

## Chapter 2

# Industrial Revolutions, Climate Change and Asia

Development of civilisation would have not happened without carbon emission in most cases. But carbon emissions are now believed to add to global warming and subsequent climate change events. Scientists believe that the world has already burnt half the fossil fuels necessary to bring about 2°C rise in global temperature.

As the humans began to settle, their energy requirement also increased with wood as main source of energy. By the 1280s, people started using coal for fuel in processes such as limekilns and metalworking which resulted in air pollution having black smoke and oxides of sulphur in its emissions.

Late eighteenth and early nineteenth centuries witnessed major changes in agriculture, manufacturing, production, mining, and transportation. The onset of the industrial revolution marked turning point for climate change. The use of coal gas in street lighting was eventually replaced with the emergence of the modern electric era. With the development of electric power in the nineteenth century, coal's future became closely tied to electricity generation. The first practical coal-fired electric generating station, developed by Thomas Edison, went into operation in New York City in 1882, supplying electricity for household lights.

Oil overtook coal as the largest source of primary energy in the 1960s, with the huge growth in the transportation sector. Coal still plays a vital role in the world's primary energy mix, providing 23.5% of global primary energy and 39% of the world's electricity in 2002.

The industrial revolution had a great effect on the socioeconomic and cultural conditions starting in the United Kingdom, followed by Europe, North America, and eventually the world. The industrial revolution marks a major turning point in human history. Starting in the later part of the eighteenth century, Great Britain's previously manual labour and animal-based economy changed to machine-based manufacturing. It started with the mechanization of the textile industries followed by development of iron-making techniques which lead to increased use of coal. The developments of machine tools in the first two decades of the nineteenth century led to manufacturing of more machines for other industries. The first industrial revolution, which began in the eighteenth century led to Second industrial revolution in nineteenth century, with the development of steam-powered ships and railways. Nineteenth century witnessed internal combustion engine and electrical power generation. With industrial revolution came a series of environmental impacts – air

pollution, water pollution, thermal pollution, noise pollution and degradation of forest and other ecosystems. Increase in carbon dioxide led to global warming due to green house effect.

Industrialized countries have accumulated 'historical' emissions, in the atmosphere since the beginning of the industrial revolution. Very recently, developing countries are only adding to this carbon pool already created in the atmosphere.

With the industrial revolution and subsequent development, climate system was overused because of its natural availability as a resource whose access is open to all free of charge. This resulted in 'free riding', a situation in which development of some individuals (the 'free riders') enjoy the benefits at the cost of others (including other species). Change in climate has significant implications for intra-generational and inter-generational equity, and the application of diverse equity approaches has most important implications for policy recommendations (Halsnæs et al. 2007).

The growing threat of global warming and climate change has alerted attention on the economic growth and environmental pollutants. Intergovernmental Panel on Climate Change (IPCC) estimated that the average global temperature will rise between 1.1 and 6.4°C in the next 100 years (IPCC 2007).

The global trade in goods depends on transportation of freight along complex supply chains (Fred 2009). Many literature published on globalization and the environment focuses on the effect trade treaties and increased global trade on the ecosystem (Boghesi and Vercelli 2003; Chapman 2007; Clapp and Dauvergne 2005; Ehrenfeld 2005; Tisdell 2001). Past studies reveal the economic growth-environmental pollution nexus (Lee and Lee 2009) and the economic growth-energy consumption nexus (Al-Iriani 2006; Apergis and Payne 2009a, b; Chen et al. 2007; Joyeux and Ripple 2007; Lee 2005; Mishra et al. 2009; Mahadevan and Asafu-Adjaye 2007; Mehrara 2007; Lee and Chang 2008; Narayan and Narayan 2008; Narayan and Smyth 2009).

Globally, CO<sub>2</sub> emissions increased from 1971 to 2004 at an annual rate of 2% with the largest regional increases in CO<sub>2</sub> emissions for commercial buildings and residential buildings from developing Asia for 30 and 42% respectively (Levine et al. 2007). Like all other continents, Asia also underwent climate change due to anthropogenic activities.

East China is witnessing abrupt change of summer climate since early 1980s with southward retreat of summer monsoon rainy belt (Qun 2001).

At the beginning of this century, most of the leaders of the world were busy to tackle the problem of climate change. Most of them are eager to solve the problem with exception of a few neutral who have not understood the problem, others are either eager to solve the problem or neutral. Still some of the leaders are looking for funds and advice to overcome the problem. Climate change is one of the major problems faced by present and immediate next generation. If these two generations are not able to solve the problem then it would be too late to solve the change which would have gained inertia. Across the world, millions of people are already forced to cope with the climate change. In the climate change scenario, developing countries suffer more than developed countries.

In spite of constant improvements in energy intensities, global energy use and supply are expected to continue to grow, especially as developing countries follow

industrialization (Rogner et al. 2007). Urbanization and growing wealth in developing countries indicate a large increase in demand for energy services in the next few decades, which mean increased carbon emission. How the world reacts to this problem will have direct bearing on the poor and rich at different time, magnitude and type. Poor people are more vulnerable to climate change but all who are vulnerable are not poor. However, eradication of poverty is not the solution of climate change (Kulshrestha 2010). According to recent findings of IPCC, increasing GHG emissions have been correlated with more energy usage especially during past two decades which led to uplifting of human society especially in developing world. If poverty is removed, technology driven population will be increased carrying more per capita CO<sub>2</sub> emissions. It is important to note that poor men society many a times recycles the materials due to poor monetary condition thus emitting limited CO<sub>2</sub>.

In many regions, religion, culture and ethnic differences have been source of conflict among the people. But one common thing about all these people is they share same planet and are subject to climate change.

Current patterns of resource depletion, if continued, lead to issues related to the food and energy security of Asian countries. Hence these nations should recognize and accept the links between the expansion of economic activity, resource depletion, and pollution.

