal will increase, particularly in post-monsoon periods, and there will be increased flooding in low-lying coastal areas. Malaria will continue to be endemic in current malaria-prone states (Orissa, West Bengal, and southern parts of Assam bordering West Bengal). It may also shift from the central Indian region to the south-western coastal states of Maharashtra, Karnataka, and Kerala. As per the new IPCC report, recession of the Himalayan glaciers could affect half a billion people in the Himalaya–Hindu Kush region and a quarter billion people in China, depending on the contribution of glaciers to water supplies.

Hence, given the projected impacts of climate change on water resources, Asia could emerge as the loci of water-related conflict, given the rapid population and economic growth in the region, coupled with the concentration of long-standing internal and inter-state tensions. Some new constraints on a nation's room to maneuvre on the energy front include possible carbon caps, potential impacts of water availability for hydro power, and possible damage to installations/pipelines on account of extreme climate events. The Maldives in the Indian Ocean could be badly affected through rising sea levels, which could result in the loss of several islands.

West Asia

The impacts will also be strong across West Asia (including the Middle East), where yields of the predominant regional crops may fall by 25%–35% (weak carbon fertilization) or 15%–20% (strong carbon fertilization) once temperatures increase by 3 °C or 4 °C Most lands that are deserts are expected to remain deserts. However, there will be changes in the composition and distribution of vegetation types of semi-arid areas, such as grasslands, rangelands, and woodlands. Small increases in precipitation are projected, but these increases are likely to be countered by increased temperature and evaporation. Water shortage, already a problem in many of the countries in the region, is unlikely to be reduced, and may be exacerbated, by climate change. Heat stress, affecting human comfort levels, and possible spread in vector-borne diseases are likely to result from changes in climate. Also, about 250–550 million additional people may be dying from hunger with a temperature increase of around 3 °C.

Asia, thus, may be affected quite adversely because of its geographic exposure, reliance on climate-sensitive sectors, low incomes, and poor social safety nets. Inadequate attention to these emerging climate-related risks could result in a possible failure of states due to new stresses, and increased competition and conflict over diminishing resources. Population movements within and across countries could create additional political and cultural stresses. Such possibilities will need to be anticipated and addressed proactively.

Adaptation and mitigation

The scale of action needed to tackle climate change is unprecedented and involves two concurrent approaches—mitigation represents activities to 'protect nature from society', while adaptation constitutes ways of 'protecting society from nature' (Stehr and Storch 2005). Thus, while mitigation seeks to reduce the principal cause of the problem, adaptation seeks to protect socio-ecological systems from the impacts of the problem.

Status of adaptation

Adaptation to climate change is a dynamic and multifaceted process that refers to adjustments through policies and actions in ecological, social, and economic systems in response to impacts of actual or expected climatic stimuli (Srinivasan 2005). Adaptation can, of course, reduce the impacts, but cannot solve the problem of climate change.

No developed country has yet formulated a comprehensive approach to implementing adaptation and the 'mainstreaming' of such measures within sectoral policies and projects. However, a handful of countries can be said to be moving towards implementing adaptation. In developed countries, progress on adaptation is still at an early stage, even though market structures are well developed and the capacity to adapt is relatively high. Many developed countries also have mature insurance markets that provide additional adaptive capacity by spreading awareness on the risks of extreme weather events across a large pool of individuals or businesses. In these countries, insurance companies have a long history of driving risk management through pricing risk, providing incentives to reduce risk, and imposing risk-related terms on policies (Stern 2006). However, market forces alone probably cannot deliver the kind of response necessary to deal with the serious risks from climate change, as governments have a clear-cut role in providing a policy framework to guide effective adaptation. For instance, in most developed countries, there is a high-quality climate information system, which is an important starting point for adaptation.

Adaptation is very crucial for developing countries, since they are most vulnerable to the negative impacts of climate change and also have the least capacity to adapt, besides having technological, resource, and institutional constraints. In various international negotiations, adaptation has received much less attention than the mitigation of GHGs, primarily due to lack of adequate knowledge on differentiating the impacts between anthropogenic climate change and natural climate variability. However, given the fact that a certain level of adaptation has to occur, even if mitigation measures are in place, negotiators from developing countries have argued for creating mechanisms to facilitate adaptation since the COP 8 (Eighth Conference of Parties). Since then, some Asian countries have undertaken some efforts, but these were limited to the national level largely due to lack of reliable and adequate information on the vulnerability and capacity of their communities to adapt to climate change.

During its Tenth Five-year Plan period (2001–2005), China had invested 362.5 billion yuans (equivalent to $43.83 billion) in building and upgrading water conservation facilities in order to prevent climate disasters (Lin and Zou 2006). China spent $3.15 billion on flood control between 1960 and 2000, which is estimated to have averted losses of some $12 billion (Stern 2006). Some government and research institutions in China have also begun to pay more attention to ecosystems so as to achieve a more sustainable development.

Bangladesh has made substantial investments in recent years to reduce vulnerability to extreme climate variability, including the following.

- Structural change in agriculture, with an increase in the planting of lower risk dry season irrigated rice
- Better internal market integration
- Increased private food imports

Bangladesh's dependence on agriculture has also been reduced by an increase in export-oriented garment manufacturing. These developments were aided by higher credit penetration, including micro-credit, increased remittances from abroad, and increased donor assistance (ODI 2005). In India, disaster mitigation and preparedness programmes in Andhra Pradesh yielded a benefit/cost ratio of 13:38.

In Vietnam, a mangrove-planting project aimed at protecting coastal populations from typhoons and storms yielded an estimated benefit/cost ratio of 52 over the period 1994 to 2001 (Stern 2006). Korea discusses adaptation options, but at a fairly generic level, with measures such as crop switching and coastal protection, without reference to their specific contexts.

Status of mitigation

The Stern Review has focused on three major points that could significantly mitigate climate change impacts—carbon pricing, technology policy, and policies on regulation, information, and financing. So far, the users of carbon-pricing mechanisms are mostly developed countries such as Australia, Japan, and those in the EU. Since most developing countries do not have commitments on emission reduction, carbon-pricing mechanism is not in much use among these countries. Also, as far as technology policy is concerned, developing countries do not yet have proper policies in place, and though the benefits of technology transfer are widely accepted, in practice this takes place within developed countries. However, the third factor – that is, regulation, information and financing – definitely has a scope to achieve better results. Regulation has an important role in product development and building markets through communicating policy intentions to global audiences;

reducing uncertainty, complexity, and transaction costs; and inducing technological innovation. Information policies to promote certificates and endorsements; more informative energy bills; and dissemination of best practices help consumers and firms make sound decisions and stimulate more competitive markets for more energy-efficient goods and services. Finally, as far as financing is concerned, private investment is key to raising energy efficiency. Investment in the public sector energy conservation can reduce emissions and improve public services, fostering innovation and change across the supply chain and setting an example to the larger society.

At the regional level, the Asia-Pacific Partnership for Clean Development and Climate launched in 2005 by the US together with China, India, Australia, Japan, and South Korea, may provide a useful step in fostering investments in clean energy and energy-efficiency initiatives. These countries have agreed to a charter, communiqué, work plan, and the establishment of eight public–private task forces to implement the partnership's agenda. The task forces cover the aluminium, building and appliances, cement, cleaner fossil energy, coal mining, power generation and transmission, renewable energy, distributed generation, and steel sectors.

China

China's effort towards mitigation of climate change has been through energy conservation measures and making a better energy structure through developing new forms of energy. The country has promoted the closure of small and inefficient industrial plants; the improvement of energy end-use efficiency and coal quality; the switching of many residential fuel users from coal to gas and electricity; and the promotion of technological progress in energy-intensive sectors. By 2010, China aims to reduce its energy use per unit of GDP by 20%, while increasing its GDP by four times with only twice as much energy use by 2020. The main drivers of these achievements would be a shift towards less energy-intensive industrial sectors and regulation on energy consumption standards in the building and transportation sectors, since the latter sectors are expected to gradually increase their relative contribution to total GDP against a decreased share of the industrial sector (Fei 2006). The Chinese government has decided to adopt a policy for building demand for renewables by mandating electricity suppliers to meet some of their needs from renewable resources. The policy is to be implemented through the enactment of a Renewable Energy Promotion Law, which was ratified by the People's Assembly in February 2005 (Jaswal and Das Gupta 2006).

India

In India, efficiency enhancement and energy conservation have received considerable attention since 1973, when the country was jolted out of complacency by the first oil shock. Since then, improvement of energy efficiency has been attempted by a mix of market mechanisms, as well as traditional command and control measures. In between, several committees were set up, like the Inter-ministerial Working Group on utilization and conservation of energy in 1981 and the Advisory Board of Energy in 1983. However, the short lifespan of some of these committees proved the lack of government strategy on energy efficiency. The National Energy Conservation Award was introduced by the Ministry of Power in 1991, for industrial units that had taken exceptional initiatives to conserve energy. Since then, such industrial units have been given national recognition through these awards. During the Ninth Plan, a need was felt to have an EC (Energy Conservation) Act and to establish an apex institution to effectively implement a programme of energy conservation. Accordingly, the EC Act, 2001, was passed and the BEE (Bureau of Energy Efficiency) was set up to introduce stringent energy conservation norms for energy generation, supply, and consumption. In spite of all these efforts, there is still considerable potential for reducing energy consumption by adopting energy-efficiency measures in various sectors. The country has also laid stress on promoting renewables. The Electricity Act, which was passed in 2003, states that each distribution company must procure some percentage of its electricity from renewable sources. This percentage varies from state to state, and the State Electricity Regulatory Commission decides on the figure. One key emerging aspect is the delinking that is occurring in India between energy growth at 3.7% and economic growth at 8%.

South-East Asia and Sri Lanka

Indonesia has a high potential for CDM (Clean Development Mechanism) projects in the fields of biomass (waste to energy), bio-diesel, energy efficiency and transportation/infrastructure, as well as various forms of renewable energy. Forestry activities in Java and Sumatra include plantation, afforestation, reforestation, and rehabilitation of critical land. In Malaysia, the major options for mitigation are identified as substitution of oil by hydro and gas and the use of efficient combined cycle gas technologies in the energy sector; while in the forestry sector, the major options include rehabilitation of cleared forest areas to permanent forest. The measures for air quality improvement, such as use of natural gas in public transport vehicles, also have secondary benefits of GHG reduction.

