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Assessment of Air Pollution and GHG Mitigation Strategies in Pakistan Using the GAINS Model

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Assessment of Air Pollution and GHG Mitigation Strategies in Pakistan Using the GAINS Model

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Contents

Abstract

Pakistan's attempt to raise the living standards of its citizens has meant that economic development has largely taken precedence over environmental issues. Uncontrolled use of hazardous chemicals, vehicle emissions, and industrial activities have contributed to a number of environmental and health hazards. Negative externalities emerge, inter alia, in the form of anthropogenic air pollution and increased rate of GHGs emissions.

This report presents a first analysis of potential implications of the current economic development plans of Pakistan on local and regional air pollution, and explores alternative approaches that could limit the envisaged deterioration of air quality. It also explores the co-benefits of air pollution control measures on the emissions of greenhouse gases that cause climate change.

The analysis has been carried out with the GAINS (Greenhouse gas - Air pollution Interaction and Synergies) model that has been developed by the International Institute for Applied Systems Analysis (IIASA). The report summarizes exogenous projections of energy use and application of emission control measures up to 2030 and discusses the resulting implications on air quality and GHGs. Illustrative emission control scenarios assess health benefits of additional measures and associated costs. Scenarios include the options of employing cleaner fuels, and of applying end-of-pipe emission control measures.

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Tahira Munir graduated in Environmental Sciences from the University of the Punjab, Lahore Pakistan, and is currently working as a Scientific Officer in the Environment Section of the Global Change Impact Studies Centre, Islamabad in Pakistan. This assignment was completed during her stay at IIASA’s Young Scientist Program (YSSP) 2008.

Assessment of Air Pollution and GHG Mitigation Strategies in Pakistan using the GAINS Model

Tahira Munir

1 Introduction

Air pollution is a rapidly growing environmental problem in Pakistan (Azam, 2006). Highly inefficient energy use, accelerated growth in vehicle population and vehicle kilometers traveled, increasing industrial activity without adequate air emission treatment or control and open burning of solid waste including plastic are some of the major causes of deterioration of ambient air quality in Pakistan. At the same time, the expansion of economic activities also spurs emissions of greenhouse gases. This results in a growing share of Pakistan to human induced global climate change, to which however historically industrialized countries have made the largest contribution.

Therefore, it is critically important to limit the increase or even reduce emissions of air pollutants that deteriorate local air quality in Pakistan. In addition, to protect the global climate emissions of greenhouse gases should be kept at a minimum.

This report presents a preliminary attempt to explore the scope for managing future emissions of air pollutants and greenhouse gases in Pakistan using the Greenhouse Gas - Air Pollution Interaction and Synergies (GAINS) model. In addition to quantifying costs and health impacts of air pollution reduction strategies, GAINS allows identifying synergies between the control of air pollution and the reduction of GHGs.

This study analyzed alternative emission scenarios, in which emissions are changed through (a) changes in the structure of energy supply, and (b) applications of end-of-pipe emission control measures. These scenarios address short to mid-term environmental benefits of air pollution reduction and analyze their implications on greenhouse gas emissions.

Pakistan is located in South Asia with

- 168 million population in 2008,
- a gross domestic product (GDP) of US$410 billion at purchasing power parity (PPP),
- a gross domestic product (GDP) per capita of US$ 2600 at purchasing power parity(PPP),

- energy consumption in Pakistan of 2596 PJ annually in 2006, with per capita-consumption at 20 GJ per year (IEA, 2007).

After the year 1990, following an industrial revolution of its own, Pakistan’s energy consumption increased at a very rapid rate due to urbanization, industrialization, and population growth. Pakistan’s GDP has been increasing at a rate of 7-8 percent annually since the year 2000 (Annex 11). Such a high level of growth has placed Pakistan among the fastest growing economies in Asia (Pakistan Economic Survey 2007-08).

Similar to other developing countries, Pakistan has focused on achieving self-sufficiency in food production, meeting energy demands, and maintaining its high rate of population growth rather than on curtailing pollution or other environmental hazards. As a result, "green" concerns have not been the government's top priority. Yet, as Pakistan's cities suffer from the effects of air pollution and other environmental degradation, environmental issues have become more salient. Safeguarding public health, as well as preserving Pakistan's natural wonders, has made environmental protection increasingly important. In an attempt to redress the previous inattention to the nation's mounting environmental problems, in 1992 the government issued its National Conservation Strategy Report (NCSR) outlining Pakistan's state of environmental health, its sustainable goals, and viable program options for the future with the National Conservation Goals (Brief Environmental Concerns-Pakistan Scenario, 2000).

2 Methodology

2.1 The GAINS-Asia model

The Greenhouse Gas Air pollution Interactions and Synergies (GAINS) model considers emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), fine particulate matter (PM2.5 and PM10), ammonia (NH_3) and volatile organic compounds (VOC) as well of the greenhouse gases (i.e., carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O) and the three F-gases) included in the Kyoto protocol (Amann *et al.*, 2008). It explores cost-effective strategies to reduce emissions of greenhouse gases and conventional air pollutants. It quantifies health impacts, impacts on ecosystems, and total greenhouse gas emissions using the global warming potentials specified in the Kyoto protocol. It is an extension of the (Regional Air Pollution Information and Simulation) RAINS model (Schöpp *et al.*, 1999) to greenhouse gases with special emphasis on the interactions between air pollutants and greenhouse gas emissions.

The model quantifies, for each of the emission source regions, mitigation potentials for the different available options and the associated costs. GAINS also quantifies health impacts that are attributable to the human exposure to fine particulate matter (PM2.5), which is formed from primary emissions of particles and as secondary products of emissions of SO_2, NO_x and NH_3. It includes exogenous projections of energy activity pathways that are source of emissions, and holds data on available control measures. Abatement and implementation cost and their resulting health impacts can be estimated by using this model. The model has been developed as a tool that could provide relevant information to policy makers on alternative emission control strategies.