## 2.1 Industrial Revolution and Asia

The industrial revolution was introduced by Europeans into Asia in the last years of the nineteenth and the beginning of the twentieth century which saw the development of industries in India, China, and Japan.

The possible reasons for Asia not catching up with industrial revolution in eighteenth and early nineteenth century could be many countries were under the control of colonial rule. Subsequent struggle of these countries for freedom as well as being busy in participation of wars rather than peace made Asian countries to catch-up industrial activity late. The blessing in disguise to Asia in twentieth century is some of industrial houses were looking forward to outsource polluting activities to avoid stringent environmental legislation and standards in their own countries. Other reasons include cheap labour and search for new market by old companies who have achieved end of growth in their own countries as most of the people in these countries possess materialistic luxury and hence does not create demand for cars, refrigerators, electronic goods etc.,

In the 1960s, about 60% of the Chinese labour force was employed in agriculture, by 1990; the fraction of the labour force employed in agriculture had fallen to about 30% and by 2000 still further. The rapid economic growth is mainly due to growth of the industrial sector in absolute terms, of up to 8% per year during the 1970s. Economic growth and the amplified integration in the world economy of other countries from Asia are contributing to the increase of international marine

transport. Globally, large enterprises dominate industrialization, but small- and medium-sized enterprises (SMEs) outnumber large industries in developing countries. In India, SMEs have major shares in the metals, chemicals, food industries (GOI 2005). China has 39.8 million SMEs accounting for 99% of the country's enterprises (APEC 2002). One disadvantage with SMEs is lower adherence to environmental laws. Many of SMEs are unorganized and will not register with government bodies to evade trade restrictions, bureaucracy, taxes, bribes and paperwork. Production of Natural Gas in the Middle East and Asia Pacific increased in the year 2009 due to growth in Iran, Qatar, India and China (BP 2010).

China has become the world's largest energy-related GHG emitter surpassing the United States. In 2007, China's energy sector accounted about 6.1 billion tons of CO<sub>2</sub> or about 21% of entire global energy-related CO<sub>2</sub> emissions (WEO 2009). China is now the world's principal producer of cement, glass, steel, and ammonia (CSIS 2010). If Asian countries continue to rapidly industrialize, transport demand will grow with extreme rapidity over the next several decades.

It is very likely that combined radiative forcing from CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O concentration augmentation, have been at least five times quicker over the period from 1960 to 1999 than over any other 40-year period for the duration of the past two millennia prior to the industrial era (Jansen et al. 2007).

Economic and population growth in Asia over the last 30 years has been extraordinary. While conventional economic indicators have been growing constantly, indicators of resource and environmental qualities are decreasing, the reason often referred to out dated technologies, numerous unorganised small scale units and intuitional failure (see Box 2.1). Extremely urbanised populations and poorly planned municipal development; 2.5 times augment in the use of passenger cars over last two decades; haze pollution from forest fires from Indonesia and other countries has resulted in urban air pollution in Asia.

### **Box 2.1 Pollution control and prevention: institution failure**

The international community often refers institution failure as key reason for failure of pollution prevention but usually do not elaborate the reasons for failure. Given below the some gist why pollution control institutions usually fail.

- **Increase in legislation and policy:** After ratification of international environmental legislation the countries usually bring out new national legislation or policy. But institutions do not grow in proportion to responsibility imposed on them due to enacting new legislation or announcement of new policy.
- **Lower manpower:** institutions often fail to recruit man power with increase in legislation and some institutions take decade between recruitments. The number of officer to country's population some time varies from one to ten officers for every million people. The officer to

*(continued)*

geographical area varies from one to ten officers for every 1,000 km<sup>2</sup>. Similarly the ratio of number of enforcing and monitoring staff to coastal stretch, river length, number of water bodies, and number of industries in developing country is far less than developed countries.

- **Non-implementation of laws in holidays and at nights:** Unlike police and fire and emergency services, pollution control institutions usually work only in week days and time in office hours. The departments usually do not work in public holiday and festivals.
- **Use of pollution control monitoring officer to other duties:** The officers and staff of pollution control authorities are used for other duties like election duties and other committees not related to pollution control and prevention.
- **Corruption:** Developing countries have comparatively more corruption and pollution control agencies are not an exception.
- **Leadership:** Most of the institutions responsible for pollution control and prevention are political nominees and quality of institution depends on quality of leadership.
- **Slow decision and communication:** Institutional procedures differ in countries to country and many country still use old paper based records and communication instead of electronic versions.
- **Technology shyness:** Many developing countries do not use remote sensing technology and continuous monitoring equipment for monitoring environmental degradation. Manual procedures are prone to errors, inconsistency and can be easily manipulated.

The term institutional failure is usually not elaborated in many literatures. Failure as understood is not delivering functions that is expected from government agencies which should act as ‘trust’ and the officers of these agency should act as trustees to protect natural resources. But it is often seen these goals are not achieved due to lack of transparency. Coping with climate change can’t be achieved if the national action plans does not include measures to curb institution failure. Economic growth in coming days is considered to be dependent on ensuring an efficient use of natural resources, and at same time striving to reduce environmental damages (Reddy and Goldemberg 1990; Byrne and Shen 1996).

In an urge to catch up with Europeans and Americans in terms of development, Asian countries are liberating the economy and regions with in the countries are competing for industrial growth. Many states in India often conduct *Global Investors Meet* to lure them to invest in the state. Such meeting often promise uninterrupted power supply, fast track clearances from all government department, adequate land and water.

In 2009, global oil use declined by 1.2 million barrels per day (b/d), or 1.7%, however global refining capacity in the period grew by 2.2%, or 2 million b/d with

the Asia-Pacific region accounting for more than 80% of the global growth, mainly due to increases in India (BP 2010).