In Vietnam, the prominent mitigation options are energy-efficiency improvement on the demand side; fuel switching; reforestation, water management and improved nutrition in agriculture; and feed management for livestock. In Sri Lanka, the major mitigation options include DSM (demand side management) in the power sector and improvement of appliance efficiency in other sectors.

Conclusion

This paper has highlighted some of the climate security risks in Asia, which can range from lost lands and livelihoods, health impacts, loss of basic life-supports like water and food, displacement and increased impoverishment, disasters, and pressures on governance. It has suggested the need for a more proactive adaptation and mitigation policy in Asian countries. The impacts of climate change on resources, both positive, in terms of increased access to some resources, and negative, in terms of reduced availability of others, and constraints on a country's room to manoeuvre on yet others through the possibility of carbon caps, may well lead to greater competition for resources and acrimony amongst states. The paper has argued that impacts and adaptation have received less attention relative to the discussions on GHG emissions and mitigation policies and measures. This is partly because mitigation has traditionally been viewed as being more central to climate policy, and also because the impacts and adaptation sections of the National Communications Guidelines of respective countries have much less detail and specificity. Hence, the adaptation processes, particularly in developing countries, need to be strengthened and accelerated keeping in mind the potential impacts of climate change on these countries. Much of the adaptation will have to be autonomous, driven by market forces and by the needs of households and firms. However, much more needs to be done internationally, especially in terms of designing new and innovative funding for adaptation. Three clear streams of funding emerge if adaptation measures are filtered according to the services they provide (Anantram and Noronha 2005).

1. 'New' funding for international and regional collaborations and programmes for adaptation measures that provide regional and global public goods to meet adaptation priorities;
2. 'Additional' funding to top up development aid programmes (greater value for resources invested) to support the provisioning of goods and services to enhance adaptive capacity at the country level;
3. Special compensatory funding designed on the basis of fairness and 'polluter pays' arguments that recognize differential vulnerabilities and the least advantaged to support activities and measures that reduce vulnerability of individuals and communities in developing countries.

Another important new task for governments will be to provide firms and communities with high-quality information systems and also integrate adaptation into their overall development objectives and plans across the board. Strategic pressure is needed to create international and regional institutions to address the gross inequity of climate change to avoid traditional security risks. There is also a need to improve the quality of collective action through better institutions for cooperation, and this requires political will, mutual trust, and shared objectives.

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Climate change in the South Asian context with a special focus on India: a review[1]

Joyashree Roy[2]

Introduction

South Asia includes the Indian subcontinent (India, Pakistan, Bangladesh, and Nepal) as well as Sri Lanka, Maldives, and Bhutan. It is argued that this region is particularly vulnerable to predicted climate change impacts because of its population load, low adaptive capacity, several unique and valuable ecosystems (coral reef, large deltaic region with rich biodiversity), and vast low-altitude agricultural activities. Although the region comprises 3% of the world's land area, it is home to more than 20% of the global population. India alone accounts for almost 75% of the landmass.

Proactive response and action in the context of climate change in the South Asia region is limited by the availability of information on the net benefit of damage reduction. There are no conscious efforts to internalize climate variability in the investment decisions of today. The real challenge is to integrate climate concerns in fast growing economies into their development agenda. For the developing countries, the top priority is development, both economically and politically.

The purpose of this article is first, to understand the status of the available information on climate variability and impacts. The second objective is to make an assessment based on reactive adaptation that communities or stakeholders have followed in the past in case of extreme climatic events. This can help us understand the possible range of adaptation costs and justification for proactive actions for mainstreaming

[1] The article is based on the report prepared and submitted by the author's team to the *Stern Review on the Economics of Climate Change*. See <http://www.sternreview.org.uk>

[2] Professor of Economics, Coordinator, Global Change Programme, Jadavpur University, Kolkata, India

climate policy. Thirdly, we intend to identify the research and knowledge gaps in the South Asia region in order to make an assessment of the economic benefits of reduction of damage associated with predicted climate variability.

Inputs for the current assessment have been collated from two sets of literature. First, the review of the model has been based on climate variability predictions and associated impact assessments in the context of countries in South Asia with special reference to India. Secondly, past reports/studies related to natural calamities and disasters in the South Asian context have been studied, which are expected to reflect the possible range of damages from predicted extreme events.

Observed climate variability

Temperature

- There has been a general rising trend in surface temperature in the order of 0.5 °C±0.1 ° C over the entire South Asia region during the past century.
- For India, a warming rate of 0.4 °C for 100 years in mean annual temperature has been observed during 1901–82. But this rate is not spatially uniform.
- Winters are becoming milder.
- Warming has been observed in Bangladesh, Nepal, and Pakistan as well.
- In Nepal, the trend is higher in higher latitudes—0.6 °C to 1.2 °C per decade.
- Pakistan has experienced a cooling of 0.4 °C to 2.6°C, as well as warming of 0.1 °C to 4.0 °C.
- Bangladesh has been experiencing moderate increases in temperature in the post-monsoon period, and strong warming (0.1 °C–0.3 °C per decade) during the monsoon season.
- For India, Bangladesh, and Pakistan, the rise in temperature is attributed to an increase in maximum temperature, while in Nepal the amplitude of variation of minimum temperature is significantly more than that of the maximum temperature.

Rainfall

- No significant trend exists in all-India rainfall over the period of record (since 1871).
- Changes are observed in smaller spatial scales.
- Inter-annual variability is a feature of the South Asia region.
- The trends have been the result of weak monsoons, negative Southern Oscillation Index, and impacts of El Niño over a century.
- There have been strong monsoons and La Niña impacts.
- Dry regions have grown drier by 10% in the last 100 years.
- The most vulnerable areas in the region are the Indo-Gangetic plains, Bangladesh, Assam, and the Sabarmati region.

Extreme events

- Extreme hydro-meteorological events frequently occur in South Asia.
- GLOFFs (glacial lake outburst flood) are common.
- Instrumental records over 130 years do not show any significant long-term trend on frequency in large-scale drought or flood.
- Over the Bay of Bengal and the Arabian Sea, significant and consistent warming of sea surface has occurred during the twentieth century.
- More cyclones occur in the Bay of Bengal than in the Arabian Sea.
- Bangladesh has suffered from more storm surges than any other country.

Predicted climatic variability: trends and extremes

Temperature

Lonergan S (1998) estimates that India's climate could become warmer under conditions of increased atmospheric CO_2 (carbon dioxide) emissions. The average temperature change is predicted to be in the range of 2.33 °C to 4.78 °C with a doubling in CO_2 concentrations. Lal, Cubasch, Voss, *et al.* (1995) present a climate change scenario for the Indian subcontinent which takes projected emissions of GHGs (greenhouse gases) and sulphate aerosols into account. It predicts an increase in annual mean maximum and minimum surface air temperatures of 0.7 °C and 1.0 °C over land in the 2040s with respect to the 1980s. Since the warming over land is projected to be lower in magnitude than that over the adjoining ocean, the land–sea thermal contrast – which drives the monsoon mechanism – could possibly decline. However, there continues to be considerable uncertainty about the impacts of aerosols on the monsoon, and the scientific information is still inconclusive on the possible impact of a decline in the monsoon. The Regional Climate Model results predict the following for India, under the A2 and B2 scenario,[3] by the end of the century (Kumar, Sahai, Krishnakumar, *et al.* 2006; Sathaye, Shukla, and Ravindranath 2006).

- A 3–5 °C rise in mean surface temperature under the A2 scenario and a 2.5–4 °C rise under the B2 scenario.
- Extreme temperatures and precipitations are expected to increase.
- Both night and day temperatures are expected to increase, but nights will be warmer in the future scenario.
- Regionally, northern India will be warmer.

Rainfall

There will be an increase in the frequency of heavy rainfall events in South and South-East Asia (IPCC 1998). By the year 2050, the average annual runoff in the Brahmaputra river will decline by 14%. Studies have indicated that the impact of snow melting in the high Himalayas will lead to flood disasters in Himalayan catchments. The impacts will be observed more in the western Himalayas as the contribution of snow to the runoff of major rivers on the western side is about 60% compared to 10% on the eastern side (IPCC 2001). Singh (1998) suggests that an increase in surface temperatures will lead to a rise in the snowline, increasing the risk of floods in North India during the wet season. In the long run, rivers that are dependent on snowmelt will have less water. Kumar, Sahai, Krishnakumar, *et al.* (2006) predict a 20% rise in summer monsoon rainfall in the Indian subcontinent. All states will have increased rainfall except Punjab, Rajasthan, and Tamil Nadu, where it will decrease. Extreme precipitation will increase, particularly along the western coast and in west-central India. The mean temperature in India is projected to increase from 0.1 °C to 0.3 °C in the *kharif* season (summer) and from 0.3 °C to 0.7 °C in the *rabi* (winter) season by 2010, and from 0.4 °C to 2 °C in the *kharif* season and 1.1 °C to 4.5 °C in the *rabi* season by 2070 (IPCC 1996). Mean rainfall is projected not to change by 2010 but may increase by 10% during the *rabi* season by 2070.

Extreme events

More frequent and extreme natural events (such as droughts, flood, storms, and cyclones) are expected to occur even with a 2 °C rise in global mean temperature. Increasing susceptibility to droughts in the western parts of the Indo-Gangetic plains have been predicted along with increased monsoon activity in the eastern parts.

Major concerns

- The monsoon governs the hydrological system of South Asia.
- Low-latitude regions of the world will be vulnerable to climate change because of agricultural density and already high temperatures. South Asian agriculture amounts to over 50% of all low-altitude agriculture.
- Crop-based agriculture will be severely constrained.
- Extreme rainfall events that last a whole day, two days, and even three days, will increase.
- The Indo-Gangetic plains have been identified as the most vulnerable area with the highest population density.
- Cross-border river, mountain, and glacial systems; and easy migration potential of people add a special dimension.
- Monsoon-dependent agriculture will remain the single largest economic activity of the region.
- The stress on water resources will increase due to population growth and urbanization.
- The residential sector continues to show rising energy intensity trends.
- The poor are the most vulnerable due to their low coping capacity.
- The cereal yield of year 2050 is estimated to be 4.1 times that of 1961 and 1.7 times that of 1999. However, population growth is expected to balance out the per capita availability if food trade and arable land remain unchanged.
- Uneven distribution of NPP (net primary product) in South Asian countries will possibly cause regional differences in predicted cereal yields and socio-economic impacts.

