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Aligning Development, Air Quality and Climate Policies for Multiple Dividends

Deepa MENON-CHOUDHARY
P.R. SHUKLA
Jean-Charles HOURCADE
Sandrine MATHY

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Centre de Sciences Humaines, 2 Aurangzeb Road, New Delhi 110011, India
Tel: (91 11) 3041 0070
Fax. (91 11) 3041 00 79
Email : infos@csh-delhi.com
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11 Saint Louis Street, PB 33, Pondicherry 605 001
Tel: (91) 413 2334168
Fax: (91) 413 2339534
http://www.ifpindia.org

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ABOUT THE AUTHORS

Deepa Menon-Choudhary is a Fellow of the Indian Institute of Management, Ahmedabad (IIMA), India. She did post-doctoral research at the Centre de Sciences Humaines (CSH), New Delhi, and is currently working as a research associate with the Public Systems Group at IIMA. Her research interests include evaluating policies, instruments and institutions for air quality management, and integrated strategies for aligning development, air quality and climate change policies. She has published articles in peer-reviewed international journals and contributed to chapters in books.

P.R. Shukla is a Professor in the Public Systems Group at the Indian Institute of Management, Ahmedabad, India. He holds a PhD degree from Stanford University. He is a consultant and advisor to governments and international organizations. Prof. Shukla is a member of several international teams working on energy and environment modeling and policy studies. He is a lead author of several international reports including eight reports of the Intergovernmental Panel on Climate Change (IPCC). His publications include twelve books and numerous papers in international journals in the areas of development, energy, environment and climate change policies.

Jean-Charles Hourcade is Director of Research at the *Centre National de la Recherche Scientifique* (CNRS), Paris. He is Acting Director of the CIRED (*Centre International de Recherches sur l'Environnement et le Développement*). Since 1990, he has played a key role in coordination of French social science research to develop the awareness and negotiating capacities of official and governmental agencies in charge of climate change issues. He is a convening lead author of chapters for the Second (1996) and the Third Assessment Report of the IPCC.

Sandrine Mathy is Research Fellow at the CIRED, a research centre of the CNRS, specializing in environmental economics. She has a PhD in environmental economics from the *Ecole des Hautes Etudes en Sciences Sociales*. She works on the links between climate and development issues, on energy prospective in relation with the development of the model Imaclim-R and on the analysis of French climate policies.

CONTENTS

INTRODUCTION

Globally, environmental degradation and socio-economic development are being widely discussed and debated. While there is general acceptance of the adverse implications of environmental degradation (though its extent is still a contentious issue), there is continuing debate on the path to be adopted to tackle the problem. The earlier mindset was that "economic growth is still the primary goal of development planning, but the criteria of sustainability will be viewed as a *necessary constraint.* This implies that economic development will be pursued in such a manner that an increase in output and consumption will not seriously impair the availability and quality, including the assimilative capacity, of natural resources over time" (Siddayao 1993). This paper argues that, rather than just be viewed as a necessary constraint, the criteria of sustainability should be made complementary to the process of economic growth in developing countries.

Environmental sustainability has often been discussed as part of the strategies for development. It received prominent attention as early as in the 1980s in the United Nations World Commission on Environment and Development Report, *Our Common Futur*e. The report defined sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Thus, sustainable development refers to the treating together of issues related to development, poverty eradication, environmental management etc, and addressing the multiple challenges in a coordinated manner. At the 1992 Earth Summit, governments made a commitment to adopting national strategies for sustainable development, which would be largely country-driven. More recently, the UN Millennium Development Goals included an undertaking to 'integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources' (IIED 2002).

Thus, it is being gradually realized that there is a need to integrate the different concerns that arise during the development process. There could be different levels of integration such as integration of short-term needs with long-term objectives or that of environmental concerns within the broader economic and social dimensions. A comprehensive approach would be to integrate local concerns with broader concerns at the national level, and further integration with global concerns – a prime example would be integrating developmental objectives at the local and national levels with air quality concerns and ultimately aligning them with global issues such as climate change. Such complex levels of integration require changes at different levels – policy changes, behavioral changes, institutional changes etc – which are onerous tasks given the high transaction costs involved in these processes. However, the benefits are immense, as will be discussed in subsequent chapters.

This paper focuses on the policy direction required to achieve socio-economic growth in developing countries while addressing air pollution concerns at both local and global levels. While greenhouse gas emissions (GHG) are a global concern due to the implications for resulting climate change, local air pollution is a primary concern due to its more immediate adverse health impacts. Thus, the focus of national policymaking is primarily on measures to tackle continuously deteriorating local air quality, while global climate change concerns are being addressed in the international forum through conferences (to disseminate information) and treaties (to decide on measures to control GHGs). The various reasons attributed to growing levels of pollution include rapid economic growth, industrial and transport growth, urbanization etc, which occur as a country progresses on the path of development. The following section highlights the linkages between development and environment.

1. Inter-linkages between development, climate change and air quality

The primary factors influencing development and environment include economic growth, urbanization, industrialization, vehicular

growth and population growth, all of which have direct implications for energy production and consumption. This is more so during the early stages of growth when policymakers focus on promoting activities that push growth, irrespective of their environmental implications. But with development comes the greater challenge of attempting to achieve developmental objectives without adversely affecting the environment, since the latter would adversely impact on the common people.

1.1. Urbanization

Increased economic development has led to rapid and unplanned urbanization, especially in the developing countries, with a large number of people concentrated in the cities. The United Nations has estimated that 60% of the population will be living in cities throughout the world by 2030 compared to the current level of 47% (UNCSD, 2001). Urban population will triple from 360 million in 1990 to over 1 billion by 2020 (UNDP, 1999), thereby creating dense centres of anthropogenic emissions. In Asia alone, urban population is projected to increase by around 48% in East Asia and 46% in Southeast Asia and the Pacific by 2015.

Apart from its positive impacts, urbanization has had negative effects too. A significant adverse impact is intensification of pollution in densely populated areas, causing deterioration in urban air quality. The emissions come from different sources – stationary and mobile. Stationary sources include industries and power plants that are usually located in the city. However, it is vehicular pollution that has emerged a more serious problem in urban areas, since vehicular population has increased simultaneously with increase in urban population. The problem with air pollution in urban areas is not just emissions, but the level of concentrations which often exceeds prescribed air quality standards. Since vehicles coexist with population, they have a greater impact on human health. Further, rapid population growth, especially in developing countries, is putting additional pressure on already inadequate infrastructure and technical and financial capacities, resulting in policy decisions that may not be environment-friendly.

1.2. Industrialization

Industrialization is central to economic growth, urbanization and improved standards of living. The positive economic and social results of industrial growth have been accompanied by serious environmental degradation. For instance, in India emissions from large industries are growing at a rate faster than the national average. The major polluting industries are thermal power plants, cement, steel, refineries, petrochemicals and mines. Increase in industrial activity is accompanied by a rise in emission levels, especially during the earlier stages of growth. This is because the use of outdated technology, poor quality fuel and lack of abatement technology aggravate the problem. However, with development, choices can be made to invest in efficient and less-polluting technologies for production, thereby reducing damage to air quality.

1.3. Population growth

Population dynamics is a primary driver influencing air quality. Economic growth and industrialization lead to the growth of urban centres. Population also grows, in terms of natural increase and migration from rural areas. As population increases, there is increase in economic activity and use of energy resources, which manifests itself in environmental degradation. The impact of population growth is, however, influenced by trends in income levels and consumption patterns. In developing countries like India, the on-going population explosion has greatly strained the environment. Along with the move toward urbanization and industrialization, rapidly growing population has placed significant pressure on infrastructure and natural resources (EIA 2004).

1.4. Vehicular growth

The expansion of urban areas creates increased mobility needs. This, coupled with rising income levels, leads to increasing demand for public and personalized vehicles. While the latter contributes to the development of society and addresses the travel needs of the population, it also results in negative externalities by way of air pollution. The level of vehicular emissions depends on emission standards for vehicles, the technologies used, fuel quality, presence

of good public transport systems, traffic management measures and road infrastructure. However, in all major urban centres of the world, rapid increase in the number of vehicles, especially personalized vehicles, and the resultant emissions especially at traffic intersections are a major contributor to deteriorating air quality. Mobile sources tend to contribute more to urban air pollutant concentrations as against large stationary sources (World Bank 1998).

In developing countries, there are issues related to high levels of particulate emissions from diesel vehicles, use of leaded petrol and use of two-wheelers with highly polluting two-stroke engines [this, coupled with the high average vehicle age and poor maintenance, has led to more emissions per km driven than in developed countries (Walsh, 1999)]. These countries are gradually taking steps to reduce vehicular emissions by phasing out leaded petrol, introducing stricter emissions standards, converting two-stroke engines in two-wheelers into four-stroke engines. Traditional, non-motorized transport (e.g. rickshaws in India) can play a major role in moving towards a more sustainable transportation system.

Transport poses a major challenge to city authorities with regard to improving the mobility of urban residents while enhancing the efficiency of transportation systems. Increase in the number of motor vehicles has not been matched by investment in infrastructure, and many Asian cities currently suffer from persistent traffic congestion. The response to increasing rates of car ownership and traffic congestion has been expensive road-building schemes, which have further encouraged motor vehicle use and dependence causing adverse environmental and health impacts (Whitelegg and Williams, 2000). China and cities such as Singapore, Hong Kong, Tokyo, Kuala Lumpur and Bangkok are now developing light rail and mass transit systems to reduce pressure on roads and provide an opportunity to reappraise citywide transportation plans (UNESCAP, 2000).

1.5. Increasing energy consumption

Combustion of fossil fuels is a significant contributor to local and global pollutants, and the quantities of these emissions vary

according to the fuel used, its composition and the measures adopted to reduce emissions. These externalities are an energy market shortcoming because they are not reflected in the equilibrium market prices for the fuel. The externalities of energy production and consumption activities are summarized in Table 1.

Table 1: Externalities of Fossil Fuel and Consumption Activities

Fossil fuel	Processes	Pollutants emitted	Impacts
Coal production	Mining Processing Transport Storage		Underground mining: black-lung disease Surface mining: potential impact on land use including aesthetics, direct effects on human settlements and impacts on the total infrastructure of an area Both types of mining have long-term impacts on water resources in the mining area e.g.: acid mine drainage
Coal utilization	Combustion	CO_2, SOx, NOx, CO, PM, VOCs.	Emissions of global and local air pollutants and the creation of ash wastes Other effects: Discoloration of building surfaces, acidification of freshwater lakes and acidification of precipitation (acid rain)
Oil production & refining	Exploration Production Transportation Refining	Sulphur emissions SO_2, NOx, CO_2	Accidents and natural hazards Concern about the disposal of brine used in oil production Oil spills on land and in the sea Impact on traditional activities like farming, fishing and tourism as well as on quality of life Large water requirements for processing and cooling

Fossil fuel	Processes	Pollutants emitted	Impacts
			Safety problems with risks of fire and explosions Liquid waste pollutants from processing (oil, grease, phenols, ammonia)
Oil utilization	Transportation	HC, CO, NOx, PM	Health impacts due to high exposure of population to vehicles
Natural gas production	Exploration Production Transportation	Sulphur, nitrous oxides, CO_2	Safety hazards in production & transportation Pipelines can be sabotaged
Natural gas utilization	Utilization	HC, CO, NOx, PM	Relatively lower emissions of CO_2, NOx

Source: Adapted from Siddayao 1993

Thus, the main cause of air pollution is the burning of fossil fuels (coal, oil and natural gas) in domestic heating, power generation, industrial processes and motor vehicles. Energy consumption for urban transport of people is often the single largest, and usually fastest-growing, component of modern energy use in developing countries, in line with fast-growing rates of urbanization (Blaustein and Shanker 2001). In addition, the burning of biomass such as firewood and agricultural and animal wastes among the urban poor and in rural areas also contributes to the level of pollution. Consumption of energy resources has different implications in urban and rural areas: outdoor pollution is prominent in urban areas while indoor pollution has become a major health hazard in rural areas, especially for women in households. This is especially true in developing countries where there are serious indoor pollution problems due to heavy dependence on fuel-wood and other biomass.

1.6. Technological growth

Economic growth has traditionally been considered a major contributor to environmental deterioration. However, this does not give due consideration to technological development, which has over the years been responsible for overcoming a vast number

of environmental problems. Technological development and penetration have an increasingly significant role to play in addressing developmental and environmental issues. Processes and products can significantly reduce pollution, safer substances can substitute for toxic or dangerous materials, transportation can be reduced and information can sometimes replace material goods. Technologies based on different kinds of fuels with different efficiencies are being used to meet the demand for the various services needed for socio-economic development and for improving standard of living. These technology choices are becoming more and more important not only for economic output but also the local and global environment. Rather than follow a path of industrialization similar to that adopted by developed countries, developing countries have the opportunity to reduce or avoid pollution at an earlier stage. Technology transfer and new technologies can lay the path to a cleaner style of development since the efficiency gains can offset the negative effects of growth, and simultaneously reduce production costs.

2. Development and energy use

2.1. Global energy consumption trends

In the coming years, developing countries will face great challenges in energy and environment. Several factors contribute to the rapid growth of developing country markets with implications for energy consumption: (i) high per capita income elasticities and population growth; (ii) growth of urban areas and industry; (iii) growth of vehicle fleets; and (iv) substitution of fuel-wood by commercial fuels. In 1970, the developing countries' total consumption of commercial energy – oil, gas, coal, nuclear and hydro – accounted for 16 mbdoe (million barrels of oil equivalent energy per day) or 15% of the world total of 104 mbdoe. Despite the oil price shocks in the 1970s and the crises of debt in Africa and Latin America, consumption rose significantly in all developing regions over the next two decades. Consumption in these regions is triple the level twenty years ago, currently around 45 mbdoe, accounting for 25% of world consumption and 44% of the growth during this period (Siddayao 1993).

The demand for hydrocarbon resources during the last century came largely from the industrialized nations in the West. However, over the last decade the Asian region led by China and South Asia has emerged as the new growing consumer. These regions are likely to become the world's largest energy markets. A study has shown that the share of Asian countries in world oil demand was 5% in 1971, 16% in 2002 and is projected to be around 25% in 2030 (IEA historical data and projection from World Energy Outlook 2004). Thus, the path of development chosen by these regions, upon which lies the future growth of energy and emission trajectories, would be greatly influenced by technological development, economic cooperation between countries and global cooperation in limiting greenhouse gas emissions.

2.2. Energy and Millennium Development Goals

Energy consumption, especially fossil fuel use, is among the most important anthropogenic causes of both climate change and air quality deterioration worldwide (Nair et al 2003). But, at the same time, energy has an important role to play in achieving the millennium development goals (MDGs). For instance, energy services such as lighting, heating, cooking, motive power, mechanical power, transport and telecommunications are essential for socio-economic development since they yield social benefits and support income and employment generation. Some examples are given below (UN-Energy 2005).

Goal	Energy Linkage
1. Eradicate extreme hunger and poverty -	Energy inputs such as electricity and fuels are essential for industrial activity, transportation, micro-enterprises and agricultural output. Most staple foods must be processed, conserved and cooked, requiring heat from various fuels.
2. Achieve universal primary education -	Requirement of electricity.

3. Promote gender equality and empower women - Through meeting their need for modern fuels and electricity. Women use traditional biomass fuels and stoves. Due to these demands on their time and energy, women and children are denied opportunities for other endeavors such as economic activities and school attendance, respectively. Having to cook indoors on poorly vented stoves, they also suffer considerable damage to their health, especially in the form of respiratory diseases from indoor air pollution. Modern fuels include natural gas, liquefied petroleum gas and modern biomass fuels such as ethanol, biodiesel and methanol.

4. Ensure environmental sustainability - Energy production, distribution and consumption have diverse effects on the local, regional and global environment including indoor, local and regional air pollution, acidification of land and water, and climate change. Cleaner energy systems are needed to address these effects and contribute to environmental sustainability.

5. Develop a global partnership for development - The World Summit for Sustainable Development called for partnerships between public entities, development agencies, civil society and the private sector to support sustainable development, including delivery of affordable, reliable and environmentally sustainable energy services.