2.2 Approach

Employing the GAINS-Asia model, this study has been carried out following these four steps:

1. Analyze the activity data that have been collected earlier for the GAINS model for Pakistan; identify and fix gaps, etc.
2. Compare estimates obtained from different emission inventories with GAINS estimates.
3. Develop emission control scenarios based on energy activity projections and control strategies.
4. Explore how different rates of implementation of available emission control technologies would affect air quality in Pakistan and estimate the associated costs.

3 Emission control scenarios

A set of scenarios was developed to explore the potential for minimizing harmful impacts of air pollution and greenhouse gases through alternative means of energy supply.

3.1 The Baseline scenario

As a starting point for the baseline scenario, the energy projection for Pakistan developed by Shahid (2008) has been employed. The implementation of emission control measures has been updated based on current environmental legislations, the National Environmental Quality Standards (NEQS, 1995) and the environmental policy of Pakistan formulated by the Government of Pakistan.

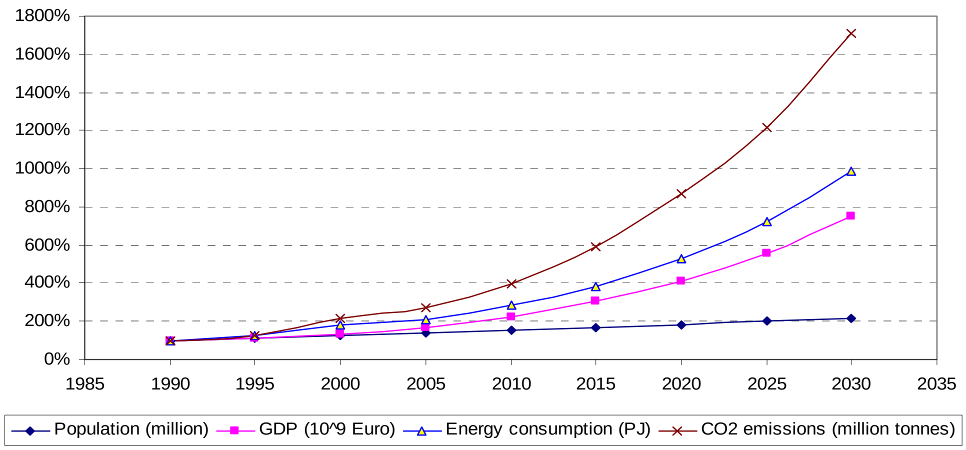

Figure 3.1: Trends in population, GDP and energy consumption assumed in the baseline scenario, relative to 1990

Table 3.1: Primary energy consumption in Pakistan (PJ/Year) in baseline scenario

Activity	2000	2010	2020	2030
Coal	109	260	910	2521
Gas	787	1962	3796	7720
Oil	743	987	2118	3121
Biomass	784	744	638	645
Hydro	81	82	85	89
Nuclear	29	35	43	50
Renewable (other than biomass)	1	4	12	26
Total energy consumption (PJ)	2534	4074	7601	14171

3.2 A “Clean Fuel” scenario

To explore the scope for replacing the most polluting fuels with cleaner alternatives, a “Clean Fuel” scenario has been developed that provides the same level of energy services to Pakistan’s industry and households as is assumed in the baseline scenario, however, by maximizing the use of clean fuels. Pakistan is rich in natural gas resources and has intentions for more exploration, inter alia, jointly with neighboring countries like Iran and India (Wikipedia, 2008). In the interest of minimizing health impacts caused by PM, SO_2 and NO_X emissions from the domestic sector, power plants and transport, the “Clean Fuel” scenario assumes that enhanced use of liquefied petroleum gas (LPG) will substitute more polluting fuels in the domestic sector, that natural gas will replace other fuels in the power plant sector, and that compressed natural gas (CNG) diesel and gasoline in the transport sector.

It is assumed in this scenario that the following measures will be implemented by the year 2020:

- In the domestic sector LPG will substitute the use of solid fuels, such as brown coal and agricultural residuals. This will not only result in less outdoor pollution, but also improve indoor pollution levels, which are detrimental to human health causing coughing, asthma, lung cancer and pulmonary diseases (USEPA, 2008).
- For the transport sector, the scenario explores the maximum scope for using compressed natural gas (CNG). According to a study carried out by the GIK Institute, Pakistan diesel vehicles are responsible for 88 percent of total NO_X emissions. The scenario assumes that CNG would replace gasoline and diesel oil in the transport sector. While Pakistan has already at present a share of transport run by CNG (4.6 percent) (Energy year book, 2006-07), the scenario assumes that 50 percent of motorcycles, mopeds and cars with two-stroke engines, 50 percent of light duty vehicles, 50 percent of motorcycles with four-stroke engines-gasoline and 25 percent of light duty vehicles will operate on CNG.
- For the power sector, the scenario considers a far-reaching penetration of natural gas. Currently, the fuel input to Pakistan’s power sector consists of 40 percent petroleum products and 35 percent of natural gas (Energy year book, 2006-2007). The scenario assumes that gasoline, heavy fuel, brown coal, and light fuel oil will be replaced by gas.

3.3 Technology-based emission control scenarios

Three emission control scenarios have been developed that explore how different degrees of implementation of available technical emission control measures could impact Pakistan’s air pollution emissions.

3.3.1 A “Low Control” scenario (LCS)

The low control scenario assumes the current situation of Pakistan regarding the implementation of environmental policies and laws. Although Pakistan does have environmental legislation and National Environmental Quality Standards (NEQS), they are not implemented as yet. This scenario assumes that this situation will prevail until 2030.