The software Industry boom was also blessing in disguise for India which could provide manpower at six to ten time cheaper than the manpower cost in USA. The fluency in English and ability to work hard with little added incentive has been the success story of software Industry in India. The development centres which work round the clock often demand a work of more than 12 hours from their employees. As a result the working population were able to generate an income 10–20 times that of their parents. This has increased purchasing power of youngster in growing population of cities like Bangalore, Pune, Delhi, Noida, Gurgaon, Mumbai and Hyderabad. The software giants have also started opening development centre in less populated cities like Mysore, Indore and Thiruvananthapuram to cut down costs.

From 1900 to 2000, world primary energy increased more than tenfold, where as world population rose only fourfold from 1.6 to 6.1 billion (Sims et al. 2007). The highest growth rate in the last decade was in Asia. A large number of the world's energy-intensive industries are now located in developing countries with China being world's largest producer of steel (IISI 2005), aluminum and cement (USGS 2005).

As a result of urbanisation, there is tremendous pressure on environment due to increase in vehicles and housing activities. The industrialisation has also resulted in formation of multiple nuclear families by splitting of joint family. Such development has created demand for personal vehicles and house hold articles. Growing pressure to deliver goods and service has also reduced time to cook and hence has increased fast food industry and restaurants and hotels in many cities. This means there is more activity and combustion of fossil fuel which has ultimately contributed to environment degradation. There is also problem of low quality of constructions due to mushrooming apartments. Increased construction activities diminished availability of quality sand around the cities. Construction companies in such area are mixing soil with high fine particles to make concrete and mortar which results in low bonding. The long term impact could only be assessed during disasters when apartments fall like castle of playing cards.

Other practices during construction like use of freshwater for buildings, and washing fertile soil to separate coarse material for construction will have impact in future due to depletion of water resource and loss of fertility in soil. There is tremendous pressure on the hills due to mining and quarrying activity for supplying construction material.

The environmental degradation is not serious issue for the governments and often ready to compromise with certain extent for development. It is also noteworthy that such acceptance has paid high dividends in terms of economic growth in some area. On the other hand opposition from local community to some of the mega projects have resulted in stagnant economic activities.

Three decades of industrial development in Asia, has translated into resource depletion and environmental impacts. Rather than reducing environmental problems, rapid economic growth has taken its cost on the environment. Hence Asian nations should direct efforts towards making and implementation of policies

that are based on long-term accommodation of population and economic growth ambition to the limitations of our biophysical world (Pradeep et al. 2001).

Of most concern in these anthropogenic factors is the increase in CO<sub>2</sub> levels due to emissions from fossil fuel combustion, followed by aerosols (particulate matter in the atmosphere).

Projected climate change-related exposure are likely to affect health of people through rise in malnutrition; increased deaths, disease and injury; rise in diarrhoeal disease; the increased frequency of cardio-respiratory diseases; change in spatial distribution of vectors (IPCC 2007). This adds to already existing disease burden due to nosocomial infections, zoonosis, poor sanitation and deteriorated environment. Further, in present days changing food habits and increase in alcohol consumption will boost the unhealthy citizens in Asia.

Increased industrialisation in Asia does not in any way imply that all the people are benefitted by the change. Figure 2.1 shows relationship between rich, poor and resources. Irrespective of the countries rich people have been benefitted due to economic growth where as poor people have suffered with pollution and other negative consequences of development. Poor is pushed and exposed to climate change. Walking more than 10 km/day each way to farms, schools and clinics is usual in parts of Asia (Kahn Ribeiro et al. 2007). While some people are enjoying the benefits of development others are being affected by negative impact. The growth in China and India as depicted in statistics is not really bringing to benefit to those who are unable to cope with changing world. Around 500 million people in India are living without access to electricity, in a country which is considered as world's global economic threat.

Development does not mean always luxury and negligence towards environment. Some Asian cities with strong governments, actively and effectively pursuing strategies to slow motorization by providing high quality public transport

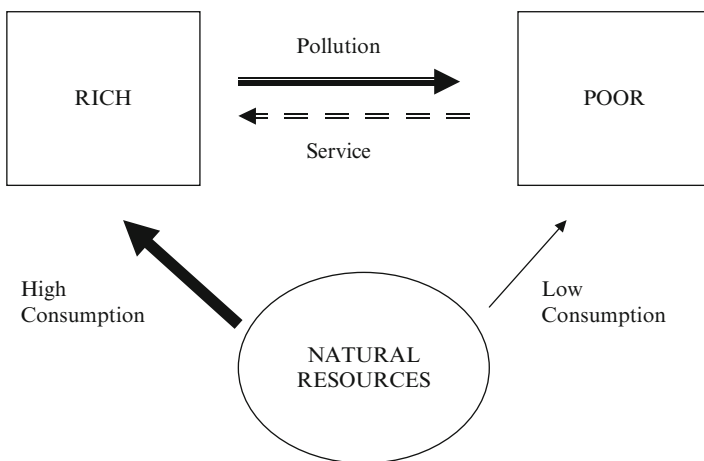


Fig. 2.1 Relationship between rich, poor and resources

(Cullinane 2002; Willoughby 2001; Cameron et al. 2004; Sperling and Salon 2002). But there are also people in the same country who exit one air-conditioned building to enter another air conditioned building after travelling in air conditioned car. There is a huge gap with in the society. The economic growth in many areas due to is taking away land of poor by compulsory acquisitions while the lands of influential people are not touched for acquisition. The poor in such situation have been pushed to further poverty and exposed to climate impact more severely than before.

## 2.2 Air Pollution and CO<sub>2</sub>

Pollution is the introduction of contaminants into environment that causes harm or discomfort to the ecosystem, human health and property.