[3] In the A2 scenario, social and political structures diversify. With substantial food requirements, agricultural productivity in the A2 world is one of the main focus areas for innovation and RD&D (research, development, and deployment) efforts, and environmental concerns. Global environmental concerns are relatively weak, although attempts are made to bring regional and local pollution under control and to maintain environmental amenities. Final energy intensities in A2 decline with a pace of 0.5–0.7% per year. The A2 scenario is characterized by lower trade flows, relatively slow capital stock turnover, and slower technological change. The B2 storyline and scenario describe a world in which the emphasis is on local solutions for economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change.

Impact assessment: market and non-market sectors

Ideally, economic impact assessment is expected to cover monetary valuation of the impacts (damaging as well as beneficial) of climate variability, covering both the market (agriculture, forest, and fisheries) and non-market (health, biodiversity, and ecosystem) sectors. The economic indicators range from income, employment, and expenditure to poverty indices. Over the last decade, a vast body of literature has emerged discussing the possible impacts of climate variability. The methodology for the economic assessment of externality is also taking mature shape in environmental economics literature (Roy and Sahu 2004). However, despite all these, almost none of the studies have attempted to analyse the impact of climate change through economic assessment exclusively for the South Asian region. Only a handful of studies have covered South-East Asian countries, looking at South Asian countries partially; or have extrapolated the results obtained for India. Most of the studies available are for India. These, too, are limited so far as economic assessments are concerned. Productivity loss studies due to climate variability and extremes have been attempted by a number of researchers. Only a few studies – Kumar and Parikh (1998); Kapshe, Shukla, and Garg (2003); and Roy, Ghosh, Majumdar, *et al.* (2005) – have tried to estimate economic damages taking into consideration a number of economic indicators, such as GDP (gross domestic product), revenue, price, yield, and expenditure. These studies cover both macro-, as well as micro-level impact assessments. Some of the micro-level studies have been done in the context of a number of countries, either by applying the same methodology (Sharma, Roy, Kumar, *et al.* 2003) or different methodologies. Micro-level studies are mostly related to extreme events through the analysis of past damages or based on people's perception surveys or stakeholder interview methods. These studies mostly cover rural areas. Several indicators, such as livelihood, income, adaptive actions, livestock loss, and health, have been tried out. Macro studies are based on varying climate scenarios and based on alternative socio-economic scenarios. They try to assess the impacts on either the aggregate economy or particular sectors.

Methodologies adopted differ across studies, leaving little scope for comparison. The two groups of literature – climate change studies and disaster-related damage studies – have used macro models and micro-analytical study models. Macro studies have tried top-down as well as bottom-up approaches.

Climate change literature

India-specific results (GoI 2004), using climate scenarios predicted from RCM (see Annexure) and SWAT model (Gosain and Rao 2003; Gosain, Rao, and Basuray 2006), BIOME 4 (Ravindranath, Joshi, Sukumar, *et al.* 2006), simulations for mean sea level (Unnikrishnan, Kumar, Fernandes, *et al.* 2006), malaria transmission window analysis (Bhattacharya, Sharma, Dhiman, *et al.* 2006), and simulations based on dynamic crop models (GoI 2004) show the following findings.

- The hydrological cycle is likely to be altered. Drought and flood intensity will increase. Overall runoff will decline. The Krishna river basin will experience severe drought conditions.
- Crop yield will decrease with temperature.
- The overall effect will be crop productivity decline induced by decline in crop duration.
- Under the A2 and B2 scenarios, there will be shifts towards wetter forest types. Due to CO_2 increase and warming, NPP will grow to double under the A2 and 70% under the B2 scenario for the forestry sector.
- Frequencies and intensities of tropical cyclones in the Bay of Bengal will increase, particularly in the post-monsoon period and there will be increased flooding in low-lying coastal areas. Sea-level rise of less than 1 mm/year has been predicted for Mumbai, Visakhapatnam, and Kochi (much evidence); but there is probability of a decrease in sea level around Chennai.
- Malaria-prone states will continue to be so (Orissa, West Bengal, and southern parts of Assam bordering West Bengal). This may later shift from the central Indian region to the south-western coastal states of Maharashtra, Karnataka, and Kerala. New regions (states like Himachal Pradesh, Arunachal Pradesh, Nagaland, Manipur, and Mizoram) may become malaria-prone and the transmission duration window may widen in northern and western states and shorten in the southern states.
- Desertification will increase.
- The carbon mitigation curve (Sathaye, Shukla, and Ravindranath 2006) for India for 2005–2035 has been estimated as upward rising and non-linear.

Agriculture

Agriculture and allied activities constitute the single largest component of India's economy, contributing nearly 27% of the total GDP, and exports account for 13–18% of the total annual exports of the country (MoF 2002). However, given that 62% of the cropped area is still dependent on rainfall (MoEF 2002), Indian agriculture continues to be fundamentally dependent on the weather. The impacts of climate change on agriculture are critical in India. As some 75% of the population lives in rural areas, agricultural performance is closely related to poverty levels. The focus is on the two main cereal crops – rice and wheat – in terms of the effects of climate change on crop yields, overall food production, and welfare. Sharma, Roy, Kumar, *et al.* (2003) predict that there will be decline in GDP for India, either due to direct effects such as changes in temperature, precipitation, or CO_2 concentrations; or indirect effects such as changes in soil, distribution and frequency of infestation of pests, and water stress. The adaptability of farmers in India is severely restricted by heavy reliance on natural factors and the lack of complementary inputs and institutional support systems, which leads to the worsening of the scenario. A major source of information is the National Communication of the Government of India (GoI 2004), where most of the results focus on productivity loss estimates, but very little on economic valuation associated with those estimates.

Acute water shortage conditions, combined with thermal stress, could adversely affect wheat and, more severely, rice productivity in India even under the positive effects of elevated CO_2 in the future. The simulations of four different sites (Kalra, Aggarwal, Chander, *et al.* 2003; GoI 2004) under various climate change scenarios for each crop suggest that the following results may be expected.

- The yields of both crops – rice and wheat – would decrease with a rise in temperature levels and increase with a rise in precipitation.
- Higher CO_2 concentrations in the atmosphere would have beneficial effects for both crops by increasing the rate of photosynthesis, radiation use efficiency, and water use efficiency.
- Increased CO_2 levels would be more favourable for wheat than for rice.

Overall, the simulation suggests that temperature rise is going to have the following effects.

- Larger negative impacts are expected to neutralize positive impacts, if any, of CO_2 fertilization.
- Net yield losses in rice under irrigation could be some 13%–22%, compared with losses of 16%–34% for wheat.
- Quality of products such as cotton, fruits, vegetables, tea, coffee, aromatic and medicinal plants, and the nutritional quality of cereals and pulses may be moderately affected.
- Decline in grain protein content in cereals could partly be related to increasing CO_2 concentrations.
- Wheat yields in central India are likely to suffer by up to 2% in the pessimistic scenario[4], but there is also a possibility that these might improve by 6% if the global change is optimistic.
- Changes in soil water induced by global climate change may affect all soil processes and, ultimately, crop growth.
- An increase in temperature would also lead to increased evapotranspiration, which may result in the lowering of the groundwater table at some places.
- Increased temperature, coupled with reduced rainfall, may lead to upward water movement, leading to accumulation of salts in upper soil layers.
- A rise in sea level associated with increased temperatures may lead to salt-water ingression in the coastal lands, making them unsuitable for conventional agriculture.
- An increase of 1 °C in soil temperature may lead to higher mineralization.

Forests

Climate is an important determinant of the geographical distribution, composition, and productivity of forests. Therefore, changes in climate could alter the configuration and productivity of forest ecosystems. NTFPs (non-timber forest products) provide about 40% of total official forest revenues and 55% of forest-based employment. In India, about 200 million people depend on forests directly or indirectly for their livelihoods. Indian forests support more than 5150 plant species, 16 214 insect, 44 mammal, 42 bird, 164 reptile, 121 amphibian, and 435 fish species. Forests meet nearly 40% of India's energy and 30% of fodder needs. In India, out of 15 000 plant species, 3000 species yield NTFPs such as fruits, nuts, edible flowers, medicinal plants, rattan and bamboo, honey, and gum.

The aggregate quantity of potentially extractable NTFPs is projected to lead to the following.

- Increase in expanding evergreen and moist deciduous forest types
- Decline in the dry deciduous, dry thorn, and montane forest areas

As a result, there will be an increase in income from potentially extractable NTFPs with the income per hectare likely to increase by about 22%. However, there is uncertainty regarding the transient response of

[4] A scenario with the highest increase in temperature and the lowest increase in CO_2 would be detrimental to crop growth and hence, is known as a pessimistic scenario.