3.3.2 The “Current Legislation” scenario (CLE)

In this scenario it is assumed that the current legislation and the National Environmental Quality Standards (NEQS) that have been decided by the Government of Pakistan will implemented after 2015.

3.3.3 A “Best Available Technology” scenario (BAT)

This scenario explores a case where advanced emission control technologies (following the “best available technology” (BAT) approach as defined in the European Union) will be implemented in Pakistan after 2020.

4 Results and discussion

The scenarios described above have been implemented in the GAINS Asia model. The GAINS model holds activity data and control strategies for future years as an emission model. It estimates emissions and costs of current and future air quality policies; with its reduced-form atmospheric dispersion model GAINS can calculate the reductions in environmental impacts as a consequence of changed air pollution policies. In addition, the optimization module of the GAINS model can be used to find sets of cost-effective control measures that meet given environmental objectives at a future point in time. These environmental objectives ('targets') can be defined either in terms of emissions or in terms of impacts, such as loss of life expectancy due to exposure to fine particles (PM2.5). A detailed description of the optimization module of GAINS is provided in Wagner *et al.*, 2007.

Input data for Pakistan have been collected by Shahid in 2007 under the IIASA Young Scientist Summer Program (Shahid, 2008). Energy and transport data were collected from the Hydrocarbon Development Institute of Pakistan (HDIP), the Ministry of Petroleum, Pakistan and the Pakistan Energy Year Book. Transport related data was collected from the National Transport Research centre (NTRC) of Pakistan. Agricultural data was obtained from the Ministry of Food, Agriculture and Livestock and Agricultural Statistics of the Federal Bureau of Statistical, Islamabad Pakistan. Country-wide industrial data have been received from the Ministry of Industries, the Pakistan Bureau of Statistics, and the provincial Statistical Bureaus. Gross value added of different products has been obtained from the Statistical Bureau of Pakistan and the Ministry of Economics and Finance (Shahid, 2008). Additional data for scenario development were obtained from Pakistan Environmental legislation and the National Environmental Quality Standards, Country Synthesis report, Environmental Policy of Pakistan, Vision 2030, Planning commission of Pakistan, Male Declaration on Control and Prevention of Air Pollution and its likely Transboundary effects, Initiatives for Clean Fuels, etc.

4.1 Emissions

The graphs depicted in Figure 4.1 - 4.4 display the development of emissions for the Clean Fuel scenario (CFS) and the Current Legislation scenario (CLE). In the Clean Fuel scenario, PM, NO_x and SO_2 emissions as well as emissions of greenhouse gases are lower than in the baseline case. In 2030, especially large reductions from clean fuel use occur for particulate matter (-43 percent) and sulphur dioxide (-17 percent), compared to CO_2 and NO_x (Fig. 4.2, Fig 4.3, Fig. 4.4). It is noteworthy that, despite the significant increase in economic development and energy consumption, the clean fuel scenario would bring PM emissions in 2030 below current levels, much in contrast to the baseline scenario, in which PM emissions would grow by more than a factor of three. However, SO_2 emissions would increase even in the clean fuel scenario, although also at a much lower rate than in the baseline case.

The most important factor leading to lower emissions is the higher penetration of natural gas as a clean fuel in all three important sectors (domestic, transport and power plant sectors).

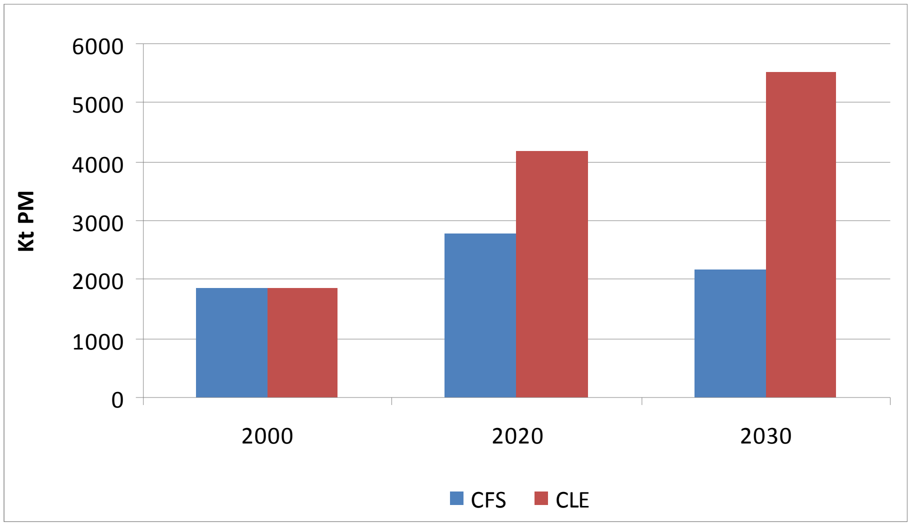

Figure 4.1 PM emissions comparison in 2020 and 2030

(CLE … current legislation scenario, CFS … application of clean fuel scenario)