According to Air (Prevention and Control of Pollution) Act 1981 of India,

*“Air pollutant” means any solid, liquid or gaseous substance present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment;*

*“Air pollution” means the presence in the atmosphere of any air.*

According to Environment Protection Act 1990 of United Kingdom,

*“Pollution of the Environment” means pollution of the environment due to the release (into any environmental medium) from any process of substances which are capable of causing harm to man or any other living organisms supported by the environment.*

It is about hundred years ago that scientists raised a concern regarding burning of fossil fuels during the nineteenth century which they warned would change climate. Most outstanding among these scientists was Svante Arrhenius of Sweden who won the Nobel peace Prize for Chemistry in 1903. Warnings of these scientists were ignored by society in an ambition to enjoy luxury. Mass production of automobiles and its ownership in developed countries lead to further increase in CO<sub>2</sub> in atmosphere.

With dawn of industrial revolution, the globe witnessed spurt of a new activities along with a new array of chemicals. Populations in industrialized countries moved from rural areas to urban areas produced larger amounts of waste and CO<sub>2</sub> emissions. In Asia, as on date biomass burning and fossil fuel burning are the major sources of air pollution which contribute CO<sub>2</sub> and GHGs. Much of the heat radiation is absorbed by the water vapours while CO<sub>2</sub> and other GHGs absorb the radiative energy not absorbed by water vapour. Biomass burning plays a major role in gaseous pollution whereas fossil fuel and biomass combustion contribute to particulate pollution (UNEP and C4 2002).

Between 1971 and 2007, global emission doubled with developing countries, led by Asia, increased economic activity at a much faster rate. Between 1990 and 2007, CO<sub>2</sub> emissions rose more than double for Asia due to striking rate of economic development particularly within China and India (IEA 2007). Natural gas



production in the Middle East and Asia Pacific was increased during 2009, driven by growth in Iran, Qatar, India and China (BP 2010). New coal-fired power stations are being put in operation in China each week making implementation of the ambitions of the UNFCCC and the Kyoto Protocol challenge to merge desired economic development with environmental protection (UNEP 2010). Asia has also some unique problem with respect to population distribution. The South Asian Region is one of the most densely populated in the world. It possesses 3% of the world's land mass with 20% of world population. Population in cities of Asia and the Pacific region is above WHO guidelines. It was as high as 98% for India and 99% for China (UNEP and C4 2002). Such population density is easily vulnerable to air pollution and climate change.

Human activities result in emissions of four principal GHGs: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time.

- Carbon dioxide concentrations are increased due to fossil fuel use, deforestation and decay of organic matter
- Methane concentrations are increased as a result of agriculture, natural gas distribution, landfills, and anaerobic decomposition in wetlands
- Nitrous oxide is emitted by chemical/fertilizer manufacture and fossil fuel burning. Natural processes like, volcanic activity, forest fire, reaction in atmosphere and oceans also release N<sub>2</sub>O
- Halocarbon gas concentrations are increased primarily due to human activities. Main halocarbons include the chlorofluorocarbons (e.g., CFC-11 and CFC-12), which were used extensively as refrigeration agents and in other industrial processes
- Ozone is continually produced and destroyed in the atmosphere by series of chemical reactions. In the troposphere, human activities have increased ozone by release of gases such as carbon monoxide, hydrocarbons and nitrogen oxide that chemically react to produce ozone
- Water vapour is generated through chemical destruction of CH<sub>4</sub> in the stratosphere, producing a small amount of water vapour and
- Aerosols are generated by both anthropogenic activity (such as surface mining, fossil fuel combustion and industrial processes) and natural sources (mineral dust released from the surface, sea salt aerosols, biogenic emissions from the land and oceans; and dust aerosols produced by volcanic eruptions)

Apart from GHGs (like CO<sub>2</sub>, CH<sub>4</sub>, O<sub>3</sub>), particles and cirrus clouds are also making significant contributions to the climate impact. Chemically active gases in the atmosphere distribute themselves with large spatial and temporal variations. Air Pollutants can change responses of ecosystems to specific climatic change impacts (Andrzej et al. 2007). The climate-chemistry is therefore characterized by regional differences. Regions such as Southeast Asia is considered as future key region due to large increase in energy consumption and pollution emission (Akimoto 2003; Kupiainen and Klimont 2007; Amann et al. 2008; Klimont et al. 2009; Isaksen et al.

2009). Similarly, ship and air traffic are important sectors because of increases in emissions in recent years (Eyring et al. 2005a, b, 2007; Dalsøren et al. 2009).

Carbonaceous aerosols in South Asia has in recent times received great attention due to its rising emissions (Dickerson et al. 2002; Reddy and Venkataraman 2002a, b; Kulshrestha et al. 2005). In less than 20 years, South Asia has become one of the most polluted areas in the world (WHO/UNEP 1992). Oil consumption in the Asia-Pacific region was more than 80% of the global growth, due to increases of consumption in India (+19.5%, or 580,000 b/d) and China (+10.5%, or 820,000 b/d) (BP 2010).

With its many low-tech industrial activities and poorly controlled combustion, high quantities of air pollutants are emitted into the air. While regulations have resulted in lower pollutant emissions in the westernized nations, rapid industrialization has generated high emissions in South Asia (Kato and Akimoto 1992; Akimoto and Narita 1994; Arndt et al. 1997; Garg et al. 2001). Increasing population and industrial activity will generate even higher emissions in the near future. This is going to affect not only the air quality, but also global climate (Venkataraman et al. 1999; Reddy and Venkataraman 1999, 2000).

While GHGs rise the temperature, non-dark particulate matters reflect the energy from atmosphere and contributes to cooling effect. But dark particles do absorb heat energy and contribute to increase in atmospheric temperature. Effects of the haze include cooling of the land surface; increase in the frequency and strength of the thermal inversion; change of the winter time rainfall patterns; and reduction in the average tropical evaporation as well as precipitation.