Thus, energy use has a significant impact on economic performance, besides contributing to environmental pollution. This symbiotic connection between environment, energy and development makes it necessary to deal with environment policy, energy policy and development policy in an integrated manner, at both the national and international level.

3. Existing policy approaches of developed and developing countries

Developed and developing countries have tackled the three issues of development, air quality deterioration and climate change in varied ways. This is because the circumstances in which these countries faced/are facing the problem have been different. Here, we highlight the key differences between developed and developing countries regarding two aspects: a) Characteristics of the problem; b) Environmental policy regimes.

3.1. Characteristics of the problem

Developed and developing countries have faced the issues of air pollution and climate change at different periods of time. As a result, there are differences in the nature of pollution and its causes – for instance, in the conditions that influence the environment including population growth rates, economic growth rates, urbanization and industrialization, vehicular growth, technological advancement etc. At present, not only is the pace of growth of these influential factors more rapid in the developing countries, but the damage to the environment and the impact on human health, ecology etc, are also more severe.

Besides, pollution has acquired a global dimension which was not the case when the developed countries were industrializing. During that period, local pollution was the only serious concern. But presently issues related to climate change and its impacts are serious concerns for both developed and developing countries. In fact, due to the limited adaptability of their populations, developing countries are more vulnerable to the adverse impacts of climate change as

well local air quality deterioration. Moreover, in developing countries, outdoor air pollution is not the only problem related to air. Indoor air pollution is also high due to the use of biomass and traditional stoves, which leads to high air pollutant concentrations indoors.

A relatively novel aspect of contemporary environmental concerns is international trade in polluting activities. In the 19th century, fast-growing cities in Britain, Germany and the U.S.A. had to contend with pollution generated mainly by domestically owned enterprises. Today, however, the scale of international relocation of industrial activities, combined with major differences between countries regarding their national pollution regulation laws, has opened up many avenues for enterprises to shift their more polluting activities from countries where strict controls are imposed to countries where environmental issues have a relatively low significance.

3.2. Environmental policy regimes

In developed countries

The developed countries progressed gradually, over a period of 200 years or more, transforming themselves first from agrarian societies to industrial economies based on heavy industry (steel, chemicals), to modern high technology service-based economies. As they reached the heights of industrial development, there were effectively no environmental controls in place. It was only later that environmental problems in the form of air pollution began to be considered a major issue. Effective counter-measures were only introduced when urban air pollution reached almost intolerable levels in many cities such as London, Sheffield, Pittsburgh, Los Angeles and Tokyo. Since the early 1970s, industrialized countries have demonstrated an increasing tendency to incorporate environmental considerations in their energy planning and management, although this has varied considerably among countries and even among various regions and sectors of individual countries (Siddayao 1993). As far as climate change issues are concerned, global awareness of the related problems arose in the late 1980s, by which time these countries were in advanced stages of development. They, therefore,

have the luxury of concentrating on climate change concerns without concern for meeting basic developmental needs.

Thus, developed countries have faced the sequential emergence of the problems of development, air quality deterioration and climate change. They have been able to manage these issues by developing systems of environmental management that control emissions and abate environmental damage without facing pressures to curb economic growth. Moreover, countries such as the U.S. have even refused to take measures that could adversely impact on their economic growth, such as refusing to ratify the Kyoto Protocol so as to avoid giving a commitment on reducing GHGs. The approach being discussed at present by a few developed countries with the intention of reducing GHG emissions in developing countries is to go in for technological agreements with the latter so as to facilitate the transfer of advanced technologies.

In developing countries

Countries in Asia, Africa and Latin America are at different stages of development. Many of them are currently addressing basic developmental needs including poverty eradication, providing basic amenities to their populations and tackling problems such as unemployment, rapid population growth, an increasing urban-rural divide etc. They are also adopting policies and reforms to enhance the process of economic growth which, apart from its positive impacts, is also creating negative environmental externalities. Thus, with growth, they are simultaneously facing the problem of increasing air pollution. Further, global level negotiations are on to address climate change concerns, and some of the rapidly growing economies (implying rapidly increasing energy consumption) are being asked to participate in addressing the same by way of making firm commitments.

With respect to local air quality, increasing public awareness of problems related to deteriorating air quality is leading to high levels of environmental activism as well as judicial activism, thereby putting pressure on governments to tackle air pollution issues. Policies for

local air quality management are being adopted through a targeted approach, whereby each issue is dealt with through regulations (and sometimes by using economic instruments). However, there are issues regarding implementation due to weak enforcement mechanisms, hence compliance is limited.

With respect to global climate change concerns, developing countries are resisting moves for specific commitments to tackle these and lay the greatest emphasis on using their scarce resources to meet developmental needs, especially in cases where there is a conflict of interest between developmental goals and environmental protection. However, these countries have been finding it increasingly difficult to dissociate themselves from environmental problems and to focus only on developmental issues due to internal pressures as well as external pressures from developed country governments, international funding agencies and international NGOs, as also during multilateral negotiations where environmental issues are often linked to other issues such as development aid, concessions etc.

Thus, the basic dilemma faced by developing countries relates to how they can manage the different problems simultaneously. Many developing countries have seen transitions from a regulated to a market economy. It is generally believed that while market liberalization has become necessary for rapid economic growth, it should not necessarily be relied upon to deal with all problems, particularly in the two closely interrelated areas of environmental protection and basic developmental issues including poverty alleviation, equitable income distribution etc. In contrast to the general trend established by conventional adjustment policies, government structures in these areas should be strengthened rather than weakened (CCICED 2002).

Therefore, there is major consensus on the issue that developing countries cannot adopt the same pathway for environmental protection as was followed in the developed countries and that there has to be a more rapid transition towards environment-friendly

development. Steps are already being taken in this direction as reflected in the increasing number of policies being adopted in developing countries to tackle local air quality deterioration. For instance, these countries are adopting measures and technologies at lower per capita incomes as compared to developed countries at the time the latter adopted those technologies. This is reflected in the table which highlights the year and per capita income for the introduction of certain vehicular pollution control technologies in developed and developing countries.

Table 2: Introduction Year of Vehicular Emission Control Technologies and Per-capita GDP (US$)

	US	**Japan**	**EU**	**India**	**China**
Gasoline/Diesel Fueled Vehicles					
Controls for Exhaust Emissions (CO, NOx, SO_2, HC, PM, Lead)					
Catalytic converters	1975 (18404)	1974 (8062)	1980s (14834)	1998 (1699)	1999* (3600)
Controls for Crankcase Emission (HC, unburned fuel)					
Positive Crankcase Ventilation	1963 (14359)	1970 (6666)	1970 (12169)	1996 (1641)	NA
Controls for Evaporative Emissions (HC)					
Charcoal Canisters	1971 (16943)	1992 (18975)	NA	1996 (1641)	NA
Alternate Fuel					
Natural gas vehicles	1965 (14965)	1990 (17254)	1995 (19964)	1996* (1641)	1998* (3600)

Note: Figures in parenthesis indicate the per capita GDP in 1997 US $ on a PPP basis; NA: Not available; * In cities

Source: Auto Oil Programme II, 2000; CONCAWE 1997; Faiz, et al 1996; He, Kebin et al 2002, Mashelkar et al 2002, Onursal and Gautam 1997 and Pundir et al 1994,
http://earthtrends.wri.org/text/ECN/variables/638.htm

Thus, developed and developing countries have tackled the multiple issues concerning development and environment in varied ways. However, despite these efforts, energy-related environmental deterioration, at both local and global levels, appears to be worsening. The driving force behind this situation is the continued rapid growth of energy resource extraction and consumption. In addition, energy policy has developed primarily in response to immediate or short-term economic and political pressures, rather than on the basis of understanding the functions and roles of ecosystems and the full costs and benefits of alternative policies, including those based on a sustainable growth pattern (Siddayao 1993). This is especially true for developing countries. Given this scenario, this paper proposes to study how development and environment can be aligned in developing countries so as to reduce the trade-offs that are usually inevitable in the development process and to optimize policy actions.

4. Case for aligning policies in developing countries

4.1. Developing country viewpoint

The United Nations Framework Convention on Climate Change, in its statement of objectives, mentions that policies for stabilizing GHG concentrations should enable economic development to proceed in a sustainable manner (UNEP/WMO 1992). At present, policies on climate and sustainable development are often discussed as being inter-related, but not implemented in an integrated manner. And, in spite of the conjoint benefits from mitigation of local and GHG emissions, they are not often considered during policy formulation. This prevents optimization of costs that could arise from aligning policies. The counter-argument also holds true – the choice of a development path has crucial implications for the future resource use patterns and energy intensities of a nation. In the past, lop-sided emphasis on economic efficiency led to extremely resource-intensive development in industrialized countries (Shukla 1996). This path is unsustainable. Therefore, the need for developing countries is to formulate policies in such a manner that they are able to address the issue of environmental sustainability in the broader context of development. This can be achieved by taking

into consideration the environmental impacts that arise from policies related to poverty eradication, health services, food security and provision of basic amenities such as water, electricity, roads etc. Further, these countries should also look for opportunities to align policies on local air quality management as well as climate change with larger socio-economic developmental needs.

Yet another reason for aligning policies is that air quality deterioration impacts more on the poor. The same is true for climate change since the impacts would be felt more by developing countries (and especially the weaker sections of the population) which have low adaptive responses in terms of financial and technological resources as compared to developed countries. So it is also in their interest to address environmental concerns at both the local and the global level with the aid of policies that do not compromise on the developmental agenda.

4.2. Role of developed countries

In developing countries, there are several competing and compelling claims to scarce resources, such as adequate health care, education and other areas of social and economic development. Scarce resources and alternate needs are a constraining factor with regard to investing specifically in environmentally sound technologies in the development process. Moreover, there is the intense and often contradictory dynamics of development processes. In this atmosphere of uncertainties and trade-offs, there is a high possibility of adverse selection of policies to minimize risks rather than to ensure sustainability.

In this context, developed countries have a significant role to play, given that developing countries would resist compromising on the developmental agenda, leading to further adverse impacts on global climate change. The high costs of addressing the causes of climate change have led to mechanisms (being discussed in climate change negotiations) that would enable developed countries to provide investment and technological knowhow to developing countries so as to reduce emissions in the latter more cost-effectively. While this in no way suggests that emissions do not have to be reduced in

the developed countries, it only reflects their responsibility towards preventing developing economies from adopting an unsustainable development pathway. We further discuss the role of the developed countries in subsequent chapters.

5. Paper structure

The Introduction presented the linkages of development and environment, focusing on the inter-linkages between development, global climate change concerns and local air quality. It further studied the approach that has been adopted in developed and developing countries to tackle related issues – the current focus is more on addressing the issues individually while this paper argues for the need to align them, especially in the developing countries.

Chapter I looks at the economics of aligning development, local air quality and climate change concerns in a developing country context.

Chapter II takes the case of India to study the various aspects of alignment. It looks at socio-economic policies and their environmental implications. The policy documents of the Central and State Governments attempt to address the issue of sustainable development through various measures. Further, targeted policies are being implemented to address environmental concerns, with emphasis on local air quality. In addition to looking at specific policies such as the use of clean fuels and transport management, this chapter also studies the multiple benefits of other measures like emissions trading and conjoint emissions mitigation.

Chapter III studies the architecture for aligning policies. It looks at various measures required to shift the development pathway in developing countries towards environment-friendliness. It emphasizes the significant role of developed countries in ensuring this movement. While there are international negotiations and agreements at the global level, mainly the Kyoto Protocol, there is still a need for specific policy actions and other initiatives. In this context, we present possible actions and approaches.

The conclusions are highlighted in Chapter IV.

I : ECONOMICS OF ALIGNMENT

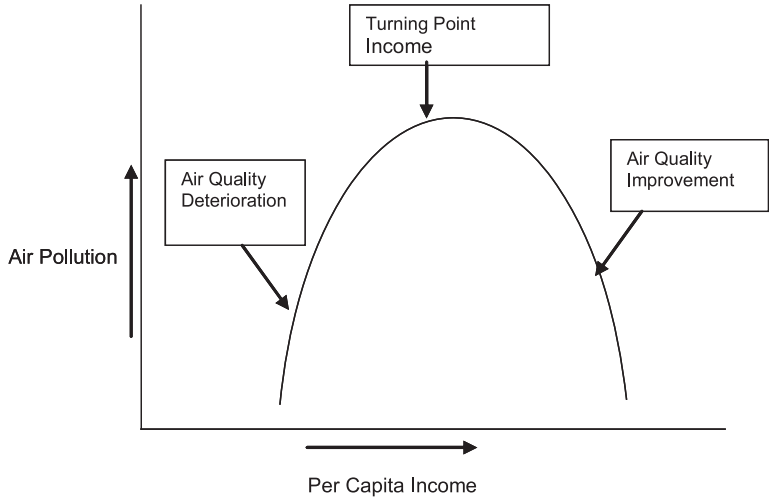
There are strong economic arguments supporting the case for alignment of development, local air quality and climate change policies in developing countries. Empirical evidence shown by the environmental Kuznets' Curve supports the argument that concern for local air quality management develops as a country moves along the development path. A more pro-active approach that could be adopted by the developing countries would be one where they focus on no-regrets options that would prevent them from moving on an environmentally unsustainable pathway. This requires the active intervention of domestic policymakers. To ensure that GHG emissions mitigation is also part of the no-regrets options would require support from developed countries, in terms of directing both climate-related flows as well as public and private flows towards a development-oriented pathway. We discuss in detail these aspects of alignment in the following sections.

1. Environmental Kuznets' Curve

As an economy grows and income levels rise, there are more resources to invest in cleaner technologies and processes. Greater significance is placed on quality of life as standard of living rises and people demand a cleaner environment. These factors lead to societal pressure and greater willingness on the part of policymakers to respond by investing greater resources to manage the environment. Given that environmental concerns become significant, policymakers would have less resistance to aligning these in their developmental policies. This argument is supported by the literature on the environmental Kuznets' Curve [so called because it resembles a similar-shaped curve found by Simon Kuznets to illustrate the relationship between income inequality and income in a developing country (Kuznets 1955)]. In a study that examined the link between total emissions and per-capita income, it was found that there is an inverted-U shaped function relating income to pollution. This curve represents a hypothesized relationship between various indicators of environmental degradation and per capita

income, in which pollution from industry, transport and households increases until development generates enough wealth to promote significant pollution control. Thus, even if pollution levels rise initially with increasing incomes, after a certain point there is improvement in environmental quality (Figure 1).

Figure 1: Environmental Kuznets' Curve



Studies have indicated the possibility that this inverted U curve is found mainly in pollutants that have local health effects and can be dealt with without great expense (Rothman and de Bruyn 1998, Toras & Boyce, 1998). The major driving forces influencing local pollutant emissions are the degree of policy interventions to limit emissions, the level and structure of energy supply and end-use and (to a lesser extent) the levels of industrial output and process mix. Grubler (1998) reviewed the literature and empirical evidence and showed that both clusters of driving forces are linked to the level of economic development. With increasing affluence, per capita energy use rises and its structure changes away from traditional solid fuels (coal, lignite, fuel-wood) towards cleaner fuels (gas or electricity) at the point of end-use. This structural

shift combined with the greater emphasis on urban air quality that accompanies rising incomes results in a roughly inverted U pattern for emissions and/or concentrations of local pollutants. Emissions rise initially (with growing per capita energy use), pass through a maximum and decline at higher income levels due to structural change in the end-use fuel mix/technologies and control measures for large point sources. An empirical study by Torras and Boyce (1998) found that apart from income, social factors such as income equality, wider literacy and greater political liberties tend to have a significant positive effect on environmental quality, especially in low-income countries. The findings do not support the same argument for GHG emissions. Therefore, if policies have to be aligned further, then climate change concerns have to be consciously aligned to development and air quality policies in developing countries.

Thus, with socio-economic growth, local air quality management gradually becomes an important concern for policymaking. However, a more pro-active approach would be one where countries adopt policies that would promote socio-economic growth as well as environmental protection. These would be no-regrets options, which are further discussed in the next section.