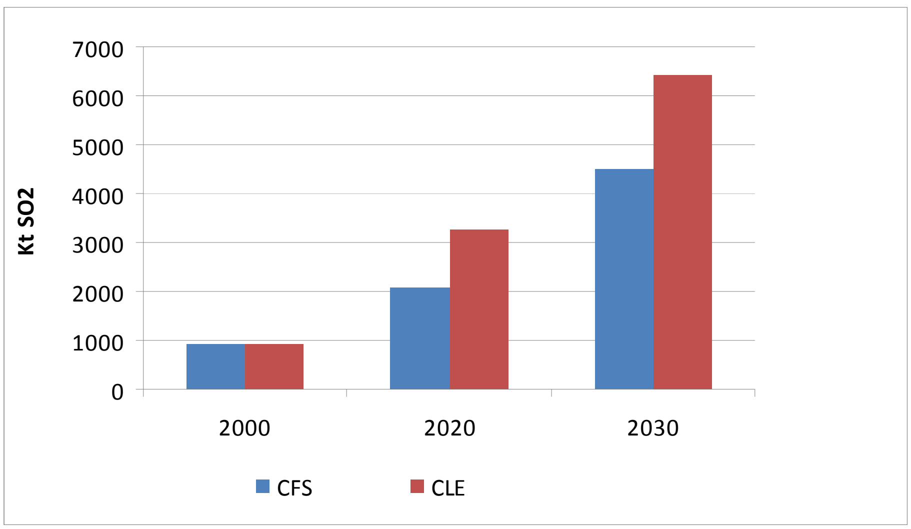

Figure 4.2 SO_2 emissions comparison in 2020 and 2030

(CLE … current legislation scenario, CFS … application of clean fuel scenario)

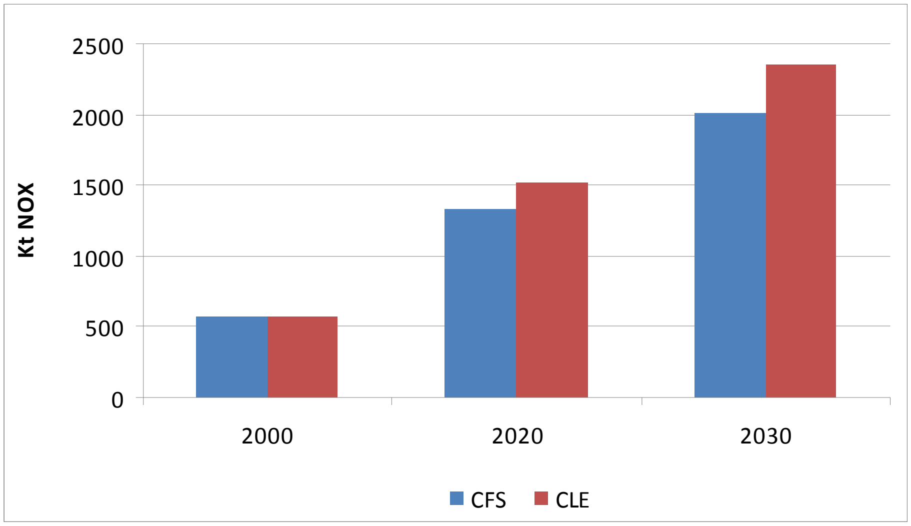

Figure 4.3 NO_X emissions comparison in 2020 and 2030

(CLE … current legislation scenario, CFS … application of clean fuel scenario)

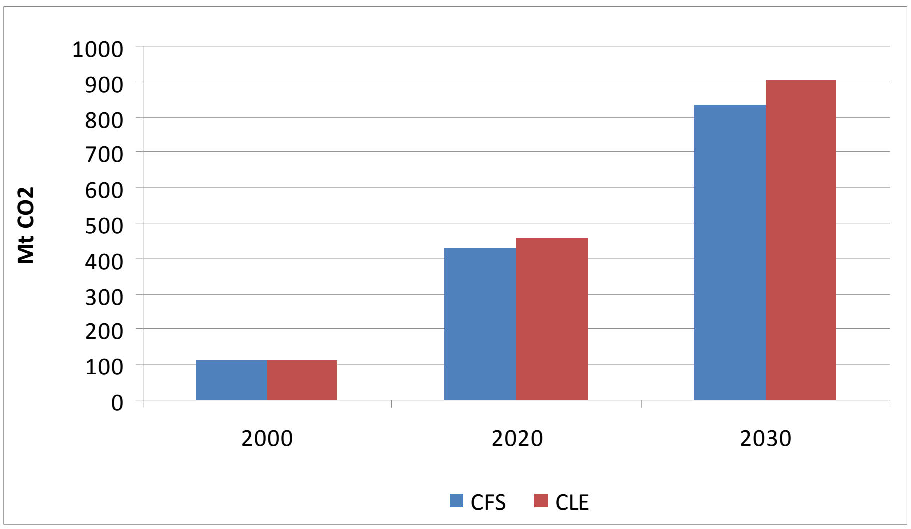

Figure 4.4 CO_2 emissions comparison in 2020 and 2030

(CLE … current legislation scenario, CFS … application of clean fuel scenario)

Emissions of SO_2, NO_x, PM, CO_2 in the Low Control scenario (LCS), the Current Legislation scenario (CLS), the Clean Fuel scenario (CFS) and the Best Available Technology scenario (BAT) are presented in Table 4.1 to

Sectors	Scenario	2000	2020	2030
DOM	CLE	429.173	922.720	990.940
	LCS	429.173	1295.127	3138.151
	CFS	429.173	5.447	8.768
	BAT	429.173	351.082	548.465

PowPlan	CLE	85.134	52.360	134.130
	LCS	85.134	114.173	245.044
	CFS	85.134	1.662	2.463
	BAT	85.134	13.391	30.202
TRANS	CLE	63.172	147.630	132.930
	LCS	63.172	210.468	297.764
	CFS	63.172	115.288	111.116
	BAT	63.172	83.664	101.213

Table 4.4.There is no change in the 2000 level emissions when compared with CLE for different scenarios as control measures were implemented after 2020 to 2030.