The most visible impact of air pollution in Asian countries is the haze, a brownish layer of pollutants and particles that pervades many regions in Asia (UNEP and C4 2002). Atmospheric brown cloud (ABC) created world over during last decade is driving global changes in the Earth's atmosphere. More visible impacts are:

- Changes of rainfall patterns with the Asian monsoon leading to weakening Indian monsoon
- Displacement of the thermal equator southwards via cooling of the air over East Asia and
- Retreat of the Hindu Kush-Himalayan glaciers and snow packs and deposition of black carbon decreasing the reflection and exacerbating the retreat

Aerosol pollution due to dust storms can modify cloud properties to reduce or prevent rain in the polluted region. Aerosol with black carbon can reduce formation of clouds. The decrease in precipitation can cause drier soil, which in turn rises into the air providing a potential feedback loop to further decrease rainfall. Anthropogenic changes of land use exposing the topsoil can start desertification feedback process.

Per capita basis, GDP, energy consumption and carbon emissions in developing Asia are much lower compared with the developed countries of the west. But over the year industries discharged foul, toxic, solid, liquid, and gaseous wastes disturbing ecosystems. The industrial revolution also sparked the first significant wave of

industrial pollution litigation in history suing industrial polluters under the common law of nuisance. Common law allowed individuals as well as governments to take legal action against nuisances. But no body took action on any body for emitting CO<sub>2</sub>. While other gases like oxides of sulphur and nitrogen found its place in discharge standards, CO<sub>2</sub> still does not find its place in either emission standards or ambient air quality standards.

The reason is evident in the fact that the first visible impact due to air pollution was by particulate matter which soiled the cloth and contributed to cough. The next culprits were toxic and acidic gases like oxide of sulphur which also irritated industrial workers as well as people in the neighbourhood. But CO<sub>2</sub> was considered as constitute of air and no body thought about its ill effect until recently when the snow started melting and temperature increased dramatically.

In spite of wide data published, there is still a large gap with respect to accurate data with regard to non-CO<sub>2</sub> GHGs, black carbon, and CO<sub>2</sub> from sources, such as deforestation, decay of biomass and peat fires; military activities and wild animals. Numerous data gaps still exists as shown in Fig. 2.2 where practices like application of degradable wastewater on land result in higher or lower emission than theoretically predicted as accurate emission factors is yet to be evolved.

### **Box 2.2 Why bother about CO<sub>2</sub>**

All gases have a unique pattern for absorption of energy, absorbing some wavelengths of energy and letting out others. Even though water vapour absorbs numerous wavelengths of infrared energy, it is transparent to others. Carbon dioxide and other GHGs absorb energy that water vapour does not. This partially closes the “window” through which heat radiated by the earth’s surface would otherwise escape to space. The Earth’s climate system depends on how much energy enters or leaves the Earth. Imbalance in Earth’s radiative equilibrium will lead to rise or fall of temperatures.

In spite of natural phenomena like absorption by oceans and vegetation, the globe is accumulating CO<sub>2</sub> in the atmosphere. The concentration changed from 280 ppm (during pre pre-industrial revolution) to 379 ppm in 2005 (TERI 2009). The uptake of CO<sub>2</sub> in land variable is because of land use change, pollution, fire, and other factors affecting soil and biomass.

CO<sub>2</sub> is greatest contribution to rising global temperatures followed by black carbon. Carbon dioxide is responsible for 40% of the earth’s warming and black carbon is responsible for 12% (Pachauri 2010).

It will be unfair not to mention the concern about GHGs inventory. The calculation of GHGs does always make series of assumption and use data available in records. But in reality numbers in records deviate from existing scenario. The GHGs emission due to fuel consumption and explosions in military activity is usually not included in GHGs calculation. Accepting the limitations of theoretical calculation,

**Fig. 2.2** Application of degradable wastewater on land – unconventional practices not considered in GHGs calculation result in higher or lower emission than theoretically predicted



over the 1900–2005 periods, the US was the world’s largest cumulative emitter of energy-related CO<sub>2</sub> emissions, and accounted for 30% of total cumulative emissions (IEA 2007). The second largest emitter was the EU, at 23%; the third largest was China, at 8%; fourth was Japan, at 4%; fifth was India, at 2%. The rest of the world accounted for 33% of global, cumulative, energy-related CO<sub>2</sub> emissions (IEA 2007).

Improper discharge of waste and experimental discharge of waste usually contributes different emissions than what is calculated. Another setback of theoretical calculation is fuel adulteration which is very common in many Asian countries. Usually, fuel adulteration is not considered during the calculation.

Coal burned in cities for power generation, industrial applications, domestic and commercial boilers and stoves may pollute remote area too. Chinese cities experience very high airborne particle. Measurements made at background sites in the countryside outside of Beijing show particulate concentrations more than half as high as in the city indicating large-scale regional air pollution problem of large geographic extent covering North China and not restricted to Beijing alone. However, in India atmospheric soil dust rich in calcium carbonate gives some relief from acidic effect of sulphur dioxide and nitrogen dioxide. Kulshrestha et al. (2003a, b) demonstrated that in the atmosphere rich with soil dust, calcium carbonate forms calcium sulphate which is not harmful to ecosystem. In addition, Kulshrestha (2009) proposes atmospheric soil dust in India as a natural geo-engineering tool to combat climate change in the region.

The top five producers of coal are China, the USA, India, Australia and South Africa. Much of global coal production is used in the country in which it was produced; only around 18% of hard coal production is sold in international coal market.

Over 4,030 Mt of coal is currently produced and used throughout the world which is more than 38% increase over the past 20 years (WCI 2009). Between 1971 and 2007, global emission doubled with developing countries, led by Asia,

increased at a much faster rate. Between 1990 and 2007, CO<sub>2</sub> emissions rose more than double for Asia due to striking rate of economic development particularly within China and India (IEA 2007). Coal production and use has grown fastest in Asia, while Europe has actually seen a decline in production. New coal-fired power station is put into operation in China each week making implementation of the ambitions of the UNFCCC and the Kyoto Protocol challenge to merge desired economic development with environmental protection (UNEP 2010).

Coal has been the major source of CO<sub>2</sub>. Global coal production is likely to reach 7 billion tonnes in 2030 – with China accounting for nearly half the increase over this period. Steam coal production is anticipated to have reached around 5.2 billion tonnes; coking coal 624 million tonnes; and brown coal 1.2 billion tonnes (WCI 2009).