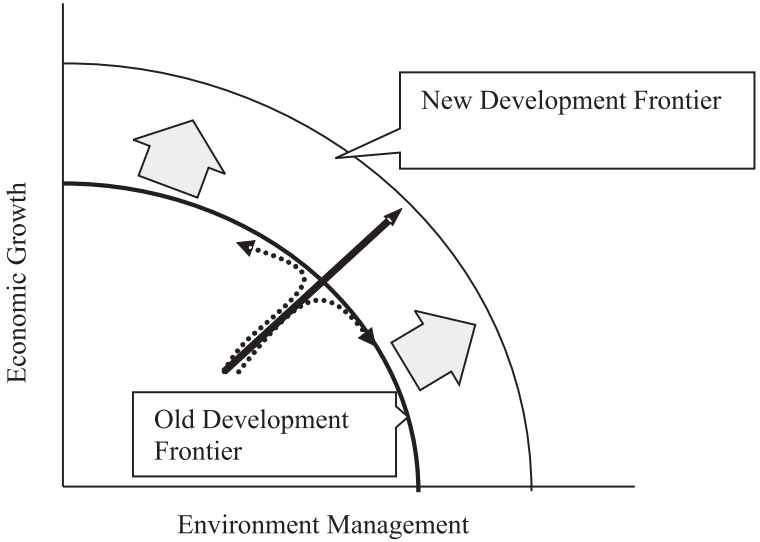
2. No-regrets options

National policies emphasize socio-economic growth which may not complement environmental goals. However, once the development process is set on a particular course and decisions and major investments are made on long-term infrastructure, the environmental consequences last for decades or even centuries to come due to lock-ins and path dependencies. If resources are directed in such a way that they address developmental concerns but have multiple dividends including positive impacts on the environment, it would prevent resource lock-ins while also enabling a shift to a much less resource-intensive trajectory through investments in infrastructure such as rail and communication, renewable resources, location planning etc. Further, there would be less need for isolated project-level interventions specifically for

air quality management at the local and global level. The co-benefits, thus generated, would minimize costs too.

A stylized representation to this effect has been made in Figure 2. In this figure, the x-axis represents the level of environmental management (i.e. the level of emission reduction which reflects the level of air quality), and the y-axis represents the level of economic growth. The curve named the production frontier refers to the trade-off between economic activity and the level of environmental management. Each point on the curve of the production frontier represents the maximum economic activity possible for a level of emission reduction or the maximum emission reduction for a given level of economic activity. So when an economy is on the production frontier, there is no way to achieve further emission reduction. But when the economy is below its achievable production frontier because of market imperfections (price distortion leading to non-optimal use of energy resources, for instance), or institutional barriers, then there is a possibility of higher movement along the y-axis irrespective of its impacts on local air quality (shown in the x-axis) which, as mentioned earlier, is a priority for national policymakers. Therefore, in this path, targeted policies are required not only for managing local air quality but also for addressing global climate change concerns. On the contrary, this path could be avoided and scarce resources utilized optimally if developmental policies are aligned with policies for achieving environmental sustainability. This would be a no-regrets policy, which promotes both economic growth and improved environmental quality. Further movement towards a new environment-friendly production frontier could be brought about through innovations and technological leapfrogging or better use of energy resources (through a tariff reform). The superior technological alternatives provide developing countries with a window of opportunity for leapfrogging developed countries in terms of moving in a more sustainable development path.

Figure 2: Promoting policies for environmentally sustainable development



We highlight the case of infrastructure development – both social and physical – which is a major focus in developing countries to understand how policies can promote environmentally sustainable development. The process of infrastructure expansion also has environmental implications and could result in multiple dividends if investments are directed in the right manner. For instance, investments in the construction of gas pipelines would generate increased employment benefits and also develop a distribution network that promotes availability of cleaner fuels. In such circumstances, policies that propose to reduce emissions in households by substituting existing cooking fuels like coal, firewood and kerosene with cleaner fuels like gas could be effectively enforced. Similarly, investments in developing health systems, especially for the weaker sections, would not only increase their productivity, but also make them less susceptible to the impacts of environmental degradation.

Yet another significant instance is the development of transport infrastructure, including public transport systems and road infrastructure (e.g. flyovers, bypasses, segregated lanes etc) that have multiple dividends by way of reducing energy consumption (e.g. due to reduced idling and wastage of fuel), reduced congestion that leads to less adverse health impacts and a shift from personalized models of travel etc. These impacts also generate positive environmental externalities, besides developing efficient transport patterns in the city. Similarly, investments in transport substitution such as developing modern telecommunications can lead to a reduction in trips to work, thereby reducing emissions. At a broader level, infrastructural designs such as zoning, linking urban transport to land-use patterns and comprehensive and integrated urban planning (this can refer to the polycentric approach of a town where distances between the place people live and the place they work or go shopping are reduced, the effect being to reduce demand for mobility) could reduce urban air pollution.

As the energy consumption of developing countries increases manifold over the next few decades, it will be imperative that they plan to address the impacts. For example, in India almost half of the existing power and steel plants are near coal mines. Strong coal-centric economic linkages have thus resulted in the development of infrastructure related to the mining industry, coal transportation networks, generation equipment manufacturers and a large labour force. All these factors strongly influence future investment decisions and encourage either capacity addition at the existing plants or the setting up of new plants in the vicinity of the older ones, thereby resulting in further environmental degradation.

Another dimension in India related to electricity production is the problem of shortage which amounts to nearly 12% of electricity demand. Apart from the weak level of capital availability, one of the main reasons for this is wasteful electricity consumption in agriculture for irrigation. This is related to the low level of Indian electricity tariffs for agriculture as it pays only 12% of the electricity cost, which might not encourage farmers to rationalize power

consumption. One possible no-regrets policy could be to implement a tariff reform in order to: a) reduce the level of electricity waste in the agricultural sector; b) increase water resource availability; and c) increase cost recovery for State Electricity Boards and capital availability to invest either in new production capacity to reduce shortage or anti-pollution systems. If this measure meets the electricity demand, it would also lead to decrease in the use of diesel generators, thereby reducing local pollution. This can equally lead to a decrease in the total oil consumption in India and reduce oil imports[1]. Thus, energy efficiency measures could lead to air quality improvement while reducing energy imports and so releasing some financing capacity.

Therefore, policymakers have to make a conscious attempt to ensure an environment-friendly development pathway. Since the multiple benefits of a policy often lie at the margin, they can be obtained at costs lower than what would be needed to implement a completely new environmental policy. Economic planning and environmental issues have to thus be addressed within the framework of a country's developmental goals. This process has begun in developing countries, where greater emphasis is being placed on local air quality impacts while framing policies. Further alignment of climate change concerns in this process of alignment requires greater incentives to be given to these countries. As long as policies to tackle climate change are viewed as constraints on the development process, they will not find favour with developing countries. Also, emphasizing climate change concerns alone without giving due attention to local air quality concerns would not find sufficient support during implementation of environmental policies.

Further, developing countries have major constraints in achieving developmental goals, the most important being the resource constraint, including financial and technological resources. For specific projects impacting on both development and environment, finances become a huge concern as, for instance, in the transport

[1] In India, import dependence in total energy was 8%, 71% and 13% for coal, oil and nuclear energy, respectively.

sector, renewables etc. In the transport sector, the modal shift to inherently environment-friendly modes such as metro systems, busways and other public transport services raises the extremely complex issues of city planning, financing of very large and capital-intensive investments, and operations and maintenance expenses. The level of tariffs expected from public transport services in developing countries is usually low, which makes it difficult to get finances. Similarly, in the case of renewable energy projects, there are high risks involved. The development of environmentally sustainable technologies especially requires large investments, huge R&D expenditure etc. For instance, development of a new emission control configuration typically costs vehicle manufacturers tens of millions of dollars per vehicle model, and takes from two to five years, which is a constraining factor in implementation (Faiz et al, 1996).

In this context, the role of the developed countries becomes crucial. At the broader level, they could help developing countries overcome their resource constraints by directing financial flows and technological knowhow, and by providing insurance coverage etc, for development projects that are environmentally sustainable. At a more specific level, developed countries have a crucial role to play in ensuring that climate policies too are aligned with other policies in the developing countries. This could be done by providing incentives that enhance the latter's development potential. The following section highlights how foreign investment can create further leverage effects through alignment.

3. Leverage effects of alignment

The investment and technological flows from developed countries that are being proposed in global climate change negotiations could create leverage effects on the implementation of domestic policies that meet the needs of developing countries; simultaneously they can overcome the transaction costs that hinder a country's development potential. These transaction costs create barriers that hinder flow of investments. Some of these barriers have been identified as follows (Jaffe and Stavins 1994):

- Negative (or poor) commercial profitability of the investment;
- Information problems (asymmetry);
- Financial constraint which limits capital availability;
- Market distortions (price distortions etc);
- Non-monetary costs (cultural acceptability);
- High discount rates;
- Non-diffusion/adoption of the technology by the host country.

This is a well-known problematic of development economics: needs and solutions are identified, but their implementation stumbles over many obstacles. Another series of obstacles may be identified which explains why the most environment-friendly solution is not chosen. Some reasons are of the same nature compared to the one preceding, but they now apply at the level of the adoption of the cleanest technological solution:

- The non-diffusion/adoption of the clean technology by the host country;
- The fact that the clean technology is not mature enough: high cost of little series, important uncertainties concerning the risk of the development at large scale of the clean technology;
- Existence of a dirty solution at lower cost;
- Market distortions in favour of the dirty technology (customs duties for imported components, institutional rigidity concerning technological choice, price distortions) and high transaction cost to reduce these distortions;
- High transaction costs for foreign investors who master the clean (new) technology (learning of the administrative procedures, and of the social and political context);
- Non-economic obstacles concerning the entry of a foreign investor who masters the clean technology (exchange rates control, ideological or religious restrictions);
- The country risk which is dissuasive for foreign investors: devaluation risk, risk of political or social troubles).

Climate-related flows from developed countries could be used as an instrument that creates leverage effects which overcome the

obstacles that make the real production frontier in developing countries below the one expected, thereby reducing the gap between ex ante expectations and ex post achievements. This could be in terms of optimal utilization of scarce resources, improving quality of life as a whole (e.g. in terms of increased access to electricity, reduced health impacts of air pollution etc) and also by overcoming the various barriers (discussed earlier) that hinder the development potential of developing countries.

3.1. Mechanism of leverage effects

We discuss the mechanism of leverage effects through a stylized representation of the investment that is being made in environmental projects and show how these investments can help remove development obstacles (for a further discussion on this issue, refer to Mathy et al., 1999) . Let us start from a conventional representation of the aggregated income *f(I)* induced by the total level of investment *I* in an economy under given technical and institutional constraints. In this representation, individual investments are ranked by a decreasing profitability order and the slope of the curve represents the profitability *r* of each marginal project. No additional investment is made when the slope of *f* equals the discount rate i_S (S refers to southern country i.e. developing country while N refers to northern country i.e. industrialized country) of this country. A higher level of income can thus be generated either through an upward movement of *f(I)* due to access to a new production frontier (Fig. 3) or through lowering the discount rate *i*.

Let us assume that a government adopts policies that remove domestic institutional constraints and market imperfections potentials. This triggers an upward move of $f_S(I)$ and, at constant discount rate i_S, of the level of investment to $I_S^{P\&M}$ (P&M refers to domestic policies and measures). In this context any inflow of foreign investment has potentially two related impacts: (a) it relaxes the capital constraint, lowers the domestic discount rate

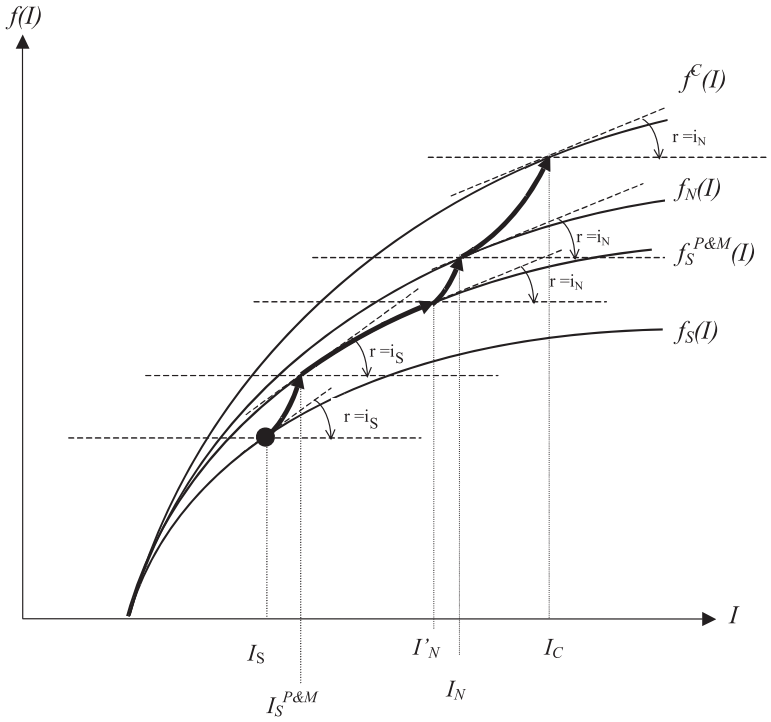
if the interest rate demanded by the foreign investor[2] (including a risk premium) is $i_N < i_S$; the volume of investment increases until $r(I)=i_N$ and the output until $I'_N > I_S^{P\&M}$; (b) by providing more efficient technologies through technology transfer, the production frontier moves up from $f_S^{P\&M}(I)$ to $f_N(I)$ which allows for a new level of investment at I_N.

The challenge of an environmental policy is thus to trigger this upward movement of the production frontier. In the context of mechanisms being discussed in the climate change regime, this trigger could be achieved through the value of carbon C (this is the case with the Clean Development Mechanism [CDM] of the Kyoto Protocol)[3], which creates an incentive for foreign investors to invest in developing countries. This can be made through two interrelated channels: (a) the creation and sharing of a carbon benefit inflate the profitability of some foreign investments and move up the curve to f^C (b) this additional benefit provides an incentive to public authorities for confronting the transaction costs of Pareto improving policies since it yields revenues to compensate the losers of such policies.

[2] Note that the suffix N (for North) is chosen for clarity and simplicity of notation. Actually the discount rate is comprised between the domestic foreign discount rate and the southern country discount rate.

[3] CDM is defined in Article 12 of the Kyoto Protocol as a project-based mechanism which allows foreign investors to invest in developing countries in projects that reduce the level of GHG emissions compared to a reference situation without the CDM project. The foreign investor then receives an amount of Emission Reduction Credits equal to the amount of GHG reduction induced by the CDM project. Participation of developing countries in the CDM is voluntary.

Figure 3: Income generated by cumulative investments ranked by decreasing profitability



Through this mechanism, climate-related investment flows from developed countries can trigger development potentials that might otherwise remain frozen due to the existence of the transaction and political costs of reforms.

To conclude, there are strong arguments on economic grounds that favour alignment of development and environmental policies in developing countries. The difficulty lies in how the alignment process is actually implemented. In this context, we discuss various opportunities for alignment in Chapter II, taking the case of India. Here, policies are gradually incorporating environmental issues in the decision-making process, thereby creating multiple dividends.