Table 4.1: SO_2 emissions (kt/year) in alternative scenarios (CLE … current legislation scenario, LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology) by main sectors (DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

Sectors	Scenario	2000	2020	2030
DOM	CLE	76.714	309.367	779.501
	LCS	76.714	314.488	793.478
	CFS	76.714	15.509	17.593
	BAT	76.714	298.812	770.974
PowPlan	CLE	475.551	1031.029	1340.713
	LCS	475.551	1318.017	2649.92
	CFS	475.551	177.232	185.412
	BAT	475.551	90.828	162.095
TRANS	CLE	126.958	248.693	63.647
	LCS	126.958	380.352	558.057
	CFS	126.958	197.142	55.509
	BAT	126.958	11.064	16.358

Table 4.2: NO_x emissions (kt/year) in alternative scenarios (CLE … current legislation scenario, LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology) by main sectors (DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector

Sectors	Scenario	2000	2020	2030
DOM	CLE	45.712	78.614	136.807
	LCS	45.712	78.614	136.807
	CFS	45.712	54.298	105.152
	BAT	45.712	58.053	94.112
PowPlan	CLE	75.001	190.190	361.340
	LCS	75.001	189.716	361.033

	CFS	75.001	151.761	290.119
	BAT	75.001	102.314	211.609
TRANS	CLE	367.585	986.830	1303.150
	LCS	367.585	1247.482	1844.024
	CFS	367.585	852.805	1065.437
	BAT	367.585	415.172	459.11

Table 4.3: PM emissions (kt/year) in alternative scenarios (CLE … current legislation scenario, LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology) by main sectors (DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

Sectors	Scenario	2000	2020	2030
DOM	CLE	429.173	922.720	990.940
	LCS	429.173	1295.127	3138.151
	CFS	429.173	5.447	8.768
	BAT	429.173	351.082	548.465
PowPlan	CLE	85.134	52.360	134.130
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	CFS	85.134	1.662	2.463
	BAT	85.134	13.391	30.202
TRANS	CLE	63.172	147.630	132.930
	LCS	63.172	210.468	297.764
	CFS	63.172	115.288	111.116
	BAT	63.172	83.664	101.213

Table 4.4: CO_2 emissions (Mt/year) in alternative scenarios (CLE … current legislation scenario, LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology) by main sectors (DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

Sectors	Scenario	2000	2020	2030
DOM	CLE	13.86	59.02	127.3
	LCS	13.86	59.02	127.3
	CFS	13.86	60.91	117.89
	BAT	13.86	59.02	127.3
PowPlan	CLE	33.31	136.21	271.7
	LCS	33.31	135.78	271.39
	CFS	33.31	107	216.3
	BAT	33.31	135.78	271.39

TRANS	CLE	27.61	98.37	146.82
	LCS	27.61	97.44	146.82
	CFS	27.61	95.62	145.41
	BAT	27.61	97.44	146.82

Figures 4.5 to 4.8 highlight the economic sectors that make in the current legislation scenario the major contributions to emissions of PM, SO_2**,** NO_x, CO_2. For PM, the domestic sector contributes more than 84 percent to total emissions (Fig 4.5) as there are no control measures currently in force. In addition, this sector causes also serious health effects from indoor air pollution (Khan et al., 2006). Fig. 4.6 illustrates that the power plant sector is responsible for most of the SO_2 emissions (65 percent). Inefficient burning of crude oil, fossil fuel and poor quality coal are major factors that cause high emissions of SO_2 (Clean Air Task Force, 2001). At sufficiently high levels, longer-term exposures to SO_2 in ambient air cause respiratory illness and aggravate existing heart diseases; Peak level emissions of SO_2 can cause temporary breathing difficulty for people with asthma who are active outdoors (USEPA, 2008). The transport sector contributes 79 percent NO_x (Fig. 4.7) and these emissions are caused by inefficient burning, poor quality of the fuel (gasoline, diesel and heavy fuel oil), inefficient working of engines, lack of implementation of Euro Standards to increase the efficiency of fuel and engines (Harijan et al, 2007). CO_2 emissions originate mainly from the power plant sector (47 percent) as Fig 4.8 indicates.