Vehicles are very less in small towns/cities of Asia. But it does not mean that pollution will not reach these small towns/cities. Due to dispersion the concentration of air pollution in small urban dwellings and rural settings are also increasing.

Irrespective of damage to climate coal trading is still a lucrative business with lot of “*investors blessing*”. Initial Public Offer to sell 10% stake (offer for sale) by Coal India Limited (CIL), was over subscribed in 2010.

The company made a public offer of 631, 636, 440 equity shares aggregating up to Rs.151,994.40 million. CIL is the major coal producing company (at the lowest cost) in the world and also has the highest coal reserves with dominant market share in India (82%) which is currently facing acute coal shortage. CIL has 471 mines in 21 major coalfields across eight states in India. Out of the 471 mines, 163 are open cast mines and 273 are underground mines. Its current coal production capacity of CIL is about 450 MTPA and beneficiation (washing) capacity is 22 MTPA.

CIL is planning to increase its production capacity to 640 MT and beneficiation capacity to 300 MT by 2017. This means there will “*some more carbon in the line*” to enter atmosphere. Oil, coal, automobile is still preferred choice of investment throughout the world. These businesses also have “*good history*” with a track of continuous net profit and dividends to investors. So carbon emissions are likely increase in coming days with added damage to environment and climate in particular.



**Fig. 2.3** There is no shortage of energy in the world as long as people can afford it. Unnecessary energy waste can be avoided to mitigate carbon emission

Asian roads which are almost empty 20 years back has now filled with variety of vehicles of all sizes and shapes releasing GHGs. Similarly there is increase of CO<sub>2</sub> across all sectors resulting in CO<sub>2</sub> concentration levels many fold and hence it is imperative that near-term investment decisions should be taken keeping long-term emissions consequences.

Further there is no clear cut boundary between energy use and energy waste. As shown in Fig. 2.3 there is no shortage of energy in the world as long as people can afford it. Such unnecessary energy waste can be avoided to mitigate carbon emission.

## References

- Andrzej Bytnerowicz, Kenji Omasa, Elena Paoletti, 2007: Integrated effects of air pollution and climate change on forests: A northern hemisphere perspective, *Environmental Pollution* 147, 438–445
- Al-Iriani M. 2006: Energy-GDP relationship revisited: an example from GCC countries using panel causality. *Energy Policy*;34:3342–50.
- APEC, 2002: Profiles in SMEs and SME Issues, 1990-2000. Asia-Pacific Economic Cooperation, Singapore, World Scientific Publishing.
- Apergis N, Payne J. 2009a: Energy consumption and economic growth in Central America: evidence from a panel cointegration and error correction model. *Energy Econ* ; 31:211–6.
- Apergis N, Payne J. 2009b: Energy consumption and economic growth: evidence from the Commonwealth of Independent States. *Energy Econ*; 31:641–7.
- Akimoto H, 2003: Global air quality and pollution. *Science* 302 (5651), 1716–1719. doi:[10.1126/science.1092666](https://doi.org/10.1126/science.1092666).
- Akimoto H, Narita H, 1994: Distribution of SO<sub>2</sub>, NO<sub>x</sub> and CO<sub>2</sub> emissions from fuel combustion and industrial activities in Asia with 1° × 1° resolution. *Atmospheric Environment* 28, 213–215.
- Amann M, Bertok I, Cofala J, Heyes C, Klimont Z, Rafaj P, Schoep W, Wagner F, 2008: National emission Ceilings for 2020 based on the 2008 Climate & Energy Package. NEC Report 6. Final report to the European Commission. Available at: [www.iiasa.ac.at/rains/reports/NEC6-final110708.pdf](http://www.iiasa.ac.at/rains/reports/NEC6-final110708.pdf).
- Arndt R.L, Carmichael G.R., Streets D.G, Bhatti N, 1997: Sulphur dioxide emissions and sectoral contribution to sulphur deposition in Asia. *Atmospheric Environment* 31, 1553–1582.
- Boghesi S, Vercelli A, 2003: Sustainable globalisation. *Ecological Economics* 44, 77–89.
- BP (British Petroleum), 2010: BP Statistical Review of World Energy, BP Oil Company Ltd., London
- Byrne J, Shen B, 1996: The challenge of sustainability. Balancing China's energy, economic and environmental goals. *Energy Policy* 24 (5), 1–8 Reprint.
- Cameron I, Lyons T.J, and Kenworthy J.R, 2004: Trends in Vehicle Kilometres of Travel in World Cities, 1960-1990: Underlying Drives and Policy Responses. *Transport Policy*, 11, pp. 287–298.
- Chapman L, 2007: Transport and climate change: a review. *Journal of Transport Geography* 15, 354–367.
- Chen ST, Kuo HI, Chen CC, 2007: The relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy*;35:2611–21.
- Clapp J, Dauvergne P, 2005: Paths to a Green World: The Political Economy of the Global Environment. The MIT Press, Cambridge, Massachusetts.