II : MULTIPLE DIVIDENDS FROM ALIGNMENT: INDIAN EXPERIENCE

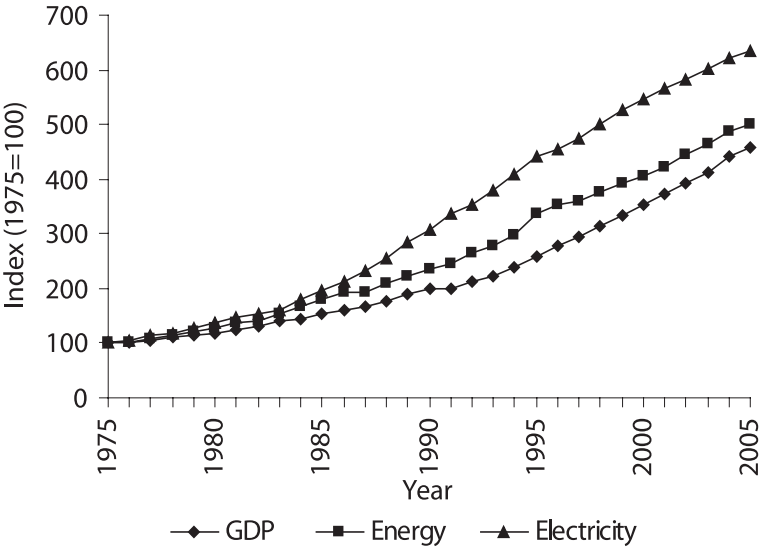
1. Energy and environment profile

India is a fast-growing developing economy, with its development following an energy-intensive path. Domestic coal is the primary energy source for electricity and energy. Oil consumption has increased rapidly to meet the growing transport demand. Domestic oil and gas production has not met the growing national demand, leading to increasing oil imports. Rapid growth of the economy, expanding industrialization, increasing incomes, rising transport and high growth in energy consumption are resulting in deterioration of air quality.

1.1. Energy, electricity and emission trends

The Indian economy has witnessed rapid growth since the 1990s and an even higher growth of the energy sector (Figure 4). The latter was because economic growth was driven by energy intensive sectors, where energy efficiency was low by international standards. Indian energy use has grown faster than its GDP for the last twenty years (GOI 1991-2005, CMIE Energy 2003). Especially in the electricity sector, electricity consumption has grown at a rate higher than the GDP and energy for the past two decades, with the trend becoming more pronounced in the 1990s.

Figure 4: Growth of Energy, Electricity and the Indian Economy



Sources: GOI (1991-2004); CMIE, Energy (2003, 2004); CMIE, National Income Statistics (2004)

Increasing demand for fossil fuels by energy intensive sectors like power generation, steel, cement, chemicals, fertilizers and transport contributes to high levels of GHG and local pollutant emissions. Demand for energy resources is expected to grow further, for reasons cited below:

- Rapid growth of the economy, urbanization, population and vehicular growth;
- Increase in per capita incomes;
- Growth of energy-intensive industries like power generation, steel, cement and fertilizers;
- Rapidly growing stock of vehicular population;
- Rapid mechanization of agriculture to improve productivity.

The dynamics of the transition from a traditional to a modern economy is expected to continue in the foreseeable future, further adding to growth in energy demands (Shukla 1997).

1.2. Emissions from energy use

High-energy growth rates have been accompanied by correlated growth in emissions (Garg and Shukla 2002). We consider the case of CO_2 and SO_2 emissions while studying the growth in GHG and local pollutant emissions respectively. Energy-related emissions contribute to a significant part of these emissions (almost half of national CO_2 and SO_2 emissions in 2000) because the energy sector encompasses all activities – agricultural, industrial and residential. During the period 1990-2000, the Indian GDP grew by 73% (GOI, 2003), commercial energy supply by 63% (PC, 2002), total CO_2 emissions by 61% (Garg et al, 2003) and total SO_2 emissions by 42% (Shukla et al, 2004a). The present growth rate of CO_2 and SO_2 emissions in India is above 5% per annum (compounded) and continued dependence on coal in the industrial sector implies a continuation of this trend (Garg et al, 2001). Coal consumption contributes to 75% of total CO_2 emissions and 63% of SO_2 emissions in India.

Currently, air pollution is widespread in metropolitan cities where vehicles are the major contributors as well as in other urban centres where high concentration of industries and thermal power plants is causing deterioration in air quality. Rapid increase in urban population has not been met by corresponding planned urban development, which further aggravates the negative impacts of air pollution.

1.3. Future trends in GHG and local pollutant emissions

As the country moves along the path of economic development, the use of energy resources is bound to grow, thereby leading to an increase in energy-related emissions.

CO_2 emissions

National carbon emissions have a close linkage with energy use, which in turn is linked to a country's economic growth. Energy

intensity and carbon intensity of GDP reflect this linkage. India's energy intensity of GDP was 20 toe/million rupees in 1975, going up marginally to 23 toe/ million rupees in 1995. It is likely that the energy intensity of India's GDP will decline in future under any growth scenario (Shukla, 1997). The reasons are operational efficiency improvements, a shift towards using more energy-efficient technologies, increased share of the service sectors in the economy and a switchover to cleaner fuels. Between 2000 and 2030, the carbon intensity of GDP will decline at 1.9% per year, though carbon emissions will grow at 3.4% per year. Decline in carbon intensity is mainly due to decline in energy intensity at 1.5% annually; it is also due to substitution of coal by gas and marginally by renewable energy (Kapshe et al, 2005).

SO_2 emissions

The CO_2 and SO_2 emission trajectories move in closer bands till 2010 due to continuation of existing vintages. Thereafter, while CO_2 emissions continue to rise, SO_2 emissions begin to decline following the Kuznets' Curve phenomenon (Menon-Choudhary et al, 2005). The decline in emissions is due to policies such as mandatory use of flue gas desulphurization (FGD) in large coal power plants, introduction of low sulphur diesel, washing of coal and stricter enforcement of local air quality regulations. These policies do not, however, affect GHG emissions. GHG and local pollutant emissions are thus decoupled in the future.

1.4. Existing policies for control of local and global pollution

Policies for managing local air pollution

There is a comprehensive structure of legislations and policy initiatives to manage air quality in India. The Central and State Governments are paying increasing attention to growing problems related to air pollution in cities and implementing policies in that direction. However, the push factor for the formulation of these policies has been public pressure, numerous Public Interest Litigations (PILs) filed in the Supreme Court and the subsequent rulings of the court.

The policies for controlling vehicular emissions in urban areas and the instruments adopted are primarily regulations-based. These include progressive tightening of auto-emission norms (1991, 1996, Euro norms since 2000) and improvement in fuel quality specifications (unleaded gasoline, reduction of sulphur content in diesel etc). There is greater focus on the transport sector in order to improve air quality because the common people's exposure to vehicular emissions is very high. Since vehicles are at the ground level, they have the maximum impact on the exposed population, whereas stacks in industries help in greater dispersion of air pollutants. In continuance with its emphasis on managing vehicular emissions, the Government of India (GOI) in August 2001 set up the Auto Fuel Policy Committee, popularly known as the Mashelkar Committee, to establish a roadmap for emission norms for vehicles and fuel quality in the country and to make recommendations for implementation. The Committee recommended various measures – primarily the implementation of Euro norms – which have been accepted by the GOI.

There are policy initiatives and legislations covering industrial emissions that are also regulations-based. For instance, according to a policy directive, use of beneficiated coal has been made mandatory for all power plants set up after 2000, as well as for plants located 1000 km away from the pithead and in urban areas (CPCB 2003). In case of industrial sources, the control measures include monitoring of air pollution from highly polluting industrial units, closure or shifting of polluting industries and a time-bound action plan to control pollution in identified "hotspots" (http://envfor.nic.in/soer/chap6.html). Other significant measures include relocating of polluting industries to the periphery of the city such as in Delhi and specific initiatives such as in the Taj Trapezium Zone in Agra, where small-scale polluting industries have been relocated while large industries have been directed to use natural gas.

Policies are also being adopted focusing on specific local pollutants. For instance, sulphur control policies include reduction of sulphur content in petroleum oil products and use of FGD in thermal power

plants (that fall under specific categories). Unleaded gasoline was introduced for vehicles in 1996 and leaded gasoline completely phased out by 2000. Policies for reduction in particulate emissions include enforcement of electro-static precipitator efficiency norms in industrial units and use of cleaner fuels and efficient vehicles.

Addressing GHG emissions

In 1992, India signed the United Nations Framework Convention on Climate Change as a non-Annex I country, meaning that it is not obligated to reduce its emissions of carbon and GHGs. It ratified the agreement in 1993. While India recognizes the importance of reducing these harmful emissions, its Government also places high priority on economic development. As such, India is not a signatory to the Kyoto Protocol which mandates specific commitments by countries to reduce their emissions of greenhouse gases by an average of 5.2% below 1990 levels by the agreed 2008-2012 timeframe. India's participation in GHG reduction is only based on CDM[4].

2. Existing policies linking development and environment

The economic reforms process that began in the 1990s has brought about changes in patterns of economic growth, which are in turn affecting the environment. This is especially true in the urban areas where rapid urbanization is having both positive and negative impacts on the environment. While awareness of environmental issues is rising, leading to increasing public and judicial pressure in favour of improving air quality, the developmental process itself has often led to environmentally harmful choices. Therefore, it is imperative for policymakers to integrate environmental management in the economic planning process. Various documents – including five-year plan documents, annual plan documents of respective departments, perspective plans of various Ministries of the Central and State Governments and Planning Commission documents – are gradually incorporating the objectives of sustainable

[4] Of the 573 projects registered (in March 2006) before the executive board of the CDM, 192 are located in India.

development. We look at some of the policies that have been formulated especially addressing air pollution concerns. Further, we look at the implications of some of the policies that have been implemented in the context of integrating development and environmental concerns.

2.1. Sectoral policies linking development and environmental concerns

Energy sector

The Tenth Five-Year Plan has laid great emphasis on environmental policies and energy conservation for sustainable development of the energy sector. It visualizes the importance of sectoral reforms for sustainable development. It specifies 'introduction of reforms through restructuring/deregulation of the energy sector to increase efficiency, demand management through introduction of energy efficient technologies/processes and appliances…' The plan also points out the importance of the environment in overall sectoral development: 'the process of producing, transporting and consuming energy has a significant impact on the environment. Pollution abatement processes would form an important part of the development of energy sector…'

Increasing consumption of oil and gas is leading to greater demand for these products, thereby creating issues such as energy security as well as environmental problems. This has been addressed in a policy document of the GOI, Hydrocarbon Vision 2025, which lays the guidelines for the hydrocarbon sector for the next 25 years. Among other things, it states that the process of meeting the growing energy demand should be environment-friendly and promote the use of natural gas.

Oil and gas

Some steps taken to improve quality in the oil and gas sector are as follows:

- Only unleaded petrol is being supplied nationwide since 1st February 2000;

- Petrol octane number has been increased and sulphur content reduced from 0.20% maximum to 0.10% maximum in the entire country from 1st April 2000 (0.05% in the four metros);
- Sulphur content in diesel has been reduced from 1.0% maximum to 0.25% maximum across the country between April 1996 and January 2000 (in the four metro towns, sulphur content in diesel has been reduced to 0.05% per cent maximum);
- Improvements in petrol and diesel quality have facilitated adoption of Euro norms.

The other important step taken towards sustainable development during the Ninth Five-Year Plan period (1997-2002) was in the direction of energy conservation (Planning Commission 1997). This was necessary since India depends heavily on fossil fuels as its primary source of energy. Energy conservation will not only lead to less consumption of energy but also less burning of fossil fuels, thereby reducing GHG and local emissions. The Energy Conservation Act, 2001 was passed and the Bureau of Energy Efficiency (BEE) was set up to effectively implement energy conservation programmes. The BEE's role is to introduce stringent energy conservation norms for energy generation, supply and consumption. It will also be responsible for benchmarking the efficiency parameters of the energy sub-sectors with international standards.

Coal

Coal is projected to remain the mainstay of the Indian energy system, especially since vast indigenous reserves – proven reserves of 90 billion tons and total reserves of 240 billion tons – are enough for over a century of consumption (MoC, 2004; Shukla et al., 2004a). Since coal is expected to remain one of the dominant energy sources, it implies the need for greater environmental protection measures during the mining and subsequent consumption of coal. Various government policies acknowledge this fact. The Ninth Five-Year Plan proposed a 'renewed thrust on improving the environmental conditions in coal mining areas.' Policies proposed in successive Five-Year Plans for environmental protection in mining areas include

environmental impact assessments, monitoring and implementation of environmental protection measures, besides also preparation of a comprehensive rehabilitation policy looking at the socio-economic impacts.

The Ministry of Environment and Forests also indicates priority areas similar to those mentioned in the Five-Year Plans. They are:

- Adoption of best practices to improve coal quality and productivity and to protect the environment;
- Adoption of environment-friendly technologies including coal gasification, beneficiation and liquefaction for value addition to domestic coal;
- Environmental protection including rehabilitation of affected land and preservation of biological diversity; and
- An acceptable rehabilitation and resettlement policy for project-affected persons.

Power sector

The power sector plays a crucial role in the overall development of the economy. A crucial input not only for industrial development but also for socio-economic progress, electricity has become an important tool for sustainable development. However, demand for electricity has consistently exceeded available supply in India. While the deficit of electricity varies among States, nationally it is estimated to be of the order of 12% peak and 9% for energy. Limited availability of finance and capital and other legal and administrative barriers have constrained the construction of new power plant capacity. During the Ninth Plan, less than half the planned power plant capacity was constructed. The Tenth Five-Year Plan envisaged an increase in generation capacity to cope with the rising demand for electricity. The demand for power in 2007 for India is around 719097 GWh, the peak load demand being 115705 MW (CEA 2000).

Table 3 presents some important government policies pertaining to the power sector, aimed at achieving socio-economic progress and sustainable development.

Table 3: Policies pertaining to the power sector

Year	Policy/ Program/Act/ Notification	Highlights
1997	Notification for use of beneficiated coal	Mandatory use of beneficiated/blended coal with ash of not more than 34% from June 2001 in power plants located beyond 1000 km from pitheads and those located in critically polluted areas, urban areas and ecologically sensitive areas.
1999	Notification for use of ash	Discourage dumping of ash and promote its utilization; Power plants are required to prepare an action plan for full utilization of fly ash and provide ash free of cost (for at least 10 years) for manufacturing ash-based products.
1998	National Hydro policy	Outlined various strategies required to exploit the vast hydro potential faster, maintain a reasonable minimum level of hydro in the power system, enable inter-state and inter-regional transfer of hydro power by suitable evacuation of power and encourage greater private investment for faster hydro development.
2001	Energy Conservation Act	Enables the creation of the BEE which would recommend energy consumption norms and standards, create awareness, disseminate information for efficient use of energy and its conservation, promote R&D in energy conservation, provide financial assistance to institutions to promote energy efficiency etc.
2003	Electricity Act	Aims at the promotion of efficient policies that would have minimal negative environmental externalities.

Apart from these policies, efforts are also being made to promote efficient use of energy and energy conservation. According to the Blue Print for Power Sector Development (Ministry of Power

2001), 'energy efficiency/conservation measures encourage consumers to use energy more efficiently, which will result in reduced energy consumption thereby reducing cost of production and increasing productivity...'

Besides, increasing importance is being accorded to the development of hydel projects in the country. Hydel power represented about 25% of total installed capacity in 2002. The Tenth Five-Year Plan projects that 35% of the additional installed capacity will be hydro plants. According to the Tenth Five-Year Plan, one of the important reasons hydropower should be given more importance in India is environment-friendliness. It says that 'greater emphasis on hydro-electricity is important; particularly to meet the peak loads…Hydro-electricity is also a clean and renewable source of energy…' According to the Ministry of Power Annual Report, 2002, 'hydropower is a renewable, economic, nonpolluting and environmentally benign source of energy. It should also be noticed that hydroelectric dams produce significant amounts of carbon dioxide and methane, and in some cases produce more of these greenhouse gases than power plants running on fossil fuels. Carbon emissions vary from dam to dam.

In the Indian context, unsatisfactory system conditions prevail especially in the Eastern and Western regions which have a predominance of thermal power. The off peak surplus power and inability of thermal stations to back down are reflected in the form of impermissible high frequencies and injurious low frequencies. To correct such a situation, the ideal hydrothermal mix should be in the ratio of 40:60. At present hydro share is below 25%, which would become approximately 27% if 31,700 MW of hydropower is added by 2012…' Various government policies give suggestions for increasing hydro potential such as through higher budgetary allocation for hydel power, identification of new projects in the Central Sector for advance action, promoting State projects which were languishing or could not progress due to inter-State disputes, improving tariff dispensation for hydel projects etc.