Table 1 Climate models and predictions of impacts for Indian agriculture

Sector	*Assumptions*	*Impact*	*Source*	*Region*	*Strength /weakness*
Aggregate agriculture	Temperature rise from 2.7 °C to 5.4 °C Cross-section data used, local adaptation included	Loss up to $87 billion,	Mendelsohn (2005)	India	Price change effect ignored, CO_2 fertilization effect not included
Rice and wheat yield	A2, B2 scenario	Decline	Sharma, Roy, Kumar, *et al*. (2003)	India	
Yields of soyabean	Increase in temperature by 2– 4 °C; ± 20% to ± 40 % change in precipitation	Decline by 18%–22 %	Lal, Singh, Rathore, *et al*. (1998)		CO_2 fertilization ignored
Farm level net revenue	Temperature rise by 2–3.5 °C	Decline by 9%–25%	Kumar and Parikh (1997, 1998)	India	Considers imperfect land market and administered price
GDP		Drop of 1.8%–3.4%	Kumar and Parikh (1997, 1998)	India	Without considering the carbon fertilization effect
Agricultural prices relative to non-agricultural prices		Increase by 7%–18%	Kumar and Parikh (1997, 1998)	India	Without considering the carbon fertilization effect
Farm level total net revenue	Rise in temperature by 2 °C and an accompanying precipitation change of +7%, with adaptation by farmers of cropping patterns and inputs	Fall by 9%	Kumar and Parikh (1997, 1998)	India	With adaptation by farmers of cropping patterns and inputs
Agricultural net revenues	2 °C rise in mean temperature and a 7% increase in mean precipitation	Drop by 12.3%	Sanghi, Mendelsohn, and Dinar (1998)	India	Includes adaptation options
Agriculture in coastal regions		Most negatively affected	Sanghi, Mendelsohn and Dinar (1998)	Gujarat, Maharashtra, and Karnataka	
Agriculture in coastal regions		Small losses	Sanghi, Mendelsohn and Dinar (1998)	Punjab, Haryana, and western UP	
Agriculture, coastal infrastructure, tourist activities, and onshore explorations		High risk	Sanghi, Mendelsohn and Dinar (1998)	India	
Rice	2 °C rise in temperature 1.5 °C rise +2 mm rainfall rise + 460 PPM CO_2	Decline by 0.06–0.075 tonne/ha Increase by 12%	Sinha and Swaminathan (1991) Saseendran, Singh, Rathore, *et al*. (1999)	Southern India	
Wheat	2 °C rise 425 PPM CO_2 2 °C rise + 425 PPM CO_2	Decline by 1.5%–5.8% Decline by 17%–18% Decline by 10%	Aggarwal and Kalra (1994); Kumar and Parikh (1997, 1998) Kumar and Parikh (1997, 1998)	Subtropical and tropical India in Punjab and Haryana	
Maize	2 °C rise + 425 PPM CO_2	Decline by 7%–12%	Chatterjee (1998)	Northern India	
Aggregate	1.5–2.5 °C	Drop by 2% of GDP	Mendelsohn (1996)	India	Baseline development trend, adaptation included

CO_2 – carbon dioxide; GDP – gross domestic product'; ha – hectare; PPM – parts per million

Table 2 Projected change in area under different types of forest in the Nilgiris, Western Ghats

Forest type	*Baseline area* (km^2)	*Most likely scenario (2020) Temp + 0.3°C, rainfall + 2%*	*Most likely scenario (2050) Temp + 0.6 °C, rainfall + 4%*	*Worst case scenario (2050) Temp +0.9 °C, rainfall –8%*
Evergreen	585	+13.4%	+22.0%	–3.7%
Dry thorn	2083	+12.8%	+12.3%	+32.9%
Moist deciduous	895	+14.0%	+26.9%	+16.8%
Dry deciduous	1624	–27.4%	–36.4%	–47.7%
Montane/grassland	289	–3.1%	–7.3%	–9.1%

Source Ravindranath and Sukumar (1998)

vegetation to climate change and this could lead to forest dieback and loss of vegetation. Conversely, fuel wood and timber production may increase due to increased productivity as a result of increased CO_2 fertilization and nitrogen deposition. Under moderate climate projections, the total area under tree cover in all biomes except the tundra and xerophytic woods in Himachal Pradesh is projected to increase by 11%. The tundra forests show a uniform downward trend with sharp reduction in area by early 2020. By 2080, more than 70% of the area under tundra forests is projected to decline under the moderate scenario. GCM (global climate model) projections (for example, the Hadley Centre Model, HADCM2) for India indicate an increase in precipitation by up to 30% for the north-eastern region, in addition to a relatively moderate increase in temperature of about 2 ºC by the period 2041–60. This could increase the incidence of flooding in the Brahmaputra basin and thus favour the maintenance of moist grasslands in the region. For the rest of the country (southern, central, and north-western) a steep increase in temperature by 3 ºC in the southern (except along the coast) to over 4 ºC in the north-western, and a decrease in precipitation of over 30% in the north-western regions would cause major changes in the composition of present-day vegetation in these regions, with an overall shift to a more arid type. Increased atmospheric CO_2 levels and temperatures, resulting in lowered incidence of frost, would favour exotic weeds such as wattle, which could invade the montane grasslands of the Western Ghats. The cool, temperate grasslands of the Himalayas could also be impacted by rising temperatures, which would promote the upward migration of woody plants from lower elevations.

Infrastructure and energy

Infrastructure includes road, rail, airways, river systems, electric power systems, and all the different types of communication and service lines. It also includes the built and engineered entities—factories, buildings, dams, and other structures that comprise cities and towns. Infrastructure refers to the man-made lifelong assets. Cyclones on the eastern and western coasts of India and landslides caused by heavy rainfall in the Konkan region indicate that infrastructure is vulnerable to extreme climatic changes. The tables below present a qualitative comparison of the author's assessment of the extent of magnitude, possibility of occurrence, sensitivity, adaptability, and vulnerability of the two sectors (Kapshe, Shukla, and Garg 2003).

Table 3 Sensitivity, vulnerability, and adaptability: infrastructure sector

CC criteria	*Magnitude*	*Occurrence*	*Sensitivity*	*Vulnerability*	*Adaptability*
Temperature rise	Medium	High	Medium	Low	High
Precipitation rise	Medium	Medium	Medium	Medium	Medium
Sea-level rise	Medium	Medium	Medium	Medium	Low
Extreme events	High	Low	Medium	High	Low

CC – climate change

Table 4 Sensitivity, vulnerability, and adaptability: energy sector

CC criteria	*Magnitude*	*Occurrence*	*Sensitivity*	*Vulnerability*	*Adaptability*
Temperature rise	High	High	High	Medium	High
Precipitation rise	Medium	Medium	Medium	Low	Medium
Sea-level rise	Medium	Medium	Medium	Medium	Low
Extreme events	High	Low	Medium	High	Medium

CC – climate change

Health

Current climate trends have shown an increase in maximum temperatures, heavy intense rainfall in some areas, and the emergence of intense cyclones. In the summer of 1994, western India experienced temperatures as high as 50 °C, providing favourable conditions for disease-carrying vectors to breed. In 1994, western India was flooded with rains for three months, while the western state of Gujarat was hit by a malaria epidemic (Bhattacharya, Sharma, Dhiman, *et al.* 2006). Changes in climate may alter the distribution of important vector species and may increase the spread of disease to new areas that lack a strong public health infrastructure. High-altitude populations, which fall outside areas of stable endemic malaria transmission, may be particularly vulnerable to malaria due to warming. The seasonal transmission and distribution of many other diseases transmitted by mosquitoes and by ticks may also be affected by climate change.

Table 5 Health impacts

Health concerns	*Vulnerabilities due to climate change*
Temperature-related morbidity	▪ Heat- and cold-related illnesses ▪ Cardiovascular illnesses (GoI 2004)
Vector-borne diseases	▪ Changed patterns of diseases ▪ Malaria, filarial, kala-azar, Japanese encephalitis, and dengue caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks, and other vectors. ▪ Resurgence ▪ In 1998, about 57 7000 DALYs (disability adjusted life years) were lost
Health effects of flood and drought	▪ Diarrhoea, cholera, and poisoning caused by biological and chemical contaminants in the water (even today about 70% of the epidemic emergencies in India are water-borne); cost of water-borne disease and/or welfare loss per household per month amounts within the range of Rs 187–297 (Roy and Sahu 2004; Roy, Chattopadhyay, Mukherjee *et al.* 2004; Roy 2007) ▪ Damaged public health infrastructure due to cyclones/ floods. (Ghosh and Roy 2006; Roy, Ghosh, Majumdar, *et al.* 2005) ▪ Injuries and illnesses (Muhammed 2003) ▪ Social and mental health stress due to disasters and displacement. (Muhammed 2003) ▪ Children are affected the most
Health effects due to crop damages from flood and drought	▪ Malnutrition and hunger, human as well as livestock (Muhammed 2003)

Disaster literature

Under climate variability scenarios – given the predictions of more frequent floods, droughts, cyclones, and storm surges – we have reviewed two types of literature. First, secondary databased studies and reports which concentrate on assessment through losses suffered, such as physical loss of assets and livelihood, and secondly, case studies based on primary-level data collected from direct interviews of the stakeholders to understand more closely the actual losses faced by the households and to understand the adaptive behaviour and technological and institutional issues involved in the adaptation process, or vulnerability assessment, have been reviewed. The goal is to assess damage as well adaptive actions—reactive as well as proactive. Vulnerability is directly linked to adaptive capacity. The more the adaptive capacity, the less will be vulnerability. Case-study-based damage assessment was done for rural areas of four countries – Bangladesh, India, Nepal, and Pakistan – to assess the impact of flood and drought by analysing people's responses and perceptions through household surveys and community responses through PRA (participatory rural appraisal). The same survey instruments were used to maintain uniformity and comparability. For India, further analysis was done to assess impact though the LIFE (livelihood, institution, food security, and empowerment) approach (Ghosh and Roy 2006). Increases have been predicted in frequent and intensive floods and droughts, which are likely to have unfavourable impacts on basics such as livelihood options, food security, health, and social infrastructure of the hotspots (Roy and Ghosh 2003; Roy, Chattopadhyay, Mukherjee, *et al.* 2004; Roy, Ghosh, Majumdar, *et al.* 2005; and Ghosh and Roy 2006) The bottom-up approach to adaptation strategy assessment starts from the identification of hotspots, understanding vulnerabilities and identifying coping mechanisms for the households and communities based on current levels of climate variability. The framework adopted here starts from the premise that adaptive actions from both the vulnerable groups with private motives as well as government and non-government external agencies with social welfare motives generate private and public goods and services. Careful analyses of these provide us with a portfolio of actions. It is useful to characterize adaptation strategies by the nature of action – public or private – and the time scale to phase out the action profile based on the stated response of the vulnerable groups. The general observation is that these effects usually put an additional burden on the poverty alleviation policies of the government.

Damage predictions due to sea-level rise are a major cause for concern for countries with long coastlines. A recent Asian Development Bank study reports that a 1-metre rise in the sea level in India in the absence of protection would have the following impacts.