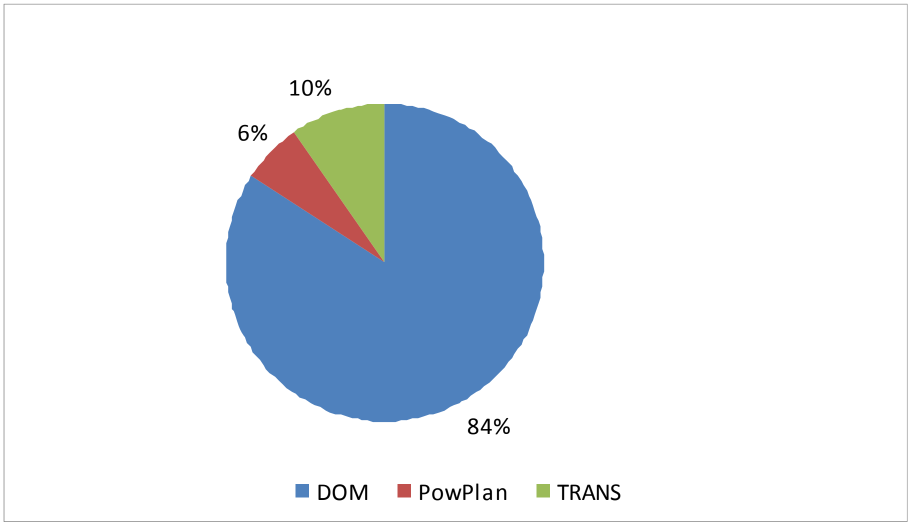

Figure 4.5 PM emissions comparison in 2020 in current legislation scenario

(DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

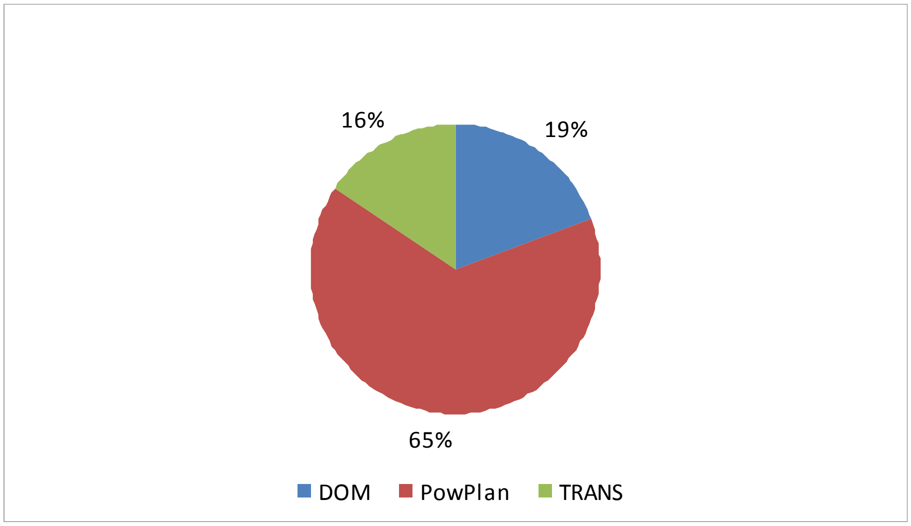

Figure 4.6 SO_2 emissions comparison in 2020 in current legislation scenario

(DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

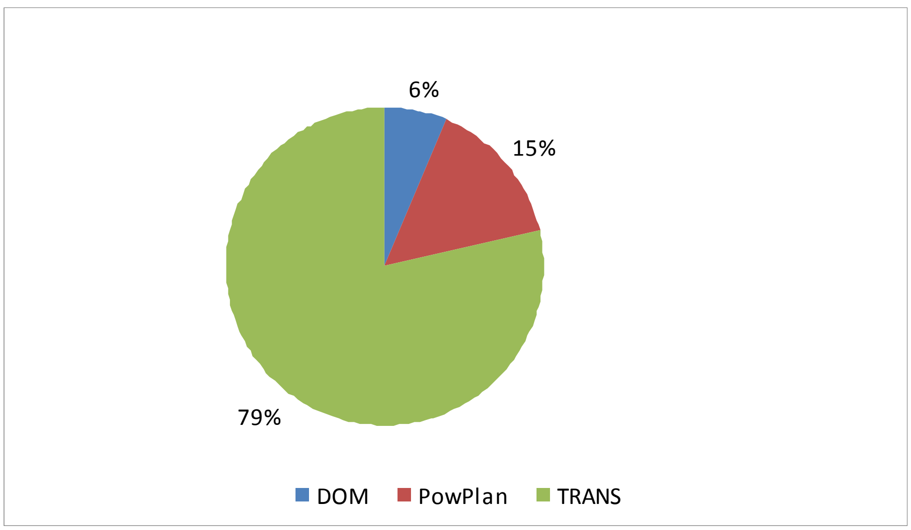

Figure 4.7 NO_x emissions comparison in 2020 in current legislation scenario

(DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

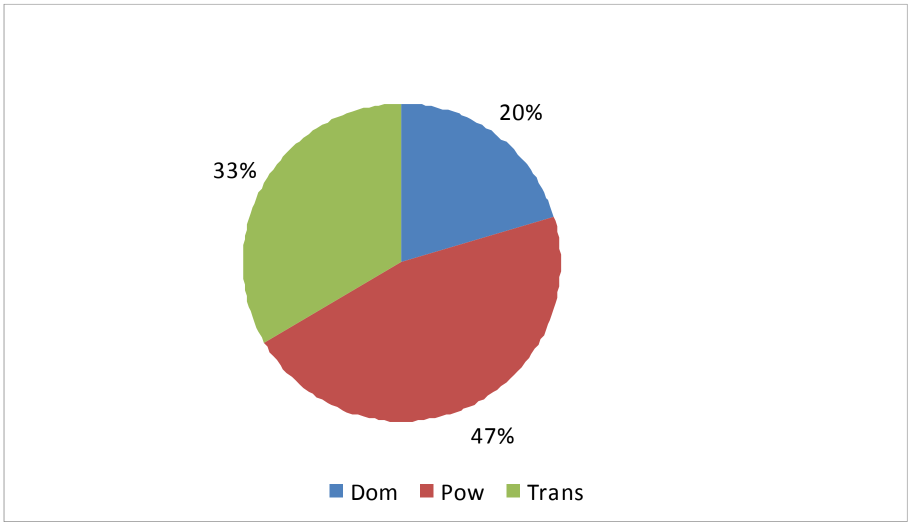

Figure 4.8 CO_2 emissions comparison in 2020 in current legislation scenario

(DOM: share of domestic sector, PowPlan: power plant contribution, TRANS: transport sector share)

Fig 4.9 presents sectoral CH_4 emissions for the three scenarios. It may be noted that CH_4 emissions were 17 percent higher than baseline in 2020 in Clean Fuel scenario, whereas the use of so called best available technology can reduce emissions by six percent (as compared to the Clean Fuel scenario for year 2030).