Rural electrification

Balanced socio-economic development requires the providing of electricity to all areas. Various policies have been framed to ensure rural electrification. Some of the results are encouraging. For example, in the Ninth Plan, under the programme of electrification of remote villages, there has been success in electrifying Sagar Island situated in the Sundarban region of West Bengal through solar energy. The Tenth Five-Year Plan proposes to cover 62,000 villages that can be electrified through grid extension. The remaining 18,000 remote villages are to be electrified by 2012 through use of non-conventional technologies. Funding is the most important challenge for rural electrification. The Indian Government has designed various schemes for this purpose, such as the Pradhan Mantri Gramodaya Yojana, the Minimum Need Programme for Electrification and other policies, the Accelerated Rural Electrification Programme, the Kutir Jyoti Programme, the Rural Electrification Corporation (REC) etc.

The Electricity Bill, 2001, contains an enabling provision with regard to decentralized generation so that cooperatives and NGOs can also bid for and supply electricity to dispersed communities. The efforts in rural electrification will substitute traditional/inefficient energy consumption practices (biomass burning or diesel generators) with less polluting electricity, thus having a beneficial effect on GHG emissions. In India, various non-conventional energy sources are used to generate power. These include solar, biomass, small hydro, co-generation etc. In 2002, India had an installed capacity of 3400 MW, which used non-conventional energy sources. But the potential of power being generated from non-conventional sources is much bigger. To achieve this, the Government has taken a number of steps. The Electricity Bill, 2001, has a number of provisions promoting the use of renewable/non-conventional energy in rural areas. For example, Section 4 (clauses 4, 5, and 6 of the Electricity Bill, 2001) stipulates that the Central Government after consultation with the State Governments prepare and notify a national policy permitting stand systems (including those based on renewable sources of energy and other non-conventional sources

of energy) for rural areas. Also, there has been a gradual increase in the financial allocation to the non-conventional energy sector. As a percentage of the total plan allocation, it increased from 0.2 % in the Eighth Five-Year Plan to 0.44% in the Ninth Five-Year Plan.

Transportation sector

While the transportation sector plays a very important role in economic growth, it is also one of the major contributors to air pollution. The various policies and strategies of the Government of India recognize this fact. The approach paper to the Tenth Five-Year Plan states that 'the growing automobile population combined with lower quality of fuels is contributing to an increase in air pollution in India. The share of the transport sector in total emissions is increasing and is a matter of concern, especially due to the serious respiratory health problems associated with air pollution. The main causes of vehicular pollution are outdated engine technology in heavy motor vehicles, poor maintenance, large number of overage vehicles, over loading, traffic jams and absence of checks on emission standards…'

The Tenth Five-Year Plan points out the importance of stricter environmental norms for the sector. It states that 'all major projects, including those in the transport sector require environmental clearance before they are taken up. In large cities like Delhi, initiatives have been taken to enforce Bharat Stage II norms for vehicular emission. Stricter norms conforming to Euro III-IV are also under consideration…' The Plan suggests the nationwide development of public transport to reduce dependence on private transport. It also suggests greater use of cleaner fuel to reduce air pollution. Following the Mashelkar Committee recommendation, Euro norms have been adopted to reduce vehicular pollution. Several other non-technical measures are also being implemented.

Thus, the planning process in India has tried to incorporate concerns for the environment in its policies. However, greater effort is required in the implementation of these policies because

the emphasis is primarily on the developmental aspect. Local air quality management is secondary and climate change concerns get even less emphasis. To achieve greater alignment of policies, it is necessary to understand the capacity gaps, build institutions to bridge these gaps, provide adequate finances and undertake advanced research-and-development. Scientific research and technology development will benefit greatly through international cooperation and collaboration. Common goals can be effectively addressed by pooling both material and intellectual resources. International collaborative programmes should be encouraged between academic institutions and national laboratories in India and their counterparts around the world.

The above discussion points to several policies that have been formulated keeping in view the environmental implications, even while satisfying the developmental needs of the country. We go on further to study the implications of some of these policies, highlighting the opportunities that were available to align them for multiple dividends.

2.2. Implications of specific policies

Use of CNG in the transport sector

The use of natural gas has traditionally been allocated primarily to the power and fertilizer sector (around 70% of consumption). However, there is a shift in policies whereby natural gas is being promoted as an environment-friendly fuel for other sectors, including the transport and residential sectors. The Government's recent policy document, Hydrocarbon Vision 2025, calls for increasing the use of natural gas as the 'preferred fuel for the future' due to its positive impacts on the environment. This is especially necessary for the transport sector, since vehicular emissions are becoming the main contributors to local air pollution. Following the PILs filed in the Supreme Court against increasing vehicular air pollution in Delhi, the court issued several directives to combat the problem. One of the landmark directives was to introduce CNG for all public transport in the city so as to reduce vehicular emissions. This policy,

in conjunction with related policies, has resulted in significant improvement of air quality in the city.

Linkages of CNG experience in Delhi with development and climate change benefits

There are several positive spillovers of the CNG experience in Delhi. While there could be debate on the choice of CNG as a solution to air pollution, there is no doubt about increased awareness of the negative externalities of air pollution, especially its adverse health impacts, and the need to find solutions. This is an important step in the development process of a developing country where other socio-economic goals have higher priority, often at the cost of the environment.

The use of CNG has improved air quality in Delhi, especially in terms of reduction of suspended particulate matter. At the same time, it has also led to reduction in CO_2 emissions since the carbon content of CNG is lower than that of diesel, the fuel it has replaced. This shows how a single technical solution can address air quality and climate change concerns simultaneously.

Moreover, the CNG experience has also expedited the process of adopting other measures for improving the transport system in Delhi, which would have considerable environmental benefits. The most important of these measures is the development of the Metro system in Delhi. This system is being developed to improve public transport as also to reduce traffic congestion, especially at traffic intersections. This would have positive environmental benefits, especially due to reduction in emissions from idling vehicles at intersections, and also developmental benefits, such as reduced health problems as well as reduction in wastage of resources. For instance, a study by the Petroleum Conservation Research Association estimated in 1998 that Delhi wastes $300,000 in fuel daily just through vehicles idling at traffic lights. These issues could be addressed to a large extent by the Metro system. The process has been expedited due to public demand for cleaner Delhi air, with all institutions feeling the need to deal with the problem. The

CNG experience and low sulphur diesel provided the immediate solutions that would be strengthened by the Delhi Metro in the long-term.

Similarly, CNG infrastructure development in the national capital has been substantial in the last couple of years and it would be appropriate to conclude that India has leapfrogged in this process of technological adoption and diffusion by at least a few years. The experience of the adoption and diffusion of a new technology would serve as a valuable lesson for other areas in the country looking for solutions to address environmental problems.

However, while natural gas is being promoted as a clean fuel, it is more from a local air quality management perspective. It could have significant implications for reducing GHG, though this aspect is not being given sufficient importance by national policymakers. If this aspect is also linked to policies promoting the use of gas, it would be better if appropriate technologies were obtained from developed countries that would enable substantial GHG reductions. The issue has been highlighted further in Chapter III, where we discuss the role of the developed countries in the context of technology transfers to developing countries.

Thus, use of natural gas in the transport sector is an important example of linking developmental and environmental problems. The need is to promote such uses through favourable domestic policies, technology transfers from developed nations etc. However, existing domestic policies in the gas markets that are often promoted for developmental reasons are also having adverse environmental implications. For instance, subsidies in the gas markets are creating distortions (e.g. leading to wrong choice of fuels) and affecting the performance of gas companies. Further, ad hoc pricing policies are affecting the availability of gas in the domestic market. These issues have to be tackled if benefits, both socio-economic and environmental, have to be derived from the use of natural gas in India.

Issues involved in promoting other clean fuels

Currently, major emphasis is being placed on promoting other fuels, especially nuclear power. The main issue here has been geo-political dynamics and, presently, political forces support the use of nuclear power for civilian purposes in India. This is reflected in both domestic and international fora. Cooperation and collaborative ventures are being considered with countries, including the US and France, for acquiring nuclear fuels and nuclear reactors. This process could have an impact on reducing consumption of fossil fuels for power generation, besides providing the fuel to enhance the country's power generation capacity.

With respect to hydropower, as discussed earlier, there is a wide gap between existing capacity and estimated potential. This is due to several externalities – positive and negative – associated with the development of hydropower. The various impacts on physical, environmental and socio-cultural systems have to be addressed so that the developmental benefits could be aligned with the environmental benefits.

The primary issues concerning investment in renewable energy are the timing of the investment and the environmental advantages inherent in renewable energy sources. In cases where renewable energy, at a particular point in time, is more costly than fossil energy, a nation may wait too long to invest in renewables. By delaying a decision, the country may suffer losses in the future due to the possibly higher costs of fossil energy, assuming some combination of increasing fossil energy prices and declining renewable energy costs. If it moves too soon, it also faces higher costs while fossil energy prices remain below those of renewable sources. The dilemma, thus, concerns the critical role of fossil energy prices and the inability to predict future prices with reliability (Siddayao 1993). The other dilemma relates to which fuel the renewable energy would substitute, since it might reduce the share of an environment-friendly fuel.

Promoting mass rapid transit systems: the case of Metro systems

Mass rapid transit systems (MRTS) are good examples of macro-strategies that aim to align policies for multiple dividends. While direct measures, like emission norms, have immediate impacts on air pollution levels in the city, MRTS not only reduce the number of private vehicles on the road, thereby reducing negative environmental externalities, but also meet the increasing transport needs of the people at reasonable prices. Here, we focus on the case of metro systems. Urban rail systems have to be looked at in a macro perspective, basically as a part of the urban development strategy (Mitric, 1998). A study of the metro rail in some metropolises shows that it developed to address the needs of urban development patterns in cities, as in Tokyo and Seoul (World Bank 2000a). Rail became important when high-density urban development expanded and created distances that were too great for efficient bus transport. In these cities, employment was centralized and, therefore, there were increasing mobility needs which required a high capacity rail network. In Metro Manila, road-based transport could not cater to high transport needs and therefore rail-based MRTS were developed.

Metro service is being considered in a large way in Indian cities. While Kolkata had a metro system since the 1980s (though for a short distance), the case of Delhi has achieved greater prominence. The Delhi Metro is divided into four phases, of which Phase I and Phase II, covering an area of 65.1 km and 53.02 km, are now complete and work is being carried out for Phase III. The last two phases would take the metro system to the suburbs of Delhi, thereby meeting the transportation needs of a large number of people without adversely impacting on air quality. The advantages of this system are in terms of high-capacity, travel speed, performance, comfort and low pollution levels and, if run efficiently, it could result in substitution of private modes of travel that are a major cause of traffic-related environmental problems.

Metro system in Delhi

The metro system has multiple benefits, some of which are discussed below:

◆*Impact on air quality*

The metro is a good transport demand management measure, which can address the two major air quality problems in Delhi: increase in personalized vehicles and in congestion levels. Widespread distribution of several economic centres in the hierarchical urban structure of the city and continuous spatial expansion of urban centres promote higher mobility and increase trip distances. This has created a demand for transport services. Since the quality of public transport service is poor, the number of personalized vehicles is increasing. Moreover, heavy vehicular density, coupled with lack of segregated lanes, results in high congestion levels. Long idling time in congested streets leads to emissions and fuel wastage. The metro has addressed this problem in various ways. An earlier study showed that the metro would utilize only about one-fifth of energy per passenger kilometre as compared to the road-based system (DMRC 1999). A recent study (Murty et al, 2006) has shown that there are savings in fuel consumption (inclusive of both CNG and petrol) due to diversion of a part of Delhi's road traffic to the metro. It has also reduced congestion of vehicles still operating on the roads, which implies reduction in air pollution.

◆*Development along the rail corridors*

The system of enlarging the catchment area around the metro has been followed successfully in cities worldwide by concentrating high-density public housing and commercial development close to metro stations (World Bank 2000a). The Master Plan of Delhi-2021 envisages something similar for Delhi, calling for densification of the transport corridors, especially around the metro (http://www.ddadelhi.com/MPD2021.html). The Delhi Metro is promoting such development of urban centres along areas close to the corridors. The development of commercial and business centres is generating growth of vibrant downtowns around stations and terminals, as well as new economic activities that provide employment

opportunities. High-density development of centres along the rail corridors should create passenger demand for the metro. This, in turn, would create efficient development patterns in areas surrounding the rail network.

◆***Technology transfers and capacity-building***

Technology and investment flows from developed countries into infrastructure projects like the metro through flow of finance, advanced technologies and knowhow play a crucial role in developing local capacities. The Delhi Metro has been designed with financial aid from Japan and latest technologies from developed countries including France, Korea, Germany and Japan. There are clauses in contracts (for most of the technology transfers) that call for the complete transfer of skills and knowhow, apart from equipment itself, in a gradual process. This has enhanced local capacity building, thereby enabling the expansions that are taking place to have a higher component of indigenous technologies. This would generate further benefits during development of the metro in other cities.

3. Alternate policies and measures

The above-mentioned cases exemplify some of the existing policies that have multiple dividends, ranging from developmental benefits to positive environmental externalities. Research has also been carried out on alternative policies that could generate similar benefits. Here, we take the case of the power sector to highlight how alternate policies and measures would not only have environmental benefits, but also help conserve resources that could be channeled towards other developmental projects.

3.1. SO_2 emissions trading

Growing consumption of energy resources, including coal consumption in industries, has increased emissions of local pollutants, especially SO_2, in India. Managing the rising negative externalities of energy use, especially of coal, is a prime concern of public policymaking. This is because coal is an indigenous resource in

abundance, while other hydrocarbon resources are limited in supply. Therefore, utilizing coal cleanly is preferable to replacing it since that could lead to national energy security issues.

The Indian power sector accounts for nearly 72% of coal consumption (CMIE, 2005), and contributes significantly to all-India SO_2 emissions (57% in 2005). A study (Menon-Choudhary et al, 2005) has looked at policies for SO_2 mitigation from coal-based power plants in India (this approach could be applied to other industries and gases) and compares a cost-effective policy instrument, namely emissions trading[5] with the existing technology-push instruments for SO_2 mitigation from these plants. The existing policies for SO_2 mitigation from power plants specify the stack height criteria (220 metres for plant capacity up to 500 MW and 275 metres for capacity above 500 MW) and require new plants with capacity over 500 MW and not using Integrated Gasification Combine Cycle (IGCC) technology to keep provisions for installing flue gas desulphurization (FGD) in the future. Another policy that has indirect implications for controlling SO_2 emissions is the mandatory washing of coal for power plants in critically polluted areas, urban areas or 1000 km away from the mine mouth. The study analyzed alternate policy pathways for SO_2 mitigation from power plants in India. It uses a long-term, energy-environment optimization model, Asia-Pacific Integrated/Local Model (AIM/Local) to analyze the implications of alternate mitigation strategies for SO_2 and CO_2 emissions from the 82 power plants. The details of the model are provided in Appendix I.

This paper takes the case of a business as usual (BAU) scenario, which assumes the continuation of macro-economic trends (such as higher share of the services sector, three-fold increase in per capita income during 2005-2030), demographic trends (1.39 billion total population with 36% urbanization by 2030), energy sector trends

[5] Emissions trading is defined as follows: "Essentially, a properly designed emissions trading programme is a form of environmental regulation that allows a group of sources to reach a specified emissions target at lower cost" (UNEP, UCCEE and UNCTAD 2002).

(such as 0.5-1.2% energy efficiency improvements per year in different sectors and technologies, penetration of clean and renewable technologies), cleaner fuel trends (low sulphur petroleum products, higher gas availability, washed and imported coal), as well as government policy trends for power plants. The end-use sectoral demands (such as steel, cement, bricks, fertilizers, passenger transport) follow a logistic regression and saturate in the long-run (Shukla et al, 2003; Kainuma et al, 2003).