- Approximately 7 million people would be displaced.
- Around 5764 km^2 of land would be lost due to inundation.
- Some 4200 km of roads would be destroyed

A rise in sea level has significant implications on the coastal population and on the agricultural performance of India. A variety of impacts are expected, which include the ones listed below.

- Land loss and population displacement
- Increased flooding of low-lying coastal areas
- Agricultural impacts (such as loss of yield and employment) resulting from inundation, salinization, and land loss
- Impacts on coastal aquaculture
- Impacts on coastal tourism, particularly the erosion of sandy beaches

Knowledge gap

More research is needed to refine the estimates of damage cost in this region and to identify potential adaptation options and associated costs and benefits for stakeholder categories. They have been summarized in tables 6 to 8.

Table 6 Economic sectors

Sectors	*Impacts studied*	*Economic valuation*
Agriculture	▪ Decline in productivity, by crop	Limited availability in both kinds of literature
Forest product	▪ Increased productivity	NA
	▪ Migration of forest types to higher elevations	NA
	▪ Transformation of drier forest types to moister types	NA
	▪ Reduced teak productivity from 5.40 m^3/ha to 5.07 m^3/ha	NA
	▪ Productivity of moist deciduous forests could decline from 1.8 m^3/ha to 1.5 m^3/ha	NA
	▪ Loss due to extremes	Quantification NA
NTFP	▪ Gain as well as loss	NA (limited availability in non-climate literature)
Infrastructure	▪ Damage to road, public health, coastal areas	Very limited availability in disaster literature

ha – hectare; m^3 – cubic metre; NA – not available

Table 7 Non-economic sectors

Sector	*Observed and predicted physical impact*	*Country*	*Economic valuation*
Grassland	▪ Favourable impact on moist grass land	India	NA
	▪ Shift in arid grass lands	India	NA
	▪ Migration of woody plantation to high elevations	India, Nepal	NA
Inland or freshwater wetlands	▪ Increased temperatures and lower precipitation as projected for central and north-western India	India	NA (limited availability in non- climate literature)
Coral reefs	▪ Bleaching of over 80% of coral cover and mortality of over 25%	Lakshadweep, India	NA
	▪ Acopora and Pocillopora that were almost completely wiped out	Gulf of Mannar, India	NA
	▪ Loss of shallow water corals	Gulf of Mannar, India	NA

NA – not available

Table 8 Health sector

Health concerns	*Vulnerabilities due to climate change*	*Economic valuation of marginal welfare loss*
Temperature-related morbidity	▪ Heat-cold-related illnesses ▪ Cardiovascular illnesses	NA
Vector-borne diseases	▪ Changed patterns of diseases ▪ Malaria, filaria, kala-azar, Japanese encephalitis, dengue caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks, and other vectors	▪ NA ▪ Limited information based on DALYs
Health effects of extreme weather	▪ Diarrhoea, cholera, and poisoning caused by biological and chemical contaminants in water (even today about 70% of the epidemic emergencies in India are water-borne) ▪ Damaged public health infrastructure due to cyclones/floods ▪ Injuries and illnesses ▪ Social and mental health stress due to disasters and displacement	▪ Limited literature available ▪ NA
Health effects due to insecurity in food production	▪ Malnutrition and hunger, especially in children	NA

NA – not available

Conclusion

Despite the absence of very systematic estimates of past and predicted damage costs caused by variability in temperature, rainfall, sea-level rise, and extreme events, the findings summarized above provide enough justification to ponder over development priorities of these countries and introduction of appropriate regulations. The total outlay for natural disaster relief has been about 0.3% of the country's GDP in India. GDP loss of 1%–5% in Bangladesh, Nepal, and Pakistan due to flood and drought can be avoided by prudent choice of actions. While the recovery period from natural disasters ranges from 2 years to 4 years if the return period also coincides with this time scale, which is very likely and has also been observed in the recent past, intensification of adaptation activities call for immediate attention. The challenge is to endogenize the adaptation measures to reduce the cost of reactive adaptation. Capacity building, when developed around traditional welfare issues such as poverty, low levels of economic activity, starvation, and health risks, can generate participation. The capacity to adapt to climate change calls for the reorganization of priorities in the development planning agenda. A climate-friendly development agenda, with a short-term agenda consistent with political realities, may be divided into two groups—technical and institutional.

Technical intervention

The ways in which technology may be best utilized, or the scope of technical intervention, are listed below, though not in an exhaustive manner.

- Improvement in weather forecast systems
- Communication of early warning systems
- Access to water sources—rainwater harvesting, local ponds, safe drinking quality water, water metering
- Designing flood-proof houses
- Creation of facilities to change surface irrigation to drip irrigation
- Designing solar active and passive buildings
- Management of local watershed areas
- Development of extreme-weather-resistant infrastructure
- Preparation of vulnerability maps
- Decentralization and conjunctive use of renewable energy technology
- Conjunctive use of water sources
- Creation of more and improved health-care facilities
- Development of vector-specific regional maps
- Recycling waste water and solid wastes

The barriers to the above-mentioned potential technological interventions are listed below.

- Huge cost burden
- Lack of information on available appropriate technology

- Lack of local know how/capacity
- Low capacity to implement
- Low financial sustainability of large-scale infrastructure investment projects

Institutional intervention

The ways in which institutional support may best be given, or the scope of institutional intervention, are listed below, though not in an exhaustive manner.

- Capacity building through continuous awareness programmes, targeted research, and training of urban local bodies and rural civic service providers and architects
- Communication of early warning systems through mass media
- Cooperation and coordination among emergency relief nodes and networks
- Strengthening of public distribution systems in extreme-event-prone zones with low coping capacity for human as well as livestock food security
- Implementation of volumetric water charges to reduce water waste
- Creation of incentives for green power
- Reportage of sustainability indicators
- Development of suitable pricing for health services
- Creation of improved risk management through early warning system and crop insurance

The barriers which may be faced while implementing these institutional features are listed below.

- Lack of awareness of the dimensions of the problem among policy-makers and implementing agencies
- Lack of knowledge about small steps in endogenizing adaptive responses
- Lack of awareness on the source of problems and actionable agendas among stakeholders

As far the interface between scientific research, physical and economic assessments of damage, and abatement/adaptation is concerned, action plans need to be strengthened through cooperation. Cooperation does not mean only global cooperation, but working out details at local levels, which provide a first learning step.

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Report of the Energy and Climate Special Event

AEI Secretariat

Background

The *World Energy Outlook 2004* predicts that in the business-as-usual scenario, the world's energy needs will be almost 60% higher in 2030 than they are now. Fossil fuels will continue to dominate the global energy mix, meeting most of the increase in overall energy use. Hence, the contemporary energy situation poses a very serious challenge, particularly for the developing countries, which are more vulnerable to energy shocks and climate-induced natural disasters. The important concerns for emerging economies at this point in time are basically two-fold. First, the availability of energy to meet the growing demand poses a serious concern regarding energy security for developing economies, which are heavily dependent on energy imports. Sustainable development of a region will depend greatly on the reliability of energy supply at reasonable prices. For instance, as a net oil importer, developing Asia is vulnerable to high oil prices, and faces tough choices in limiting inflationary pressures and reducing fiscal burden due to fuel subsidies, which again hurt the region's growth momentum. Moreover, the world's vulnerability to supply disruptions may increase with geopolitical uncertainties. Secondly, climate destabilizing carbon dioxide emissions will continue to rise, given the current and projected high dependence on hydrocarbons. The path of development chosen by countries, which determines the future growth of energy and emission trajectories, will be greatly influenced by technological developments, economic cooperation between countries on energy security issues, and global cooperation in limiting GHG (greenhouse gas) emissions.

Energy and Climate—a special event at DSDS 2007

In the context of the twin concerns of energy security and climate change, the 'Energy and Climate' workshop, organized as a special event on 23 January 2007 during the DSDS (Delhi Sustainable Development Summit) 2007, was designed to provide an opportunity for the energy and climate change community to come together to identify issues for discussion that would help develop a collective and long-term vision for a more energy and climate secure world.

The workshop was organized by TERI and AEI, and supported by the Nand & Jeet Khemka Foundation.[1] Over the years, the DSDS has emerged as an important annual event, and a credible platform for international deliberation and dialogue on issues of long-term sustainable development. The DSDS was the most opportune time to organize this workshop, since it brought together prominent leaders in government, corporate, non-profit organizations, and other stakeholders, resulting in discussions for practical and workable strategies to take the sustainable development agenda forward. The workshop aimed to address the following questions.

- What is the impact of the changing energy landscape on the global climate system?
- What are the means through which countries aspire to address both energy and climate concerns?
- Is there any institutional mechanism through which the twin concerns of energy and climate could be addressed?
- How far do the international initiatives on energy and climate address concerns in the developing countries?
- How are the developing countries coping with energy and climate concerns?

The workshop was technically planned in two sessions. In Session 1, energy and climate concerns were discussed within an international perspective. Session 2 of the workshop dealt with more Asia-specific issues. Dr R K Pachauri (Director General, TERI and Chairman, IPCC [Intergovernmental Panel on Climate Change]) and Dr Adnan A Shihab-Eldin (Former Acting Secretary General, OPEC [Organization of Oil Exporting Countries] and Adviser to Kuwait Petroleum Corporation) chaired the two sessions respectively. The panel of speakers for the first session included Mr Claude Mandil (Executive Director, International Energy Agency); Dr Adnan A Shihab-Eldin; Mr C Dasgupta (Distinguished Fellow, TERI, India)

[1] The Nand & Jeet Khemka Foundation is an Indian public charitable trust, whose mission is to develop and promote institutions and initiatives that make a substantial impact on poverty, deprivation, and disempowerment of the human and natural environment through an approach that is long-term, strategic, and leveraged. It has launched, in partnership with the Resource Alliance, the India NGO Award–a new initiative aimed at advancing India's non-profit sector by promoting financial and organizational stability, and strengthening community support of civil society.

and Dr Jaakko Helminen (Senior Meteorologist, Finnish Meteorological Institute, Finland). The panel of speakers for the second session included Prof. Akio Morishima (Chair of the Board of Directors, Institute for Global Environmental Strategies, Japan); Dr Ajay Mathur (Director-General, Bureau of Energy Efficiency, India); Dr R B Grover (Director, Strategic Planning Group, Atomic Energy Commission, India); Mr Vikram Singh Mehta (Chairman, Shell Group of Companies, India) and Prof. Wei Zhihong (Former Director, Global Climate Change Institute, Tsinghua University, China).