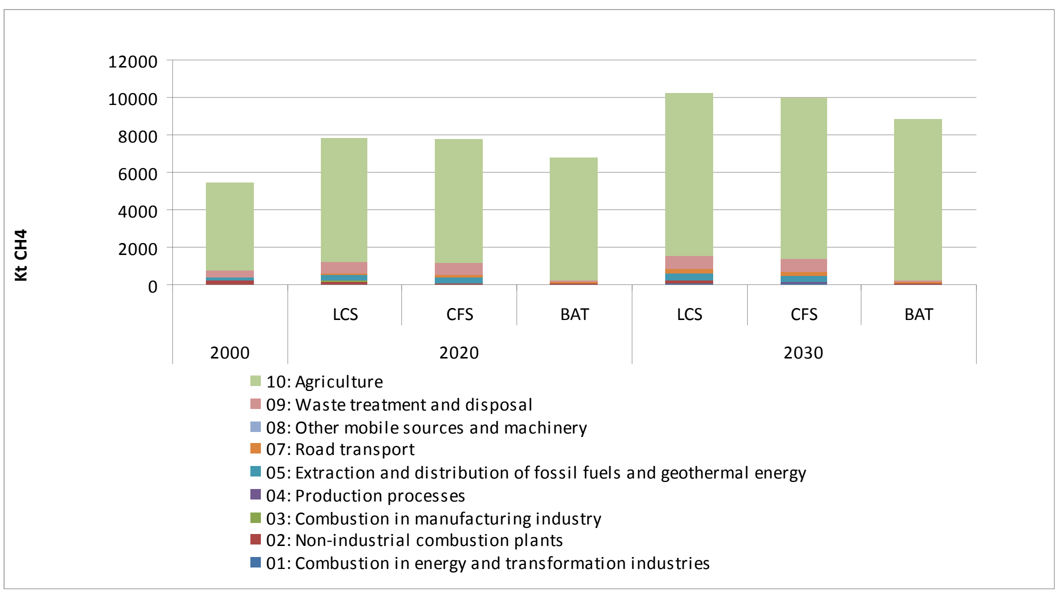

Figure 4.9 CH_4 emissions aggregated by CORINAIR SNAP1 sector in 2020 and 2030

(LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology)

NO_x emissions in the low control, clean fuel and best available technology scenarios are shown in Figure 4.10. In 2000, NO_X emissions amounted to more than 0.5 million tons in Pakistan. NO_X emissions increase by 32 percent (as compared to the 2000 level) in 2030 in the best available technology scenario, but if the emission controls policies would be more strongly implemented it can be reduced to eight percent in 2030 when compared with 2020 in the clean fuel scenario.

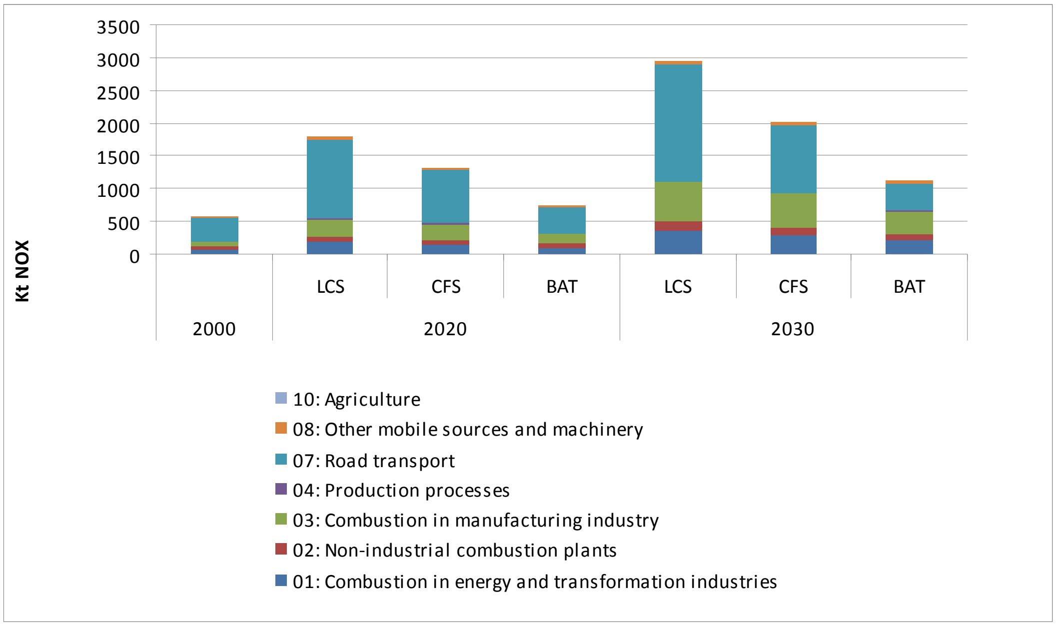

Figure 4.10 NO_x emissions aggregated by CORINAIR SNAP1 sector in 2020 and 2030

(LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology)

PM emissions in the low control, clean fuel and best available technology scenarios are shown in Figure 4.11. PM emissions are 1.5 times higher in the clean fuel scenario in 2020 than in 2000. But if emission controls technologies are more strictly implemented than it can be reduced to three times in 2030 (as compared to the low control scenario 2020 level).