The BAU scenario results in an SO_2 emissions trajectory, which we term as BAU SO_2 emissions trajectory. We analyze two alternate policy pathways to achieve a similar SO_2 emissions trajectory. These are the technology-push pathway and the emissions cap-and-trade[6] pathway. Both employ the same macro-economic assumptions and end-use sectoral demand projections. The difference lies in the SO_2 mitigation options employed by the two pathways. As mentioned earlier, currently, government regulations specify the technology and fuels to be used by plants – this is termed the technology-push policy. An alternate policy could be to use an emissions trading system that leaves the abatement choice with the plants and allows for trading. Since the two pathways achieve the same benefits (similar trajectory of SO_2 emissions), the implications can be compared in terms of their costs[7]. In a perfect market, the costs of adopting emission control technologies should be optimal using either instrument. But due to

[6] There are three forms of emissions trading: 'cap-and-trade', 'baseline and credit' and 'offset'. This paper focuses on the cap-and-trade system (also known as allowance trading). In this system, individual control requirements are not specified for sources. Instead, regulators set an overall cap, or maximum amount of emissions per compliance period that will achieve the desired environmental effect. Authorizations to emit are then allocated to participating sources in the form of emission allowances through some mechanism (e.g. grandfathering or auctions), with the total number of allowances not exceeding the cap. The sources must completely and accurately measure and report all emissions and turn in the same number of allowances as emissions at the end of the compliance period.

[7] However, to clarify, SO_2 emissions are a flow concept usually measured as annual emissions. Therefore, annual SO_2 emission caps can be set dynamically in future based on ambient air quality standards. Here, we take BAU emissions as the cap just to equalize the benefits (SO_2 emission levels) and compare costs across two pathways.

imperfections in the system, this does not happen and there are cost differences to achieve similar outcomes.

Our modeling assessment gives an overall estimate of compliance costs between the two pathways over the period 2005-2030. Emissions cap-and-trade results in lower compliance costs as compared to the costs of technology-push for equivalent emissions reductions. The compliance cost of technology-push policies is around US$ 5.5 billion over the 25-year period; however, over the same period and for equivalent reductions, compliance costs in an emissions cap-and-trade regime is around US$ 3.1 billion. Thus, the cost of a cap-and-trade regime is 44% lower for the same emissions trajectory; this would accrue a saving of US$ 2.4 billion in 25 years, i.e. an average annual saving of US$ 96 million. We elaborate the differences in compliance costs for three mitigation options, namely FGD, coal washing and energy efficiency improvements.

FGD: The capital costs of FGD for new plants and retrofit plants over the modeling period are taken to be between US$ 40-70 per kW of generation capacity (http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqsowet.stm). Considering that the total coal-based power generation capacity in India in 2030 would be over 150 GW as per our modeling projections, it is estimated that the costs for adopting FGD in a technology-push pathway would be around US$ 3.6 billion for the period 2005-2030, while it would be around US$ 1.4 billion under emissions trading. The difference arises because there are different grades of FGD technologies available, which vary in costs and extent of SO_2 reduction. A technology-push policy is most likely to specify the use of the best available technology among the different grades. This limits the flexibility of plants to choose the grade of technology for marginal abatement.

Coal washing: The capital costs for setting up a coal washery is around US$ 7-12 per ton of coal, and the process costs are estimated to be below US$ 1 per ton of coal washed (http://

www.coalwasheries.com/; http://www.teri.res.in/teriin/news/terivsn/issue5/analysis.htm). India has over 70 Mt non-coking coal washing capacity at present and another 20 Mt is proposed under various expansion plans (http://coal.nic.in/)[8]. The Indian power sector is projected to consume between 527-570 million-ton of coal in 2030 under different pathways to achieve BAU SO_2 emissions. In a technology-push pathway, around 18% of the total coal used will be washed in 2030 depending on distance of use from the mine-mouths and share of imported coal. This implies a total washing capacity of 115 Mt in 2030 at 90% utilization level – an addition of 45 Mt over existing capacity. Therefore, capital investments for setting up coal washeries in a technology-push pathway are around US$ 315 million. Cumulative coal washing costs for power plants would be around US$ 1 billion during 2010-2030. In an emissions trading pathway, this would be around US$ 35 million and US$ 623 million respectively for the same period.

Efficiency improvements: In this case, the costs would be around US$ 0.6 billion in a technology-push pathway, while it would be around US$ 1 billion in an emissions trading system.

Thus, the cap-and-trade regime induces, through price signals, wider and incremental measures like efficiency improvements in old plants, pre-combustion coal beneficiation and installation of less advanced but more cost-effective FGD technologies. Besides, the current trend in technology-push policies suggests that regulations place few costs or burdens on plants that choose to operate older and dirtier units, but require those building new units to install specific controls. The new units would anyway be less polluting; however, they are required to become even cleaner to mitigate additional SO_2 emissions, a task that should otherwise have been imposed on the existing dirtier units. The emissions trading pathway would at least make dirtier units pay for their pollution, while simultaneously allowing cleaner units to recover part of their costs by selling

[8] No clear data is available on their present utilization levels. However, coking coal washeries owned by Coal India Limited were utilized only 23% in 2003-2004 (capacity 20.1 Mt, washed coal 4.54 Mt; MoC, 2004).

additional emission credits earned due to cleaner operation. The marginal mitigation costs of additional SO_2 mitigated from a plant that already has low emissions are much higher than those from older plants with high emissions and fewer emission control technologies. Finally, a technology-push pathway results in firmly installing and maintaining the same technology; however, a cap-and-trade system is more dynamic since firms have continuous incentive to reduce pollution to meet their quota or create additional allowances.

3.2. Conjoint GHG and local pollutant mitigation

The paper (Menon-Choudhary et al, 2005) also considers the dynamics of policies for SO_2 (local pollutant) and CO_2 (GHG) mitigation since they are often emitted together. 82 coal-based power plants in India contributed to around 50% of all-India CO_2 emissions and 54% of all-India SO_2 emissions in 2000. There is an opportunity to develop conjoint markets for emissions mitigation, which would provide synergies and optimize mitigation actions in both markets. This paper uses the AIM/Local model, described in Appendix 1, to analyze the implications of alternate mitigation strategies for SO_2 and CO_2 emissions from the 82 power plants.

Our modeling assessment for the conjoint emissions market of power plants in India, presuming the CO_2 price of $5 per ton and identical SO_2 trajectory as in a business-as-usual scenario, shows that mitigation costs for the 20 year period would be lower in the conjoint market by US$ 400 million compared to those under two separately operating markets. Besides, the conjoint market would deliver 520 million ton of additional CO_2 mitigation and thereby add US$ 2.6 billion to the carbon revenue. The details of the co-benefits of a conjoint market are shown in Table 4.

Table 4: Mitigation strategies for SO_2 and GHG mitigation

Mitigation Regime (from 2005-30)	Mitigation Cost (2005-30)	Direct Benefits (2005-30)	Co-benefits (2005-30)
SO_2 mitigation alone [via technology-push policies in business-as-usual scenario (BAU)]	$5.5 billion	-	Little carbon mitigation benefit
CO_2 mitigation alone at $5 per ton price	$7.9 billion	$17 billion carbon revenue	Concurrent reduction in SO_2 saves $1.2 billion for SO_2 mitigation in BAU
Conjoint mitigation: CO_2 mitigation @ $5 per ton and SO_2 cap-and-trade for BAU trajectory	$10.6 billion	$19.6 billion carbon revenue	Cost of conjoint market operations are lower by $0.4 billion

However, the conjoint mitigation strategy would have to be consciously designed by policymakers because the relationship between sulphur and carbon control is asymmetric (Pandey and Shukla, 2003; Garg et al, 2003). Cost-effective carbon mitigation measures, like better combustion efficiency and fuel-switch from coal to natural gas, reduce SO_2 emissions to an even greater extent than CO_2 emissions. However, cost-effective SO_2 control policies like FGD or low sulphur diesel have little or no impact on CO_2 emissions. Thus, local emission control measures fail to net the co-benefits of concurrent SO_2 and CO_2 mitigation. Moreover, presently, mitigation of SO_2 emissions enters the national agenda prior to CO_2 mitigation. This is because mitigation of the former generates local health benefits. On the other hand, low per capita CO_2 emissions in India – 0.98 t-CO_2 as compared to the global average

of 3.93 t-CO_2 in 2002 (EIA 2004) – provide the practical and moral reasons for delayed national action on CO_2 mitigation in the absence of a facilitating global regime. Therefore, a conscious decision has to be taken by policymakers as to how they could accrue benefits from a conjoint emissions market.

To conclude, the path of development chosen by India will greatly dictate the country's future energy and emission trajectories. This path is being influenced by the direction of its economic reforms, technological advancements, sectoral policies especially pertaining to the energy sector etc. While the various Plan documents of the Government emphasize the need for sustainable development, what is crucial is how far these environmental issues – both local air quality and GHG emissions-related activities – are addressed in developmental policies. We have highlighted certain cases where policies have had multiple dividends in terms of development and environment. Greater emphasis has to be placed on achieving these dividends through consciously aligning the different policies.

III : DEVELOPING AN ARCHITECTURE FOR ALIGNMENT

1. Policy approaches

1.1. Evaluating policy interfaces

The alignment of development, air quality and climate change policies generates both synergies and conflicts at different levels. At the global level, these dynamics are visible during negotiations on global climate change. It is difficult to mobilize the support of the developed and developing countries on a range of issues, which include equity issues, the level of commitment to reduce emissions and issues related to the high costs of any programme and the unequal distribution of benefits. These arise because, on the one hand, developed countries find it difficult to change their existing lifestyles and move along a different path of development that would be less carbon-intensive; on the other hand, developing countries want to prioritize developmental goals over and above environmental goals due to their limited resources. These issues need to be resolved through greater cooperation between countries, especially since the implications of climate change are far-reaching and affect one and all.

At the individual country level too, there exist synergies and conflicts in specific policies. For instance, development measures such as the construction of flyovers, synchronized signaling etc reduce congestion and pollution at traffic intersections; however, they also lead to an increase in the number of private vehicles since traveling is made easier. Again, pricing of basic amenities such as power, water, public transport etc is a contentious issue in developing countries. The high subsidies being given in these sectors on socio-economic grounds are also creating distortions in the markets and leading to environmentally harmful uses. These conflicts have to be tackled through well-directed policy measures so that the benefits of aligning policies are achieved.

1.2. Top-down and bottom-up approach

Given the various levels of synergies and conflicts, alternate approaches have to be adopted to integrate environmental concerns in the development process. These range from top-down to bottom-up approaches. These are not completely segregated "either"-"or" options; rather, the choice of a particular approach depends on the level of intervention required. In the top-down approach, policies are formulated at the national level and provide guidelines for environmental decision-making. These include environment-related laws and legislations formulated at the Central level. More specifically, they would also include specific policies and instruments such as a national-level emissions trading scheme for the large point sources (Menon-Choudhary et al, 2005), emission standards for various pollutants emitted from the industrial and transport sectors etc. Besides, support could also be provided for research and collaborations on advanced energy technology systems that could have developmental impacts while also reducing emissions (e.g. alternate clean fuels).

In the bottom-up approach, local area-specific policies are required to internalize local characteristics within the broad framework of national policy. For instance, this could imply setting ambient air quality standards that are more stringent than the national ambient air quality standards in hotspots, developing public transport systems such as the metro, light rail transit depending on the specificities and needs of the area concerned. Further, cleaner fuels such as natural gas could be promoted depending on accessibility or proximity to the supply network. Thus, a bottom-up approach is also required to tackle specific problems, within the ambit of national policy guidelines.

2. Shifting towards an environment-friendly pathway

2.1. Prerequisites for developing countries

- ***Formulating long-term policies***

A necessary condition for aligning developmental policies in an environment-friendly pathway would be to understand growth

patterns and the corresponding environmental responses expected. Further, the emphasis should not just be on short-term goals and objectives; rather, there should be a long-term perspective, where the pathway is time-aligned to future projects of economic growth, income changes, urbanization, industrialization, technological growth, population increase etc. The long-term perspective is required because of the high levels of inertia in systems that influence this problem. These include transport systems, infrastructure, health systems, ecology and institutions. Any change required in these systems would take place only in the medium to long-term. Moreover, identifying priorities and necessities for the long run could help bring about the required institutional and policy reforms and direct investment flows in that direction. It would also provide greater flexibility to the government, allowing it to make adjustments and adapt as the country moves along the pathway rather than having to make regular changes in policies. Thus, developing a long-term vision in the short-term and aligning policies accordingly could lead to efficient allocation of resources.

Long-term economic and scientific models would help in evaluating different options based on an understanding of the dynamics, and generate scenarios that would guide policymakers today in making decisions for the long-term. Modeling exercises and impact assessment studies are crucial for understanding the costs and benefits of proposed policies. Inputs for analyzing these issues are required from varied disciplines including engineering, atmospheric sciences, health, ecology, sociology and economics to address the different aspects of the problem.

◆ ***Integrating environmental concerns in reforms***

Developing countries are going through a series of reforms, especially economic and structural reforms, which have environmental implications. Therefore, it is necessary to understand the factors that cause adverse impacts on the environment and to internalize precautionary measures in the reforms process. Further, in principle, the wide-ranging and complex linkages between economic activities and the environment imply that more of a general

equilibrium approach is required if economic policy is to be managed in a sustainable way.

One of the essential reforms required is pricing reforms. Subsidization of services like power, water etc often leads to wasteful uses and generates pollution, but for various socio-economic-political reasons, it persists in spite of other reforms. Therefore, it is necessary to introduce pricing reforms that equate prices to the real economic costs of supply so as to achieve environmental benefits by discouraging wasteful resource use. There should be other targeted approaches to provide basic services to the weaker sections of the population. Further, the adjustment process often leads to improved efficiencies in production and consumption, provided that sufficient awareness is generated. This improvement in efficiencies should be such that it also addresses the environmental concerns of the production process and not just the economic aspect.

Apart from pricing reforms, it is necessary to introduce sectoral reforms, especially energy sector reforms. Sustainable development pathways in energy production and consumption include decisions on promoting carbon-intensive fuels like coal in countries like India and China where it is a primary resource; construction of dams (it could be used to tap hydro-potential for power generation and agricultural benefits, though the negative impacts include wide-scale displacement etc). Projects that would reduce dependence on oil in developing countries would have multiple benefits – it would reduce emissions if the alternate fuel is cleaner like gas; it would also reduce energy security concerns and save foreign exchange required for importing oil. Further reforms are required in demand-side management (such as through efficiency in delivery of energy services; promoting energy efficient devices) and supply-side management (use of renewable energy).

◆ ***Adopting environmentally sustainable technologies (ESTs)***
The technology trajectory chosen plays a crucial role in moving a country towards an environmentally sustainable development path. In this trajectory the country adopts: a) appropriate technology

adapted to specific national circumstances and conditions; b) fusion of traditional and modern technologies, by which hybrid solutions which combine old and new technologies turn out to be optimal in a particular circumstance; c) movement towards technology leapfrogging (Blaustein and Shanker 2001). Modern technologies permit lower levels of specific energy-consumption. For instance, in industries, gains can be obtained from a combination of optimal design and installation of systems, choice of energy-efficient components and optimal maintenance and operation practices, which apply to cross-cutting technologies such as fluid pumping, refrigeration, use of steam, or to specifically energy-intensive industries. Energy efficiency in buildings is factored into every step of a building's life cycle: design and architecture, choice of materials, modern components for heating and cooling, O&M.

The need, therefore, is to promote these energy-efficient technologies by generating awareness, acquiring required knowhow through transfers from developed countries and further supporting its absorption and commercialization in domestic conditions. Developing countries also have to tackle the broader issues of implementation, which are often institutional and a consequence of related policies. Yet another challenge is the capital-intensive nature of these technologies, even though they are essential to move in an environmentally sustainable pathway. Approaches to tackle this problem could include public-private partnerships. Since most public services are 'natural monopolies' that require long-lasting, costly infrastructure, the public authorities may choose to delegate the operation and management of public services to private sector operators. There are many instances of this happening in developing countries; however, yet again the issue arises about the people's ability to pay the tariffs needed to ensure efficient returns to private operators.