Session 1: summary of the presentations

The changing global energy landscape—supply and climate concerns,

Mr Claude Mandil (Executive Director, International Energy Agency)

The world is on an unsustainable path as far as global warming is concerned. In the BAU (business as usual) scenario, CO_2 emissions worldwide will increase by more than 50% between 2007 and 2030. To combat this, technology breakthroughs such as carbon capture and sequestration and alternative energy sources such as nuclear and renewables are very much needed. This entails a lot of R&D, (research and development) with results that would be expected in the long term. Hence, energy-efficiency improvements are the key to immediate actions and immediate results if emissions have to be reduced. Every country in the world has to accomplish its share of increased energy efficiency, but it is even more important in countries that face the need for huge investments. Though the consumer countries agree that combating global warming is important, they consider that it is more important to resolve the shortage of oil in their economies given the 'peak oil theory'. On the other hand, the producer countries argue that it is not right if the consuming countries reduce oil consumption, since it is the only source of income for the former.

However, according to the speaker, the peak oil theory is probably not correct. If coal, gas, and biomass are all added to liquids, then there is no foreseeable future for peak oil demand. There will be enough oil in the future (though it will come from a limited number of countries, and in particular, from OPEC countries). Hence, in the long-term scenario, even with a lot of energy-efficiency improvements in consuming countries, oil consumption is likely to increase. Hence, it is necessary to invest and increase production in OPEC countries even if consuming countries do their best to reduce their consumption of oil. For this to happen, there is a need for dialogue between consumers and producers to ensure that enhancement of energy supply capacity is well-coordinated with expected changes in energy demand over time.

Energy security and climate concerns from a producer perspective

Dr Adnan Shihab Eldin (Former Acting Secretary General, OPEC, and Adviser to Kuwait Petroleum Corporation)

There is a strong correlation between energy consumption, development, and creation of wealth. Oil consumption is bound to increase in future, and if oil consumption has to increase in a sustainable manner then it has to be consistent with not only economic development but also with other sustainability issues such as the environment. It is expected that renewables will continue to grow by double-digit figures, but starting from a small base, it would be a long time before they became a significant part of the equation. There is also the probability of a resurgence of fission nuclear power. The peak oil argument is a matter of concern, since at present, there are about three barrels left for every barrel that is consumed. Further, there is a need to examine energy security challenges from both the consumer and producer country perspectives. Sustainability for consumers is very important, where adequate resources are needed at affordable prices, but sustainability from a producer point of view will deal with making timely investments to get good returns. With regard to the problem of sustainability of high energy prices, recent price rises were demand-driven but there were other factors at work, which made it very difficult to predict the probable stable price level.

With regard to energy consumption, even if developing countries grow, their per capita energy consumption will be very low as compared to that of the developed nations. The industrial countries had gone through the same phase in the past, and if a country was developing fast, it was inevitable that it would be wasteful. This raises the question of fairness and equity. Technological advances to improve the environmental credentials of oil production and use must accompany the expected increase in the use of oil. Developing and making fuller use of all such technologies in an orderly fashion will point towards more sustainable energy patterns, alleviating some of the downside risks to oil demand (from the producers' perspective) and ameliorate the resulting uncertainties in the magnitude and timing of future investment requirements. The global dimension of the challenge points to the need for identification of opportunities for cooperation on technological issues as an important objective. Dialogues between consumers and producers have improved significantly over the last few years and it is expected that these dialogues would be action-oriented in the future.

On the other hand, when the producing countries talk about demand security, they do not ask the consuming countries to guarantee consumption at a certain level, but they ask for a more orderly view of what the demand policy is going to be and what the demand would look like in the future. In this respect, the issue of carbon sequestration is very important. Particularly, CO_2 sequestration with enhanced oil recovery should receive more attention both from the producers' and the consumers' point of view. It is important from the producers' point of view since all of the CO_2 that is going to be produced over the next 20–30 years could be put in the global reservoirs of oil and gas. According to the IEA (International Energy Agency) estimates, 50% of the CO_2 emitted in 2030 could be put into depleting oil and gas fields. However, most of the sources are not located near storage places—if this problem could be overcome, then it would be possible to augment global reserves quite substantially. A number of international collaborations on this issue already exist. For instance, the IEA had one international collaboration called Greenhouse Gas Reduction, which OPEC has joined or was about to join. However, most of these collaborations are still focused on R&D and on sharing information. What is needed is an international collaboration, led by the OECD (Organization for Economic Cooperation and Development) – well funded – and focused on launching demonstration projects in various parts of the world, particularly where large storage potential exists.

It is important that consumer countries such as India follow up on these demonstration projects, being a carbon-intensive country, and consider the possibility of transporting CO_2 back for reinjection to the nearby fields in the Gulf and, thereby, add to the oil recovery there.

Energy and climate in society

Dr Jaakko Helminen (Senior Meteorologist, Finnish Meteorological Institute, Finland)

Energy and climate issues are very much societal issues. The important question that arises at this point is how to create awareness of energy and climate issues amongst the general public. The IPCC and the media have raised the general awareness on climate change and mitigation as concepts fairly well. However, knowledge among the general public is still inadequate. There are great challenges to be faced in bringing these concerns to the level of general education and among societal topics.

Climate change risks can be reduced by reducing vulnerabilities and creating better early warning systems so that necessary buffers could be built to avert potential disasters. For long-term planning, if adaptation is considered, there are four different issues of concern. First, humans will have to adapt themselves to the normal and natural variability of climate. Secondly, planning is required for adaptation to long-term changes resulting from anthropogenic emissions of GHGs (greenhouse gases). Thirdly, human-induced climate changes must be strategically mitigated through GHG emission reduction; and finally, adaptation is required in social and economic systems in order to keep human-induced changes of climate below dangerous levels. There are several planning horizons associated with this, starting from the intermediate horizon (starting from one month to a few years) to the centennial horizon (stretching over 100 years). As far as institutional mechanisms are concerned, bridges must be built between islands of ignorance. This means that multidisciplinary and multi-organizational collaborative interactive work needs to be facilitated much more than it has been in the past. Here, resilience is needed both in national and international solutions, and a lot of stability and versatility is needed to act proactively. Outcome orientation is a key for constructive interaction. For developing countries, vulnerabilities must be reduced by strengthening the baselines. While summarizing, the speaker mentioned that energy and climate issues were increasingly interconnected with society. Energy considerations cannot be limited just to mitigation issues. Proactive energy sector actions need to be taken both in climate mitigation and adaptation, and there is need for a wider interaction between the energy and climate sectors.

Mitigating climate change: role of developing countries

Mr C Dasgupta (Distinguished Fellow, TERI, India)

With negotiations in progress for the post-2012 Kyoto Protocol, the role of developing countries in climate change mitigation is increasingly being discussed and debated. There are insistent calls on developing countries to take on new commitments after 2012, either emission limitation commitments similar to those of Annex I countries, or some form of alternative commitments, possibly energy-efficiency targets. However, before discussing the role of developing countries, it is necessary to clear up two widespread misconceptions. The first misconception is the oft-repeated assertion that developing countries have no commitments under the Kyoto Protocol. This is quite untrue, since Article X of the Kyoto Protocol lays down a set of common commitments applicable to all parties, Annex I and non-Annex I alike. The national communications of developing countries such as India, China, and Brazil detail many important measures that they have taken, which have significantly moderated the rate of increase of GHG emissions. While the Kyoto Protocol and the Framework Convention do include commitments for developing countries, the basis of their participation is different from that of Annex I parties. The second misconception concerns the implications of the inevitably increasing emissions originating from developing countries. It is being argued that these growing emissions would swamp any reductions effected by industrialized countries and that developing countries should, therefore, be required to limit their emissions. There is no doubt that there is a need to moderate the rate of increase of emissions originating in developing countries to a feasible extent. The real question is who should pay for it. The Framework Convention and the Kyoto Protocol made it clear that the industrialized countries should cover all incremental costs. The developing countries are thus, not opposed to moderating emissions originating in their territories. They only oppose the attempts to shift on to their shoulders a part of the financial burden, which under the Framework Convention and the Kyoto Protocol should be borne by the industrialized countries. However, it is important to strategize on what the developing countries can and should do.

First, the developing countries should intensify their implementation of the provisions of Article X of the Kyoto Protocol. Many measures designed primarily to promote developmental objectives also produce important co-benefits for mitigation. Measures to promote energy conservation or energy efficiency, for instance, may be designed primarily to promote development, but they also have an important co-benefit in terms of moderating emissions. Promotion of new and renewable sources of energy and nuclear energy may be primarily motivated by energy security considerations, but they also result in cutting down carbon emissions. In all these cases, mitigation is a co-benefit, meaning that the measures could be independently justified by developmental considerations alone, and therefore these measures do not entail additional or incremental costs. The mitigation benefits of measures taken so far by these countries have largely been identified in retrospect. Climate change considerations should be integrated with development planning in this manner. This would result in important co-benefits for mitigation without any diversion of resources from the first and overriding priorities of the developing countries, which is economic and social development and poverty eradication. These measures could, for instance, include sectoral energy-efficiency targets. Sectoral targets or programmatic targets are more realistic than targets that could be set in a manner that avoids diversion of resources from priority developmental tasks. The speaker, however, emphasized that such targets were like all other planned targets, which were aspirational in nature. They must not be interpreted as constituting binding international commitments, just as growth targets of developing countries did not amount to binding international commitments.

The other important issue is that it is essential to raise the CDM (Clean Development Mechanism) from a project-based level to a sector or programme-based level. This holds the key to increased participation by developing countries in the international effort to mitigate climate change. This would facilitate equitable burden sharing between Annex I parties, and would answer the legitimate concerns of countries like Japan, which have already attained very high levels of energy efficiency and, therefore, feel that further commitments might involve disproportionately high costs for the economy. It would also provide much needed funds for adaptation.