- CSIS (Centre for Strategic International Studies), 2010: Asia's Response to Climate Change and Natural Disasters. Implications for an Evolving Regional Architecture.
- Cullinane C, 2002: The Relationship between Car Ownership and Public Transport Provision: A Case Study of Hong Kong. *Transport Policy*, 9, pp. 29–39.
- Dickerson R.R, Andreae M.O, Campos T, Mayol-Bracero O.L, Neusuess C, Streets, D.G, 2002: Analysis of black carbon and carbon monoxide observed over the Indian Ocean: implications for emissions and photochemistry. *Journal of Geophysical Research* 107 (D19), 8017. doi:[10.1029/2001JD000501](https://doi.org/10.1029/2001JD000501).
- Dalsøren S.B, Eide M.S, Endresen Ø, Mjelde A, Gravir G, Isaksen I.S.A, 2009: Update on emissions and environmental impacts from the international fleet of ships: the contribution from major ship types and ports. *Atmospheric Chemistry and Physics* 9, 2171–2194.
- Ehrenfeld D, 2005: The environmental limits to globalization. *Conservation Biology* 19.2, 318–326.
- Eyring V, Harris N.R.P, Rex M, Shepherd T.G, Fahey D.W, Amanatidis G.T, Austin, J, Chipperfield M.P, Dameris M, Forster P.M, De F, Gettelman A, Graf H.F, Nagashima, T, Newman P.A, Pawson S, Prather M.J, Pyle J.A, Salawitch R.J, Santer B.D, Waugh D.W, 2005a: A strategy for process-oriented validation of coupled chemistry-climate models. *Bulletin of the American Meteorological Society* 86, 1117–1133.
- Eyring V, Köhler H.W, van Aardenne J, Lauer A, 2005b: Emissions from international shipping: 1. The last 50 years. *Journal of Geophysical Research* 110, D17305. doi:[10.1029/2004JD005619](https://doi.org/10.1029/2004JD005619).
- Eyring V, Stevenson D.S, Lauer A, Dentener F.J, Butler T, Collins W.J, Ellingsen K, Gauss M, Hauglustaine D.A, Isaksen I.S.A, Lawrence M.G, Richter A, Rodriguez J.M, Sanderson M, Strahan S.E, Sudo K, Szopa S, van Noije T.P.C, Wild O, 2007: Multi-model simulations of the impact of international shipping on atmospheric chemistry and climate in 2000 and 2030. *Atmospheric Chemistry and Physics* 7, 757–780.
- Fred Curtis, 2009: Peak globalization: Climate change, oil depletion and global trade, *Ecological Economics* 69, 427–434
- Garg A, Shukla P.R, Bhattacharya S, Dadhwal V.K, 2001: Sub-region (district) and sector level SO<sub>2</sub> and NO<sub>x</sub> emissions for India: assessment of inventories and mitigation. *Atmospheric Environment* 35, 703–713.
- GOI, 2005: Annual Report, 2004-2005 of the Ministry of Environment and Forest. Government of India, New Delhi.
- Halsnæs K, Shukla P, Ahuja D, Akumu G, Beale R, Edmonds J, Gollier C, Grübler A, Ha Duong M, Markandya A, McFarland M, Nikitina E, Sugiyama T, Villavicencio A, Zou J, 2007: Framing issues. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Metz B, Davidson O.R, Bosch P.R, Dave R, Meyer L.A (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
- IISI, 2005: World steel in figures, 2005: International Iron and Steel Institute (IISI), Brussels.
- Intergovernmental Panel on Climate Change (IPCC), 2007a: Climate change Synthesis report 2007.
- IEA, 2007: World Energy Outlook 2007 Edition- China and India Insights. International Energy Agency (IEA), Head of Communication and Information Office, 9 rue de la Fédération, 75739 Paris Cedex 15, France. pp. 600. ISBN 9789264027 (International Energy Agency)
- Isaksen, I.S.A, Dalsøren S.B, Li L, Wang W.C, 2009: Introduction to special section on 'East Asia Climate and Environment'. *Tellus* 61 (4), 583–589. doi:[10.1111/j.1600-0889.2009.00432.x](https://doi.org/10.1111/j.1600-0889.2009.00432.x).
- IPCC, 2007b: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7–22.
- Jansen E, Overpeck J, Briffa K.R, Duplessy J.C, Joos F, Masson-Delmotte V, Olago D, Otto-Bliesner B, Peltier W.R, Rahmstorf S, Ramesh R, Raynaud D, Rind D, Solomina O, Villalba R and Zhang D, 2007: Palaeoclimate. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the*

- Intergovernmental Panel on Climate Change [Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt K.B, Tignor M and Miller H.L.(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Joyeux R, Ripple R.D, 2007: Household energy consumption versus income and relative standard of living: a panel approach. *Energy Policy* 2007;35:50–60.
- Kahn Ribeiro S, Kobayashi S, Beuthe M, Gasca J, Greene D, Lee D. S, Muromachi Y, Newton P.J, Plotkin S, Sperling D, Wit R, Zhou P.J, 2007: Transport and its infrastructure. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Metz B, Davidson O.R, Bosch P.R, Dave R, Meyer L.A(eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Kato N, Akimoto H, 1992: Anthropogenic emissions of SO<sub>2</sub> and NO<sub>x</sub> in Asia: emission inventories. *Atmospheric Environment* 26A, 2997–3017.
- Kupiainen K, Klimont Z, 2007: Primary emissions of fine carbonaceous particles in Europe. *Atmospheric Environment* 41/10, 2156–2170. doi:10.1016/j.atmosenv.2006.10.066.
- Klimont Z, Cofala J, Xing J, Wei, Wei, Zhang C, Wang S, Kejun J, Bhandari P, Mathura R, Purohit P, Rafaj P, Chambers A, Amann M, Hao J, 2009: Projections of SO<sub>2</sub>, NO<sub>x</sub>, and carbonaceous aerosols emissions in Asia. *Tellus B*.doi:10.1111/j.1600-0889.2009.00428.x.
- Kulshrestha 2010: <<http://www.icsu-visioning.org/open-forum/open-forum-input/comment-page-1/>> retrieved on 21 November 2010
- Kulshrestha U.C, Kulshrestha M.J, Sekar R, Sastry G.S.R and Vairamani M. 2003a Chemical characteristics of rain water at an urban site of south-central India. *Atmospheric Environment*, 37 (21), 3019–3026.
- Kulshrestha M.J, Kulshrestha U.C, Parashar D.C and Vairamani M. Estimation of SO<sub>4</sub> contribution by dry deposition of SO<sub>2</sub> onto the dust particles in India. 2003b. *Atmospheric Environment*, 37 (22), 3057–3063.
- Kulshrestha U.C, Sreedhar B and Kulshrestha M.J 2005: Carbon as major constituent of atmospheric aerosols at urban sites in India. *Proceedings of Asian Aerosol Conference held at Mumbai during Dec 13–16, 2005*.
- Kulshrestha U.C 2009: Atmospheric dust in India- A natural geo-engineering tool to combat climate change. *ENVIS Newsletter SES JNU ISSN-0974-1364*, vol 14(3), pp 2–5.
- Levine M, Ürge-Vorsatz D, Blok K, Geng L, Harvey D, Lang S, Levermore G, Mongameli Mehlwana A, Mirasgedis S, Novikova A, Rilling J, Yoshino H, 2007: Residential and commercial buildings. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Metz B, Davidson O.R, Bosch P.R, Dave R, Meyer L.A(eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Lee C.C, Chang C.P, 2008, Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. *Resour Energy Econ*; 30:50–65.
- Lee C.C, 2005: Energy consumption and GDP in developing countries: a cointegrated panel analysis. *Energy Econ* 2005;27:415–27.
- Lee C.C, Lee J.D, 2009: Income and CO<sub>2</sub> emissions: evidence from panel unit root and cointegration tests. *Energy Policy*;37:413–23.
- Mahadevan R, Asafu-Adjaye J, 2007: Energy consumption, economic growth and prices: a reassessment using panel VECM for developed and developing countries. *Energy Policy*;35:2481–90.
- Mehrara M. 2007: Energy consumption and economic growth: the case of oil exporting countries. *Energy Policy*;35:2939–45
- Mishra V, Smyth R, Sharma S, 2009: The energy-GDP nexus: evidence from a panel of Pacific Island countries. *Resour Energy Econ*;31:210–20.
- Narayan P.K, Narayan S, 2008: Does environmental quality influence health expenditures? Empirical evidence from a panel of selected OECD countries. *Ecol Econ*;65:367–74.