◆ ***Institutional requirements***

Institutions for environmental management include informal ones such as social and cultural norms and formal ones such as the political-legal structure and organizations, both governmental and

non-governmental. They influence the effectiveness of policy formulation and implementation. They include the ministries of Central and State Governments, state departments and local authorities for different sectors that affect the environment (industry, transportation, power and others), enforcement and monitoring agencies, the judiciary, environmental activists, NGOs and other stakeholders. These institutions exist for the purpose of minimizing the transaction costs of formulating and implementing policies, though in the absence of coordination they could generate further transaction costs. The need to develop suitable institutions for effective policy implementation has been brought out by Prof. Schmalensee: "The creation of durable institutions and frameworks seems both logically prior to and more important than the choice of a particular policy program that will be viewed as too strong or too weak within a decade" (Schmalensee 1996).

2.2. Greater role required of developed countries

Developed countries have a crucial role to play in promoting sustainable development in developing countries. Some of the channels for this process are described below:

- ***Technology transfers***

Countries have historically gone through different stages of inventions, innovations and diffusion in the process of technological change. Given the huge resource requirements in innovations and the commercializing of new technologies, technological innovations are more prominent in developed countries, while diffusion in developing countries takes place through technology transfers. Technology transfers from developed countries encompass a broad set of processes, including flow of finance, knowledge, experience and equipment. This process strengthens the human, technological and institutional capacity of the recipient countries since all flows are adapted to meet local conditions. Thus, this diffusion process would be crucial for reducing the technological gap in developing countries and would assist environment-friendly development.

◆ ***Promoting ESTs***

There is still little progress made towards promoting optimal use of Environmentally Sustainable Technologies in developing countries. For instance, in the case of the European Union, there are all too few projects focusing on EST issues in the EU project portfolio for developing countries, i.e. renewables and energy efficiency in the energy sector, public urban transport and rail/fluvial freight. The energy sector as a whole only accounts for 3 to 4% of European Development Fund outlays. The Development Aid Committee of the OECD should now take up the issue of mainstreaming environmentally sound technologies systematically in developmental and aided projects, particularly those of Export Credit Agencies (Blaustein and Shanker 2001).

Most developing countries continue to face scarcity of technologies and the human and institutional capacity required to apply these. The existing tools for encouraging transfer of ESTs dispose of very limited financial resources, as compared to FDI. The main multilateral tool, the Global Environment Facility, is marginal with respect to FDI. Furthermore, government-to-government aid mechanisms have proved to be inefficient in increasing the flow of technologies to developing countries (Blaustein and Shanker 2001)

◆ ***Encouraging innovations***

Innovations in environmental management reduce trade-offs with development. These innovations could be in varied forms – technical, economic, policymaking, institutional and behavioral. Moreover, they could be directly linked to the environment or indirect but having positive impacts on the environment. In recent years, there is growing interest in the potential of technological innovations and investments for sustainable development in developing countries. Technological innovations are significant because they enhance the process of technology leapfrogging in a country, and new processes and products as well as knowhow can reduce the trade-offs between development and environment in an efficient manner.

3. Global mechanisms to facilitate alignment, with emphasis on climate change negotiations

Historically, there has been a high-level political thrust globally on environmental issues in international cooperation. The emphasis has been to promote sustainable development, which includes environmental sustainability. The first United Nations Conference on Human Environment in Stockholm in 1972 stressed the need for development in a sustainable manner. Several rounds of negotiations on global climate change have also recognized sustainable development as a necessity that would help address the climate change problem in an integrated manner. The issue has also been discussed in Agenda 21 (an outcome of the 1992 United Nations Conference on Environment and Development) and the associated Kyoto Protocol.

As far as local air pollution issues are specifically concerned, the WHO Commission on Health and Environment (1992) identified urban air pollution as a major environmental health problem deserving high priority for action. The 1992 United Nations Conference on Environment and Development (UNCED) in Rio highlighted the need to focus on urban environmental problems. Agenda 21 too states in Chapter 6 – dealing with 'human health and environmental pollution' – that nationally determined action programmes in this area, with international assistance, support and coordination where necessary, should include the following (UNCED 1992):

(a) Urban air pollution:

(i) Develop appropriate pollution control technology on the basis of risk assessment and epidemiological research for the introduction of environmentally sound production processes and suitable safe mass transport.

(ii) Develop air pollution control capacities in large cities, emphasizing enforcement programmes and using monitoring networks, as appropriate.

(b) Indoor air pollution:
(i) Support research and develop programmes for applying prevention and control methods to reduce indoor air pollution, including provision of economic incentives for the installation of appropriate technology.
(ii) Develop and implement health education campaigns, particularly in developing countries, to reduce the health impact of domestic use of biomass and coal.

The next major conference in this direction was the Johannesburg Summit (also known as the World Summit on Sustainable Development), held in 2002. This Summit aimed at taking concrete steps and identifying quantifiable targets for better implementing Agenda 21.

However, even though the intellectual argument for integration of sustainable development issues in climate change measures has been emphasized, its realization in the policy realm has not been very successful. This is because the measures have several limitations, ranging from differences at the conceptual level to the implementation issues of the mechanisms suggested in a developing country context. These limitations have been highlighted in the section below.

3.1. Continuing climate-centric approach of global negotiations

In spite of a strong theoretical argument for integration, there has been limited application of this concept in policies suggested for tackling climate change issues. The climate change issues discussed in the late-1980s by natural scientists were divorced from their social context; normative aspects were also ignored. Socio-economic analysis was gradually given more importance in climate change research – though even this was initially seen mainly through the lens of economic analysis at the global level, rather than of the social sciences or humanities. Not only was climate change treated separately from broader sustainability issues, it may have received disproportionately high political and scientific attention. This is partly

due to the perceived high costs of addressing the problem in industrialized countries, the economies of which depend on cheap fossil fuels. In fact, there still exists the belief that linking climate change and sustainable development could draw attention away from the main negotiations issue, which is climate change. As such, climate policies have long been perceived as a constraint on development. According to the conclusions of the Club of Rome, environmental protection and policies could only conciliate with zero economic growth. This is a contentious issue and as long as environment is considered a new form of Malthusianism, it will be difficult to achieve greater cooperation from the developing countries.

As far as sustainable development issues are concerned, they have been framed more through problem-driven social science addressing current economic, social and environmental problems at the local level and have been characterized by a more human behaviour-centred approach. The result of these different approaches in climate change negotiations and sustainable development discussions is that the international system of coordination related to climate change has been framed in a climate-centric approach disconnected from other issues of international governance and development. The existing international agreement related to climate change is the Kyoto Protocol, defined in 1997, which has been ratified by more than 100 countries. However, in spite of its general acceptance, there are drawbacks in the mechanisms mentioned in the Kyoto Protocol. These limitations, especially from a developing country viewpoint, include the following:

- **Disagreement on the principle for emission allocation**

The Protocol has set quotas of emissions to industrialized countries belonging in the group of Annex I countries. The overall emission reduction target is 5.2% compared to the emission level in 1990. The mode of definition of emission targets relates to the grandfathering principle, which was at the time a well-known mode of regulation for environmental jurists. This principle sets future emission objectives according to the prevailing level of emissions.

It is based on the fact that any new environmental regulation is a renegotiation of the social contract and it is fair to account for prevailing interests vested in the existing contract. Actually, given the need for development and economic growth in developing countries, the reference to historical emissions which are low for them is very unfair. Hence, they are opposed to the use of the grandfathering principle while fixing the developing country quota allocation.

A polar principle to the grandfathering principle was proposed as early as in 1991 by A. Agarwal and S. Narain on the basis of equal per capita distribution of emission rights. Industrialized countries believe that this proposition is unfair because infrastructure, modes of production and economic systems were built at a time no one knew about climate change and the consequences of GHG emissions and that, therefore, they should not be penalized.

◆ **Carbon markets not adapted to developing country context**
Application of any instrument, especially an economic instrument, assessed in a theoretical and perfect world may have perverse effects in a real and non-perfect world. Developing countries are undergoing numerous transitions and the technologies available are very heterogeneous. In such cases, the influence of a carbon market on investment choices will be very weak or distorted. In fact, the emergence of a carbon price may induce substitution of commercial energy towards free but inefficient and highly GHG-emissive energy resources. For instance in India, the share of non-commercial biomass in total energy declined from more than half in 1950 to 20% now. However, in absolute terms its use continued to rise till late. Only in the recent past has this form of energy use stagnated – due to supply-side constraints from deforestation and other land-use changes. The emergence of a carbon price may have the perverse effect of both increasing carbon emissions through use of non-priced and inefficient energy resources (Sagar 2005) and negatively impacting on the development of the traditional sector (for example, through initially reducing electricity access in rural areas). This is not only a matter of relative ratio price/service of

both forms of energy. Rural markets have informal lending mechanisms which provide credit to small enterprises and households with high interest rates in a context of low labour rates in the absence of firm wage contracts. The benefits associated with formal energies therefore vanish. Decentralized, climate-favouring projects would materialize only if development processes altered baseline parameters, like interest rates and wages, which are not modified by climate-centric mechanisms.

Developing countries often refuse to consider carbon exchanges because the nature of the transfers could adversely impact on development. One would think that any financial flow entering a country automatically increases per capita income. On the contrary, because of differences in purchasing power and exchange rates, a unique (international) carbon price expressed in dollars on energy prices will induce greater increase of the energy price in developing countries compared to Europe or the US. The net impact will be positive only if this effect on income is compensated by benefits from carbon transfers (this depends on choices made for recycling these financial flows in the economy).

◆ Limitations of clean development mechanism (CDM) in inducing any alignment

The CDM defined in Article 12 of the Kyoto Protocol is a mechanism which allows private investors from industrialized countries to invest in projects in developing countries in order to reduce GHG emissions compared to a situation without project (called the reference scenario) and to contribute to development. The investor receives as compensation for emission reductions an amount of emission reduction credits (ERC) which can be sold in the carbon market.

The difficulty related to this mechanism is to calculate the precise amount of emission reductions. The way the clean development mechanism emerged on the international scene led to a very strong demand for environmental integrity: any emission reduction credit delivered must refer to a real and measured emission reduction.

This de facto excludes from the mechanism projects for which it is totally impossible to guarantee a certain level of precision of the measure: some projects which are not realized in the reference scenario for different kinds of reasons (and not only financial) but which would have a very strong impact both in terms of development and in reducing GHG emissions are not eligible for the CDM.

3.2. Future efforts/initiatives required

It has been nearly three decades since the issue of climate change began to be discussed in international forums. During this period, there have been several transitions in developing countries which have to be taken into consideration in any future effort. Any climate change negotiation has to adapt to these conditions. For instance,

- The climate regime cannot impose deterministic decisions related to the decarbonization of the economy. Further, it should ultimately select win-win policies which contribute positively to development, air quality and climate mitigation. To do this, operational approaches compatible with long-term economic signals that also consider the social value of GHG emission reductions will have to be favoured.

- Instead of dictating uniform solutions, the climate regime has to consider many solutions depending on specific development contexts. This means taking into account the diversity of the real world, and guaranteeing the predictability of economic signals. It also has to support any form of regional or sector-based cooperation that could achieve multiple benefits.

- The climate regime has to support and not constrain domestic policies. This is why it is important to clarify the notion of legally binding commitments. On one hand, no economic signal will emerge without some forms of commitment; on the other, many countries will not accept a system limiting the sovereignty of their legislative institutions. Even though an agreement is expressed in legal terms, what would really secure its

enforcement is the gains from implementation vis-à-vis the costs of economic and political retaliations against those who default.

4. Some specific policy options

◆ Fragmented initiatives

New initiatives are being taken as an alternative to the Kyoto Protocol which has been criticized on the grounds that it is impossible to define an overall architecture independently from other international governance issues. Therefore, fragmented regimes are required which give more flexibility to the actors, and these regimes could converge at a later stage. One such international agreement is the Asia-Pacific agreement, which involves the ASEAN (Association of South-East Asian Nations), whose members account for around 50% of the world's GHG emissions, energy consumption, GDP and population. The US, Australia, the People's Republic of China, India, Japan and South Korea have agreed to cooperate on development and transfer of technology which enables GHG reduction. Under this pact, countries can set their goals for reducing emissions individually, with no mandatory enforcement mechanisms. The intent is to:

- Develop, deploy and transfer existing and emerging clean technology;
- Meet increased energy needs and explore ways to reduce the GHG intensity of economies;
- Build human and institutional capacity to strengthen cooperative efforts; and
- Seek ways to engage the private sector.

The areas for collaboration may include, but not be limited to: energy efficiency, clean coal, integrated gasification combined cycle, liquefied natural gas, carbon capture and storage, combined heat and power, methane capture and use, civilian nuclear power, geothermal, rural/village energy systems, advanced transportation, building and home construction and operation, bioenergy, agriculture and forestry, hydropower, wind power, solar power and other renewables. In addition, the agreement promotes long-term

transformational technologies that could radically reduce emissions while promoting economic growth, including next-generation nuclear power, fusion power, hydrogen energy distribution, biotechnology and nanotechnology.

There are pros and cons to this agreement. A favourable aspect is that developing countries would actively participate in reducing GHG emissions, but without mandated reductions. The transfer of various ESTs could prevent these countries from following the same polluting pathway as the developed countries. This would help in ensuring that the economic growth of these countries is not affected on environmental grounds. However, this agreement does not require firm commitments from developed countries, even though it tries to bring down reductions in developing countries. While emissions from developing countries are rising, per capita emissions are still higher in developed countries and there is also the need for them to adapt their path of economic growth so that it is sustainable. Moreover, this approach has relatively less chances of achieving ambitious results in terms of sending economic signals that could lead to concrete action in large infrastructure or energy-intensive sectors quickly.

◆ **Adapting the mechanisms in Kyoto Protocol**

In spite of fragmented efforts, there is no denying the presence of a global agreement like the Kyoto Protocol, which has achieved a high level of legitimacy in the international arena. It could be further adapted to achieve a higher degree of benefits from various mechanisms. For instance, binding global commitments for Annex I countries (and for countries reaching an agreed level of per capita income) would coexist with:

- Non-binding global quotas whereby countries would have access to international carbon markets if they met their targets but would not be penalized in case of overshoot[9].

[9] The fact that non-binding commitments render unknown the final level of emissions is not a weakness of the system since the alternative is no commitment at all.

- Non-binding sector-based targets allowing sectors for which this participation could bring developmental benefits.
- Forms of clean development mechanism extended to programmes in order to support action in countries and sectors not mature enough to make any pledge in terms of emission limits.

◆ Directing funds towards environmentally sustainable developmental projects

The above-mentioned options suggested the means of directing climate-related funds in a more development-oriented manner. However, even the funds that come from developed countries in the form of investment and technology flows have to be directed towards environmentally-sustainable projects (Heller and Shukla 2003). Public financing from both domestic resources and official development assistance (ODA), as well as private entrepreneurship and investment have to be the primary channels of investment and technology flows. Official aid can support the development of infrastructure like roads, highways, flyovers, transit modes like metro and gas pipelines that promote sustainable development. They could provide assistance programmes, support demonstration projects and assist in strengthening the institutional and organizational structure of recipient countries, thereby promoting technological diffusion. Technical cooperation grants[10], which are a part of the official aid, assist in the process of promoting the use of cleaner/improved technologies in developing countries by supporting capacity development through use of instruments like demonstration projects, training and education.

While foreign private investment is becoming a major component of private investment in many developing countries like China and India, there is still the feeling of high risk among investors. Private

[10] The ODA includes free-standing technical cooperation grants intended to finance the transfer of technical and managerial skills or of technology for the purpose of building up general national capacity and investment-related technical cooperation grants, which are provided to strengthen the capacity to execute specific investment projects.

investments are highly correlated to the stabilization of anticipation. Climate-friendly investments like those in infrastructure are subject to diverse kinds of risks (exchange rate risk, risk on demand) which explain their volatility. Development Finance Institutions can provide risk mitigation instruments, e.g. contract risk insurance or policy risk mitigation.

These investments, especially FDI, can become an important instrument for upgrading existing technologies and introducing efficient production methods through new equipment and skills. They generate spillovers to national businesses through imitation, employment turnover and the higher quality standards demanded of supplier companies by the investors. Further, the role of energy and the costs of energy services should be factored into overall national economic and social development strategies, including poverty reduction strategies and MDG campaigns, as well as into donor programmes in order to reach development goals in an environmentally sustainable manner (UN-Energy 2005).