A programmatic CDM would enable the developing countries to greatly increase their contribution to international cooperation and mitigation. It would encourage these countries to formulate and incorporate into their development plans sectoral or programmatic measures with climate change benefits.

Session 1 summary

The main issues that emerged form Session 1 are summarized below.

- There are compelling reasons for shifts in the energy trajectory globally.
- To combat this, technology breakthroughs such as carbon capture and sequestration, alternative

energy sources, such as nuclear and renewables, are urgently required.

- Short-term focus on energy-efficiency technologies, which can have immediate impacts, is particularly important in developing countries.
- There is a necessity to invest and increase production in OPEC countries.
- While energy efficiency extends the life of reserves, there is need for dialogue between consumers and producers to ensure that enhancement of energy supply capacity is well coordinated with expected changes in energy demand over time.
- Sustainability for consumer countries is very important where adequate resources are needed at affordable prices.
- Demand security for producer countries does not mean asking for a guarantee of demand, but for an orderly view of demand policy and consequences.
- Making fuller use of technological advances in an orderly fashion will point towards more sustainable energy patterns, alleviating some of the downside risks to oil demand (from the producers' perspective), and ameliorate the resulting uncertainties in the magnitude and timing of future investment requirements.
- CO_2 sequestration with EOR (enhanced oil recovery) should receive more attention from both producers' and consumers' point of view.
- International collaborations led by the OECD and focused on launching demonstration projects in various parts of the world, particularly where large carbon storage potential exists, are the need of the hour.
- Linkages between India and the Middle East as an example can be considered, where CO_2 will be exported from India to the Middle East for EOR.
- There is a need for institutional changes to reflect climate concerns.
- There is a need to facilitate multidisciplinary and multi-organizational collaborative interactive work much more than it has been done in the past.
- Proactive energy sector actions are needed both in climate mitigation and adaptation.
- Developing countries should intensify their implementation of the provisions of Article X of the Kyoto Protocol.
- Measures to promote energy conservation or energy efficiency may be designed primarily to promote development, but they also have an important co-benefit in terms of moderating emissions.
- Mitigation is a co-benefit, which means that certain measures can independently be justified by developmental considerations alone and, therefore, these measures do not entail incremental costs.
- The CDM could play an important role, especially if it is programme- or sector-based rather than project-based, and holds the key to developing country participation in the international efforts to mitigate climate change.
- Countries such as India could set an example in energy transition to meeting the twin challenges of energy security and climate change mitigation because India is a large country and is going through the development process.

Session 2: summary of presentations

Opportunities of the Asia–Pacific Partnership to address energy security and climate change in Asia

Prof. Akio Morishima (Chair of the Board of Directors, Institute for Global Environmental Strategies, Japan).

The APP (Asia–Pacific Partnership) on Clean Development and Climate is an innovative new effort to accelerate the development and deployment of clean energy technologies. Ministers from Australia, China, India, Japan, Republic of Korea, and the United States established the APP in January 2006, agreeing to a charter, communiqué, work plan and the establishment of eight public–private task forces to implement the partnership's agenda. The task forces cover aluminium, building and appliances, cement, cleaner fossil energy, coal mining, power generation and transmission, renewable energy and distributed generation, and steel sectors. The basic objective of the APP is to encourage cooperation among countries to meet both the increased energy needs and associated challenges, including those related to air pollution, energy security, and GHG intensity.

With regard to the pattern of energy consumption in developed and developing countries, by 2010–2020, the primary energy demand of Asian and other developing countries would reach the levels of the OECD countries, or may even exceed those. When the energy intensities of India and China were compared to those of the rest of the world, the figure was found to be about ten times that of Japan, and five times that of the US. Hence, if both China and India cooperate, there is potential to increase the energy efficiency in these countries, and at the same time, reduce GHG emissions, which could be a co-benefit to the countries.

The APP is a very new initiative and the task forces have just started work. Japan has already started to get involved in the steel and cement sectors. These two sectors were picked up to start with because 48% of world's steel and about 61% of the world's cement production comes from Asia. The intention of the APP is to put priority on the eight sectors as mentioned above, since these are some of the energy-intensive sectors, and promoting energy efficiency in these sectors would lead to co-benefits.

Can nuclear energy be a response to energy and climate in India?

Dr R B Grover (Director, Strategic Planning Group, Atomic Energy Commission, India)

Hydrocarbon usage in India is about 2.5% of worldwide usage and this would grow to about 10% by the middle of the century. Also, at present, coal usage in India is about 6%, which could grow to over 45% of the likely world usage. The DAE (Department of Atomic Energy) report looks at present hydrocarbon usage in India, which is very low, but would grow to about 10% of global use by the middle of the century. This implies that an increase in the share of nuclear energy in India's energy mix, beyond what is possible based on the domestic programme is desirable to minimize stress on global fuel resources. This is also desirable from local, regional, and global environmental considerations. The Indian economy has a modest hydrocarbon base. The Ministry of Petroleum and Natural Gas has set a target to locate at least 12 billion tonnes as per the 'Hydrocarbon Vision 2025'.

In India, uranium resources reserves at present are about 61 000 tonnes, but thorium is available in plenty. The country has a three-stage nuclear programme. The first stage consists of PHWR (pressurized heavy water reactors) with 14 reactors operating and four under construction. There are also plans for more reactors, and currently, the biggest unit size is 540 MW (megawatt). Additionally, there are some light water reactors at Tarapur and at Kudamkulam on the East Coast in Tamil Nadu; the latter being under construction in technical collaboration with Russia. The second stage consists of fast breeder reactors, which have realized all technology objectives and have been operating since 1985. Based on this experience, the DAE has designed a 500-MW fast breeder reactor prototype, which is under construction. The power potential through this route is very high. At stage three, there are the thorium-based reactors. A mini reactor called Kamini is in operation at Kalpakkam, and is used for neutron radiography and other experiments. The DAE has also designed a 300-MW advanced heavy water reactor, which was going through regulatory reviews. This reactor has been planned to gain large industrial scale experience in the handling of thorium. To summarize, it is a challenge to provide access to clean energy at affordable prices to all in the country. A country the size of India cannot afford to plan its economy on the basis of large-scale import of energy resources or energy technology. No single option can answer the issue of climate change. Indigenous development of energy technologies based on domestic fuel resources should be a priority for the country. Diversity of energy sources and technologies is necessary to ensure security of supplies. For India, nuclear power is one option. In order to limit energy import dependence in percentage terms at about the current level, nuclear power must contribute about a quarter of the total electric power estimated to be required by the middle of century.

Engaging the private energy sector in responding to climate change

Mr Vikram Singh Mehta (Chairman, Shell Group of Companies, India)

Science has clearly established the implications of human activity on climate change and global warming, and the key issue now is the energy challenge in a climate-stressed world. Energy is the fuel for economic development and growth. Between 2007 and 2050, it is estimated that global energy consumption would double because of the increase in population and because of expanding economies. Hydrocarbons will continue to fuel economic growth, and in a sense, power people's lives, especially in countries like India. The important question is managing the CO_2 footprint, given the fact that hydrocarbons will remain the most accessible and affordable fuel source for the time to come. Alternative energy fuels, such as solar, wind, and biofuels, represent low CO_2 sources of energy; but as of today they are certainly not economically competitive with the conventional sources.

Shell as a company has made a strategic choice to work responsibly across a broad energy portfolio, and this includes conventional oil and gas, gas to liquids and conventional oils, and also alternative energy. About 95% of Shell's portfolio is accounted for by conventional oil, including LNG (liquefied natural gas), which is the core of Shell's business. However, the company is also engaged in unconventional oil and gas technology, representing 5% of its business. Shell is the largest distributor of biofuels today. The company distributes about three billion litres of biofuels. It is also the biggest investor in wind energy. In India, the company has an MoU (memorandum of understanding) with leading car manufacturers to see how the frontiers could be pushed with regard to hydrogen use. Shell has very stringent CO_2 emission targets. The company has set itself a target to reduce emissions in 2010 to a level at least 5% lower than in 1990. The company has also increased natural gas production by over 30% between 1995 and 2005. Shell is currently pursuing a number of CO_2 mitigation and technology development activities in order to improve its ability to manage CO_2 emissions. These include energy-efficiency projects, reduction in flaring, and large-scale CO_2 sequestration demonstration projects. Efficiency improvements have already delivered CO_2 savings of approximately a million tonnes per year, and further investments are being made to exploit this potential. The company is playing an important part in developing alternatives to fossil fuels, and that is why it had invested a billion dollars in these businesses between 2000 and 2005.

With regard to the future course of action, it is important to acknowledge and recognize that every country and every company needs to choose its own way in addressing the world's energy challenges and in addressing the management of CO_2 emissions. Fundamentally, this issue should be addressed through a market-based approach. No one company, government, or particular stakeholder could indeed address this problem on its own: it requires a partnership. If one is looking for a public–private partnership, then it is important that governments identify the regulatory and the incentive framework very clearly. They should set very clear targets for emissions trading and other related policies beyond 2012, which would provide greater certainty with regard to the long-term value of certificates and a more stable investment climate. It is important to look for flexible market mechanisms like an effective cap and emissions trading scheme. Carbon capture and sequestration should be credited under the CDM. Finally, it important to note that the absence of an appropriate investment climate would limit the ability of companies to deliver on the required solutions.

Energy security and climate concerns: how is China coping?

Prof. Wei Zhihong (Former Director, Global Climate Change Institute, Tsinghua University, China)

With regard to the energy consumption pattern in China, whereas the energy consumption mix in the world is 25.7% coal, 38.5% oil, 23.3% natural gas, and 12.5% consisting of others; the corresponding figures for China are 67.8%, 21%, 2.8% and 8.4% respectively. The energy-intensity figure in China is the highest among Asian countries. This is because of the high share of industries and low share of the service sector in the GDP (gross domestic product). It was understood that, for most important industry products, energy efficiency is about 20%–50% higher than that in developed countries. The challenges facing China at present include fast increase in energy consumption, fast increase in oil consumption and oil import, and severe shortage of electric supply in recent years. This has affected industrial production and daily household life. Primary energy consumption increased by 15.3% from 2002 to 2004. Oil and electricity consumption increased by 9.3% and 15.7% respectively during the same period. The fast growth in primary energy consumption was due to excessive growth of heavy and chemical industries, urbanization (average annual increase rate of 1% point) and the consumption structure shifting to car and housing. As far as the energy demand scenario is concerned, total energy demand in 2020 would range from 2500 MTCE (million tonnes of coal equivalent) to 3300 MTCE, and power capacity would reach 860–1000 GW (gigawatt). In 2050, total energy demand will be beyond 5000 MTCE and per capita energy consumption would increase to 2–3 MTCE in 2050, compared to 1 TCE in 2000.