- Narayan P.K, Smyth R, 2009: Multivariate granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries. *Energy Policy*;37:229–36.
- Pachauri R.K, 2010: Climate Change and the Forthcoming Energy Revolution, *Manorama Year Book 2010*, 198–201
- Pradeep J, Tharakan, Timm Kroeger, Charles A.S. Hall, 2001: Twenty five years of industrial development: a study of resource use rates and macro-efficiency indicators for five Asian countries, *Environmental Science & Policy* 4, 319–332
- Qun Xu, 2001: Abrupt change of the mid-summer climate in central east China by the influence of atmospheric pollution, *Atmospheric Environment* 35, 5029–5040
- Reddy A.K.N., Goldemberg J, 1990: Energy for the Developing World. Readings from Scientific American. Energy for Plant Earth. Freeman, New York.
- Reddy M.S, Venkataraman C, 1999: Direct radiative forcing from anthropogenic carbonaceous aerosols over India. *Current Science* 76, 1,005–1,011.
- Reddy M.S, Venkataraman C, 2000: Atmospheric and radiative effects of anthropogenic aerosol constituents from India. *Atmospheric Environment* 34, 4511–4522.
- Reddy M.S, Venkataraman C, 2002a: Inventory of aerosol and sulphur dioxide emissions from India: (I) fossil fuel combustion. *Atmospheric Environment* 36, 677–697.
- Reddy M.S, Venkataraman C, 2002b: Inventory of aerosol and sulphur dioxide emissions from India: (II) biomass combustion. *Atmospheric Environment* 36, 699–712.
- Rogner H.H, Zhou D, Bradley R, Crabbé R, Edenhofer O, Hare.B (Australia), Kuijpers L, Yamaguchi M, 2007: Introduction. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the intergovernmental Panel on Climate Change* [Metz B, Davidson O.R, Bosch P.R, Dave R, Meyer L.A(eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Sims R.E.H, Schock R.N, Adegbulugbe A, Fenhann J, Konstantinaviciute I, Moomaw W, Nimir H.B, Schlamadinger B, Torres-Martínez J, Turner C, Uchiyama Y, Vuori S.J.V, Wamukonya N, Zhang X, 2007: Energy supply. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Metz B, Davidson O.R, Bosch P.R, Dave R, Meyer L.A(eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Sperling D. and Salon D, 2002: Transportation in developing countries: An overview of greenhouse gas reduction strategies. *Pew Center on Global Climate Change, Arlington*, 40 pp.
- TERI (The Energy and Resources Institute), 2009: Simplifying Climate Change, based on the findings of the IPCC Fourth Assessment report, pp140
- Tisdell C, 2001: Commentary: globalisation and sustainability: environmental Kuznets curve and the WTO. *Ecological Economics* 39, 185–196.
- UNEP and C4, 2002: The Asian Brown Cloud: Climate and Other Environmental Impacts UNEP, Nairobi
- UNEP, 2010: Air pollution promoting regional cooperation
- USGS, 2005: Minerals Yearbook 2004. US Geological Survey Reston, VA, USA. <<http://minerals.usgs.gov/minerals/pubs/myb.html>>, accessed on 31/05/07.
- Venkataraman C, Chandramouli B, Patwardhan A, 1999: Anthropogenic sulphate aerosol from India: estimates of burden and direct radiative forcing. *Atmospheric Environment* 33, 3225–3235.
- WEO (World Energy Outlook), 2009: Annex A: Tables for Reference Scenario Projections, 647.
- Willoughby C. 2001: Singapore's Motorisation Policies: 1960-2000. *Transport Policy*, 8, pp. 125–139.
- WHO/UNEP, 1992: Urban Air Pollution in Mega Cities of the World. Blackwell, Oxford.



<http://www.springer.com/978-3-642-19673-7>

Coping with Climate Change

Principles and Asian Context

Chandrappa, R.; Gupta, S.; Kulshrestha, U.C.

2011, XXI, 370 p. 78 illus., Hardcover

ISBN: 978-3-642-19673-7