However, several barriers exist in the process of such flows from developed to developing countries. Table 5 highlights the barriers as well as the instruments that could overcome them.

Table 5: Promoting technology transfers for sustainable development

Barriers to transfers	Instruments to overcome barriers
◆ *Technological* - Inferior choice of technologies in developing countries - Lack of necessary manufacturing companies in the recipient countries. - Lack of specialized local sub-contracting companies - Absence of suitable facilities for training and R&D	◆ Flow of environmentally sound technologies, proven in developed country markets ◆ R&D investments for capacity development in recipient countries ◆ Cooperative R&D investments between countries and also between private players to share costs and benefits

	◆ Developing R&D networks within and between countries ◆ Technical assistance programmes from developed countries, such as a) Technical services b) onsultancy services c) Management services d) Demonstration projects
◆ *Financial* - Heavy investments required for developmental purposes - Unsuitable choice of investments due to alternate needs - Difficulties in accessing capital	◆ Directing official and private flows towards environment-friendly developmental projects ◆ Cooperative agreements among private players - Through equities among firms - Through financial, marketing and management cooperative agreements among firms - Through bilateral agreements
◆ *Institutional* **Developed country** - Reducing R&D expenditure in improved energy technologies - Undirected flows - Uncoordinated flows **Developing country** - Absence of suitable legislations - Absence of intellectual property rights - Weak compliance and arbitration institutions	◆ *Creating an enabling environment* **Developed country** - Governments enhancing R&D outlays - Directing official aid towards globally identified developmental priorities that are also environment-friendly - Linking flows to developmental priorities of recipient countries, rather than to political considerations. - Enhancing private sector transfer through incentives **Developing country** - Governments creating suitable legislations - Effective property right legislations and enforcement - Effective compliance and enforcement mechanisms

- Lack of knowledge about new environment-friendly technologies due to high information asymmetries	- Greater participation of private sector - Developing human and organizational capacities through educational and training institutions - Promoting partnerships among the different stakeholders for greater diffusion of the technologies - Building an information network through local NGOs
◆ *Social and cultural barriers* - Difference in perceptions about the need for the technology	- Adapt transfers to suit local needs - Internalizing transfers to suit the conditions and traditions of recipient countries

While some of these barriers, especially institutional ones, relate to most kinds of technology transfers, the nature of other barriers could vary depending on the area of transfer as well as the country-specific context. Developing an enabling environment, sufficient human and institutional capabilities and having an adequate understanding of the local needs, demands and potential of recipient countries are crucial for the success of the transfer. On the other hand, developed countries also have to take steps for directing and linking the flows to sustainable development. There is a need for coherent public policies that provide incentives for the development, adoption and dissemination of new, environmentally sound technologies.

To conclude, there are several dimensions involved in the alignment of policies on development, climate change and air quality. It involves deliberations on the approach to be adopted in the planning process so as to avoid decisions that can be environmentally harmful in the long-term; further, developed countries have a crucial role in this process. All these issues have to be taken into consideration while developing a comprehensive policy for alignment.

IV : CONCLUSION

The past few decades have witnessed serious discussion on how to tackle the dual issues of development and environmental deterioration. Environmental deterioration is embedded in the development process since both concern the fundamental issues of energy, transport, land use etc – all of which have implications for achieving developmental goals as well as for global and local air quality. Different countries have tackled the issue according to the importance placed on it at various points in time. Since developed and developing countries have faced the problem at different stages of development, their approaches towards addressing it have differed.

Developed countries, during their initial stages of development, primarily faced the problem of local air pollution and not much debate took place on global climate change. These countries, therefore, adopted suitable measures to tackle the local air quality problem. The steps taken were not necessarily linked to developmental policies, and were often individual measures to tackle a specific air quality problem. Apart from these targeted policies, other factors such as income effects and rising demand for cleaner environment led to an improvement in local air quality. Currently, developing countries are grappling with developmental concerns such as poverty, food security, health, infrastructure etc, and providing basic amenities to all; they are simultaneously facing the problem of rapidly deteriorating local air quality in many urban centres. Therefore, their focus is on policies seeking to achieve developmental goals. Local air quality management is also one of the important concerns. They are tackling the problem of local air quality deterioration at lower per capita incomes as compared to incomes in developed countries when the latter tackled the same (this pattern of development and local air quality management is supported in literature by the environmental Kuznets' Curve).

The debate on the climate change problem emerged during the late 1980s, and since then it has become a highly contested issue. Various rounds of negotiations are going on regarding the mechanisms to tackle the problem. The developed countries have reached a stage of development where there is a substantial lock-in of resources; therefore, they have to adopt new approaches to tackle this problem, often through targeted policies. As far as developing countries are concerned, climate change issues are presently at the margin of their public policy concerns. This is because their per capita GHG emissions are far below those in developed countries, even though absolute emissions are rising rapidly. This rapid rise in developing country emissions is driven by developmental imperatives, in particular the need for energy and economic growth. Constraining economic growth for global environmental concerns is not an option for policymakers in these countries. Therefore, a suitable approach has to be found whereby both developed and developing countries participate, in a win-win manner, in addressing the global concern of climate change while also addressing the developing country concerns of development and local air quality management.

This paper proposes that developing countries are currently at a stage of development where the three issues of development, local air quality and climate change exist simultaneously. Since there are inter-linkages between the policies required to address these concerns, there are ample opportunities to align policies to achieve multiple objectives. For instance, in the energy sector, issues related to the availability, security and sustainability of energy sources is a strong developmental concern; the type of fuel used has implications for both local and global emissions. Specific policies adopted for reducing pollutant emissions could have conjoint benefits too. If we consider the case in India, policies introduced for improving local air quality, such as using CNG as a fuel for all vehicles, would also have implications for GHG emissions. But these implications are often not given due importance since climate change concerns are at the margin. Thus, the additional environmental benefits that could be obtained at lower costs in the business-as-usual scenario are often not achieved. This is also true for various other sectoral

policies, such as in the infrastructure sector etc, where multiple benefits can be obtained through a single policy. Achieving these multiple dividends would require conscious decisions on the part of policymakers so that developmental and environment-related policies are aligned. Especially since the past decade, developing countries are going through structural and economic reforms processes and the environmental implications would be felt in the long term. Therefore, the planning process has to incorporate environmental issues, such that the options chosen support both economic growth and environment protection.

In order to ensure that climate change concerns too are aligned with the developmental goals of developing countries, it is necessary to direct climate-related flows from developed countries towards processes that are development-oriented as well. Investment and technological flows from developed countries, which are being proposed in global climate change negotiations, could create leverage effects that meet the needs of developing countries; they can simultaneously overcome the transaction costs that create barriers to meeting the development potential of the country. This would enable an upward movement of the production frontier. The leverage effects created overcome obstacles that make the real production frontier in developing countries below the one expected, thereby reducing the gap between ex ante expectations and ex post achievements. Among the different mechanisms being discussed in the climate change regime, this trigger could be achieved through the value of carbon.

This paper has looked at the case of India to understand some specific examples of policies – formulated and implemented – that have generated multiple dividends. As such, planning policies in India, especially the later plans, have considered the environmental implications of different sectoral policies and incorporated measures to address these concerns. However, greater effort is required in the implementation of these policies since priority is still given to achieving developmental goals, sometimes irrespective of local air quality impacts. Climate change concerns are still not emphasized

during policy implementation, unless there is added incentive. Specific policies including those in the transportation sector – use of CNG, development of metro systems – have resulted in meeting the transportation needs of the people, at lower emissions than alternate methods. However, national policymakers have focused on local emissions mitigation. Equal significance accorded to the impacts of these measures on reducing GHGs could have helped in obtaining advanced technologies from developed countries that could have reduced GHGs via these measures at lower marginal costs than the costs of adopting separate policies altogether. There is also an opportunity for adopting alternate measures in the power sector which, due to the use of coal, is a significant contributor to national SO_2 and CO_2 emissions. Measures such as emissions trading lead to equivalent SO_2 emissions reduction at much lower costs than do the existing measures, thereby allowing scarce resources to be channeled towards other developmental projects. Similarly, policies that promote conjoint reductions of SO_2 and CO_2 emissions also create high savings as compared to separate policies. However, adoption of these measures requires conscious attempts on the part of policymakers, with support from technological and investment flows from developed countries.

Thus, aligning policies requires the support of policies in both developing and developed countries. This has to be reflected in the negotiations taking place on different issues at the global level, where in spite of all the intellectual arguments for integration of sustainable development issues in climate change measures, there is limited realization at the policy level. The climate-centric approach continues to be adopted in climate change negotiations. Disagreements persist on the various mechanisms referred to in the Kyoto Protocol, including the guidelines for carbon emissions trading (disagreement on the principle of emission allocation, limitations of carbon markets in a developing country context) and CDM projects. As a result, concrete measures to control global climate change have yet to be systematically adopted in developed and developing countries. One way out of this dilemma is to adopt a win-win approach: rather than imposing deterministic decisions

related to the decarbonization of an economy, climate policies should support measures that would ultimately achieve this objective without constraining development. These could include fragmented approaches such as the Asia-Pacific Agreement, whereby transfer of ESTs could ensure an environment-friendly development pathway. Adapting the mechanisms suggested in the Kyoto Protocol is also necessary. For instance, binding global commitments for Annex I countries (and for countries reaching an agreed level of per capita income) would co-exist with non-binding sector-based targets allowing sectors for which this participation could bring development benefits. Further, the CDM could be extended to programmes in order to support action in countries and sectors not mature enough to make pledges in terms of emission limits. At a broader level, rather than only directing climate-related flows, all investment and technological flows from developed countries in the form of ODA, aids and private flows could be channeled towards environmentally sustainable development. These technology transfers would not only enable leapfrogging to advanced technologies, but also enhance local capacity-building and ensure the sustainability of these processes.

To conclude, it is appropriate to state that a comprehensive approach is required to address the multitude of issues faced by developing countries related to development and environment. They are at a threshold where the policy decisions taken would have long-term implications. Therefore, a conscious attempt has to be made by both developing and developed countries to adopt a path where developmental goals can be achieved without compromising on the environment, local and global. Alignment of different policies as described in this paper is one such attempt that should enable developing countries to achieve their common objective of environmentally sustainable development.

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APPENDIX I: AIM/LOCAL MODEL

The AIM/Local model follows a linear programming approach to find an optimal solution by selecting a combination of technologies with least cost, while satisfying given constraints of fulfilling demand and meeting environmental targets (Kainuma et al., 2003; Shukla et al., 2004a). The objective function is the total cost in a given year, which comprises total annualized fixed cost (only for recruitments in that year), total running cost and total cost of emission tax in that year. Total national emissions are the sum of those from LPS and area sources (such as transport, agricultural activities). Emissions from LPS for energy consumption and production processes are given by

$$Q_l^{LPS} = R_l^{LPS} \times \{\sum_k (E_{l,k}^{LPS} \times f_k) + \sum_\nu (V_{l,\nu}^{LPS} \times f_\nu)\}$$

Where,

Q_l^{LPS} : Net emission from large point source l

R_l^{LPS} : Release rate of pollutants after removal technology of large point source l

$E_{l,k}^{LPS}$: Energy consumption of energy kind k for large point source l

f_k : Emission coefficient of energy kind k

$V_{l,\nu}^{LPS}$: Production quantity of production process ν for large point source l

f_ν : Emission coefficient of production process ν

k : Energy kind

ν : Production process

The emissions not from LPS are taken to be from area sources and are given by the following equation:

$$Q_j^{AS} = \sum_k (E_{j,k}^{AS} \times f_{j,k}^{AS}) + \sum_\nu (V_{j,\nu}^{AS} \times f_{j,\nu}^{AS}) \qquad (2)$$

$$E^{AS}_{j,k} = E_{j,k} - \sum_{l \in \{\text{point sources belong to sector } j\}} E^{LPS}_{l,k} \quad (3)$$

$$V^{AS}_{j,\nu} = V_{j,\nu} - \sum_{l \in \{\text{point sources belong to sector } j\}} V^{LPS}_{l,\nu} \quad (4)$$

Where,

Q^{AS}_{j} : Emissions from sector j from area sources

$f^{AS}_{j,k}$: Emission coefficient of energy kind k from sector j, taking into account the effect of removal technologies

$E^{AS}_{j,k}$: Energy consumption of energy kind k for sector j

$E_{j,k}$: Total energy consumption of energy kind k for sector j

$f^{AS}_{j,\nu}$: Emission coefficient of production process ν from sector j, taking into account the effect of removal technologies

$V^{AS}_{j,\nu}$: Production quantity of production process ν for sector j

$V_{j,k}$: Total production quantity of production process ν for sector j

j : Sector

The sectoral emissions estimated on the national level are then allocated to the districts based on a suitable allocation index like district population, area, road density etc., for which the information is available on district level. Suitable parameters, which were considered as the major drivers for emissions from a particular sector, were used to generate this index. The emissions from district can thus be given by

$$q^{AS}_{i} = \sum_{j} (Q^{AS}_{j} \times \frac{I_{i,j}}{\sum_{i} I_{i,j}}) \quad (5)$$

Where,

q^{AS}_{i} : Emission in district i from area sources

$I_{i,j}$: Emission intensity index for sector j in district i

Equation (1) gives the emissions from the large point sources and equation (2) gives the emissions from a sector in an area. The total emissions from sector j in a region can thus be given by

$$Q_j = Q_j^{AS} + \sum_{l \in \{\text{point sources belong to sector } j\}} Q_l^{LPS} \quad (6)$$

The total emissions at the district level can be calculated by summing up the allocated area source emissions and point source emissions from a district.

$$Q_i = q_i^{AS} + \sum_{l \in \{\text{point sources in district } i\}} Q_l^{LPS} \quad (7)$$

This emission estimation methodology used in AIM/Local is in line with the recommended methodology of the Intergovernmental Panel on Climate Change (IPCC, 1996). The Geographical Information System (GIS) interface of this model allows for a spatial representation of the distribution of emissions.

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Aligning Development, Air Quality and Climate Policies for Multiple Dividends

SUMMARY

This paper proposes that environment protection should be made complementary to the development process, by aligning different policies that avoid trade-offs and generate multiple dividends during policy implementation. This is especially true for developing countries where crucial development policies with long-term implications are being formulated. There is a good opportunity to align development, local air quality management and climate change policies that both reduces costs and achieves multiple dividends. Empirical evidence, including the Environmental Kuznets' Curve, shows that, as a country progresses economically, concern develops for the environment due to availability of resources and public pressure. This is found more for local pollutants, while policies preventing greenhouse gas emissions need conscious policymaking. This approach is reflected in developing countries, where air quality problems are being addressed individually. A more pro-active approach would generate no-regrets options, moving a country on a pathway that prevents local air quality deterioration and is also less carbon-intensive. Since developing countries fear that climate change negotiations can impede development, developed countries should support their move to align policies by directing climate-related as well as public/private flows towards a development-oriented pathway. This would create leverage effects on implementation of domestic policies and help overcome transaction costs. A win-win situation can thus emerge, which addresses the developing countries' concerns of development and local air quality management along with the global concern for climate change.

Taking India's case, this paper looks at policies in the planning process incorporating the environmental agenda. The focus is on preventing local air quality deterioration. But, since benefits related to preventing greenhouse gas emissions often lie at the margin, conjoint benefits can be obtained at optimal costs. This paper looks at measures like use of CNG in public transport and development of mass rapid transit systems. Systems like the Metro Rail address congestion problems besides providing suitable means of public transport. Similarly, promoting CNG on environmental grounds would enhance CNG availability for power generation. Research shows opportunities for conjoint mitigation of CO_2 and SO_2 emissions from the power sector. Adoption of these measures requires conscious attempts by national policymakers, with support in the form of technological and investment flows from developed countries.

CENTRE DE SCIENCES HUMAINES

2 Aurangzeb Road, New Delhi - 110 011, India
Tel. : (91 11) 30 41 00 70
Fax : (91 11) 30 41 00 79
E-mail : infos@csh-delhi.com
Website : http://www.csh-delhi.com