At present, China is facing energy security challenges in terms of its oil production, which is expected to reach its peak of around 180 MT (million tonnes) in 2020, following which it will decrease. About 60% of oil and 40% of natural gas in 2020 will come from import and also from new coal production capacity of 1000 MT needed before 2020. The country also needs to improve its energy efficiency. The specific energy consumption for most energy-intensive products is 20%–50% higher than that of the industrialized countries. China is also the second largest CO_2 emitter in the world, and its emission will increase in future. In 2020, if no additional control measure are taken, SO_2 (sulphur dioxide) and NO_x (oxides of nitrogen) emissions could reach 40 MT and 35 MT respectively, exceeding their limits of 16 MT and 19 MT. The priority programmes for better energy management up to the year 2020 are energy-saving technologies, clean coal technologies, oil security supporting systems technologies, advanced nuclear energy technologies, and technologies of large-scale deployment of renewable energy facilities. China has been quite active in the matter of climate change. To set up the CDM management rules, the Chinese government has identified three major priority areas. These includes energy efficiency, renewable energy, and methane storage. As of January 2007, among the total registered projects in the world (477), China accounted for 36, and emission reductions for China accounted for 43% of the total emission reductions in the world. China will also establish some CDM funds from the CDM revenue to raise public awareness on climate change and support capacity building on climate change.

Clean energy and energy-efficiency initiatives in India

Dr Ajay Mathur (Director-General, Bureau of Energy Efficiency, India)

Energy consumption in the Indian economy is growing fast and is expected to grow further. This will strain the economy and society in terms of limited domestic fuel availability, volatility in availability, and prices of imported fuels and negative environmental impacts. Hence, renewables and continuous energy efficiency increases are an essential part of the national energy strategy. The Integrated Energy Policy document also talks about the centrality of both renewables and energy efficiency in the energy picture, in the years to come.

As far as measuring energy intensities is concerned, if energy intensity is based on GDP at market exchange rates, then it is bound to be very high. On the other hand, if energy intensity is measured using GDP conversions based on power purchasing parity, then the picture is not as bad. It has been found that the intensities are more or less in the same band across countries. The issue is that both in India and in China, domestic energy consumption is extremely low. And once that was factored in, energy intensities would be low. The emphasis on energy efficiency and renewables in this country is largely because of deficit in energy supply and lack of access to energy services. It is very clear that it will not be possible to meet these kinds of deficits only on the basis of increase in supply of conventional fuels.

India is probably the only country in the world which has a full-fledged ministry for renewable energy—which clearly shows the political commitment to the cause. The government has also stated its commitment by creating a financial institution – IREDA (Indian Renewable Energy Development Agency) – which grants loans for the promotion of renewable energy technologies. An energy management centre was created many years ago, which at a particular moment of time moved into the BEE (Bureau of Energy Efficiency). Apart from this, there has been a huge amount of effort in capacity building, financial institutions, curricula consultants training, and so on. Over the past few years, energy efficiency and renewables have been institutionalized through the Energy Conservation Act. The Electricity Act passed in 2003 had a provision, under which each distribution company must procure some percentage of its electricity from renewable sources. The percentage could differ from state to state and the State Electricity Regulatory Commission decided on that. This had led to a rapid growth in the use of renewables.

Coming to the issue of commercial buildings in India, because of the phenomenal growth in the services sector, buildings with high level of amenities are being built. These are constructed and designed as if they were in Europe or the US, with materials such as glass and steel. Such buildings absorb a huge amount of solar energy in the hot Indian climate and then require a huge amount of electricity to cool them. This shows a lack of sensible design options. Hence, there is a need to evolve MEPS (minimum energy performance standards) for notified equipment and appliances, prohibit manufacture, sale and import of equipment and appliances not conforming to MEPS, and introduce energy labelling to enable consumers to make informed choices. The BEE has come out with an energy-conservation building code, of which the draft is out and comments have been received.

In the industrial sector, a real problem is the bandwidth of energy efficiency. The most efficient cement plant in the world, the most efficient refinery, and the second most efficient fertilizer plant are all in India, but the least efficient cement plant in the world is also in India. The key ongoing challenge is to see how the efficient plants pull up the inefficient ones.

Because of the Electricity Act, there has been a great increase in renewables connected to the grid, particularly wind. India is already at 6200 MW or 6300 MW of wind power, making it the fourth largest wind energy producer in the world. Today, electricity from renewables such as wind and small hydro produce more electricity in kilowatt hours than all nuclear power plants put together. However, decentralization of renewables has not occurred as efficiently as it should have, though the potential is huge. To conclude, India has been doing a lot of exciting things to monitor energy use in high energy-consuming units and to promote energy efficiency and clean energy.

Session 2 summary

The main issues that emerged from Session 2 have been summarized below.

- Both India and China face the challenges of bridging their growing demand–supply gap while ensuring security of energy supply and minimizing environmental damage.
- There is a lot of potential, if both China and India cooperate, to increase energy efficiency, and at the same time, reduce GHG emissions, which can be a co-benefit.
- Increase in the share of nuclear energy in India's energy mix is desirable to minimize stress on global fuel resources.
- It is a real challenge to provide access to clean energy at affordable prices to all in the country.
- In order to limit energy import dependence in percentage terms at about the current level, nuclear power must contribute about a quarter of the total electric power required by the middle of century.
- Every country and every responsible private sector company needs to choose its own way of addressing the world's energy challenges and the management of CO_2 emissions.
- Governments should set very clear targets for emissions trading and other related policies beyond 2012, which will provide greater certainty and a more stable investment climate to enable the private sector to deliver on the required solutions.
- The priority programmes in China for better energy management up to the year 2020 are energy-saving technologies, clean coal technologies, oil security supporting systems technologies, advanced nuclear energy technologies, and technologies of large-scale deployment of renewable energy facilities.
- China is also planning to establish some CDM funds to raise public awareness and support capacity building on climate change.
- Developing countries will need to indigenously develop/adapt technologies to suit their unique requirements such as catering to the needs of the small-scale industrial sector or the development of decentralized energy options in rural areas.
- In order to plan energy use in a proper manner for commercial purposes, India must try and evolve minimum energy performance standards for notified equipment and appliances; prohibit manufacture, sale and import of equipment and appliances not conforming to MEPS; and introduce energy labelling to enable consumers to make informed choices.

Conclusion

The basic objective of the 'Energy and Climate' workshop was to focus on the interlinkages between energy and climate, with a view to exploring ways in which the twin concerns on securing energy and at the same time meeting climate and other environment-related concerns could be addressed. To that extent, the workshop was highly successful, since valuable experiences were shared on these issues. The workshop was also highly participatory. Active participation from the dignitaries truly made the energy and climate community come together. The participants included representatives from international organizations; multilateral, bilateral, and national organizations; government officials and policy-makers; representatives from energy industries; and researchers and students. It was felt that countries all over the world were now becoming increasingly concerned and proactive about the security of energy supply, reduction of energy import bills, promotion of renewable energy and energy efficiency, and climate policies.

Annexure

About the models

RCM (regional climate model) is based on the PRECIS (Providing REgional Climates for Impact Studies) system developed by the Hadley Centre for climate predictions. It takes care of features at a finer scale; it takes better care of summer monsoon. The horizontal resolution is (1.24 degree latitude × 1.88 degree longitude in the driving GCM [global climate model]) and 0.44 degree × 0.44 degree in the RCM with nominal resolution of 50 km × 50 km (for GCM 150 × 150 km). The results from RCM with high resolution for the South Asian region are more reliable than other global models (detailed discussions are in Kumar, Sahai, Krishnakumar, *et al.* 2006) and can predict extremes better.

The distributed hydrological model SWAT (soil and water assessment tool) has been used to simulate hydrological conditions for 12 river systems in India. It considers natural parameters such as soil characteristics and current land use, but not man-made interventions such as dams/diversions and predictions of land use pattern change. So the results here provided limited evidence.

The BIOME 4 model is a successor of BIOME 3 and uses data based on temperature, precipitation, and sunshine hours. It has been customized to accept location-specific data. The model is sensitive to CO_2 concentration levels, and also considers water-holding capacity and depth of the topsoil. The model's results will be biased by the level of uncertainty in climate prediction models.

For agricultural impact analysis, controlled environment facilities, such as open top chambers, phytotron, and greenhouses, and the FACE (free air CO_2 enrichment) method is being used to understand the impact of temperature, humidity, and CO_2 on crop growth and productivity by the Indian Agricultural Research Institute, New Delhi. Interactive effects of CO_2, rainfall, and temperature are studied through the use of crop growth simulation models. Models of various crops have been used—for rice, the ORYZA series of models have been effectively used. For wheat, Indian models such as the WTGROWS (wheat grown simulator) have been the basis of a large number of studies. InfoCrop, a decision support system, has been developed.

For economic welfare impact assessments, both econometric as well as CGE type of models have been used, but they are mostly regional and global with adjustments for the agriculture sector. Even though they have been developed for the Indian economy, they have not considered either the trade sector or price adjustments properly. For some of the models, details are not in the public domain. Most of the studies have tried to include the CO_2 fertilization effect and have found a positive response if taken partially.

For malaria studies, no specific mathematical or computer simulation models have been used. Climate change projections have been linked to spatial distribution of malaria and transmission windows based on the analysis of interdependence of temperature, precipitation, humidity, growth patterns of the vector species and the current incidence of malaria.

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South Africa
Energy Research Centre, University of Cape Town

For further information, contact

Mitali Das Gupta
Asian Energy Institute
Darbari Seth Block, IHC Complex, Lodhi Road
New Delhi – 110 003

Tel. 2468 2100 or 4150 4900
Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11
E-mail mitalig@teri.res.in

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