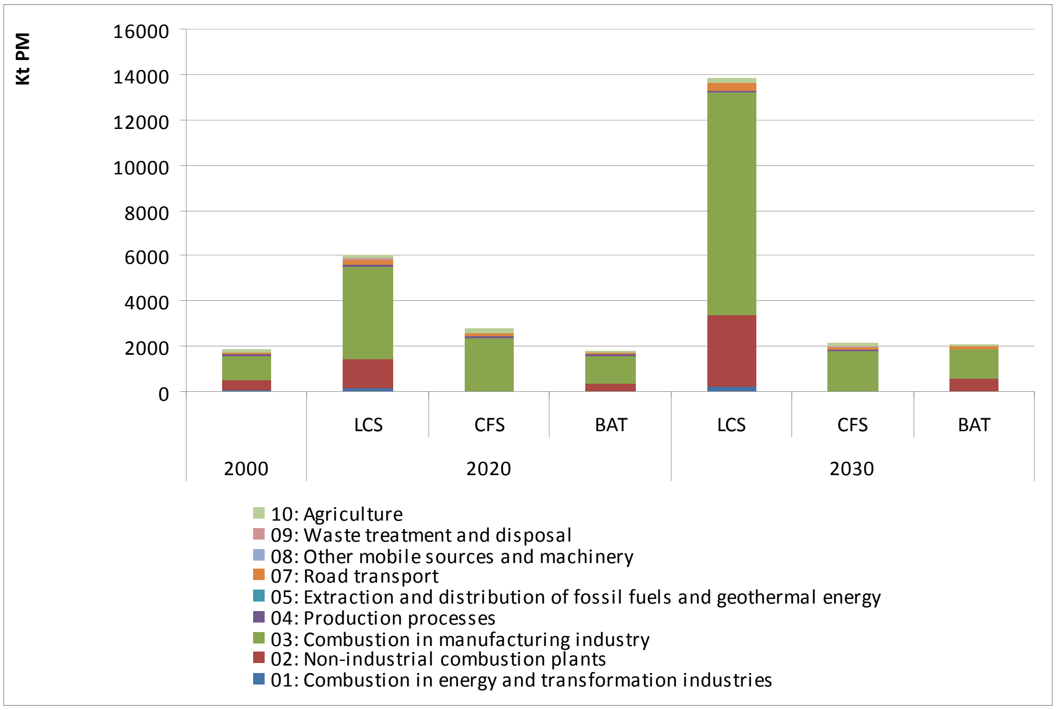

Figure 4.11 PM emissions aggregated by CORINAIR SNAP1 sector in 2020 and 2030

(LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology)

SO_2 emissions in the three scenarios are shown in Figure 4.12. By 2020 SO_2 emissions were 68 percent in the clean fuel scenario as compared to 31 percent in the 2000 base level. SO_2 emissions can be reduced to 28 percent by complying with best available technology as compared to the clean fuel scenario (for 2030 level)

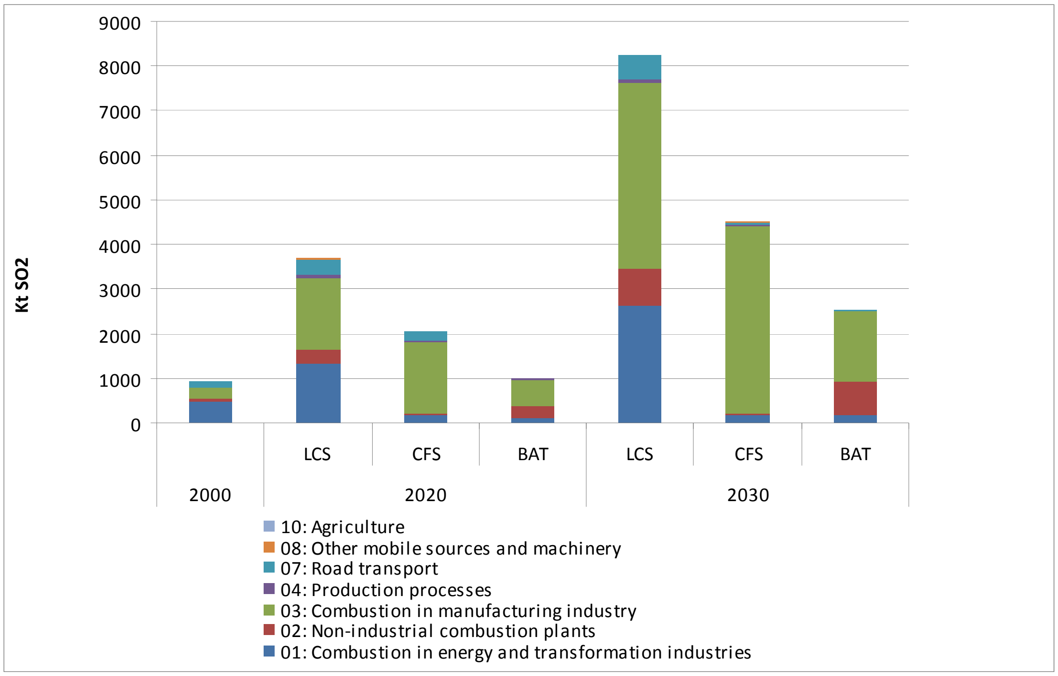

Figure 4.12 SO_2 emissions aggregated by CORINAIR SNAP1 sector in 2020 and 2030

(LCS … low control scenario application, CFS … Clean Fuel scenario, BAT … application of best available technology)

Pakistan is an agricultural country, where large parts of the economy depend on agriculture (Federal Bureau of Statistics, 2006). The agriculture sector contributed more in CH_4 emissions than other sectors (Fig 4.9). Main sources of methane emissions are rice cultivation, cattle and sheep ranching and decaying material in landfills (Bouwman, 2004). For the most part the transport sector is responsible for the NO_x emissions (Fig 4.10) due to use of gasoline and diesel oil in automobiles and it is increasing with the increasing number of vehicles (Harijan et al, 2007). Particulate matter and SO_2 emissions originate mostly from manufacturing in combustion industries, as Fig 4.11 and 4.12 indicate. Manufacturing in combustion industries like cement industry, lime etc., are major sources of PM and SO_2 emissions (Responding to the Environmental Challenge, 2000).

4.2 Air pollution control costs

According to a study nearly 2500 people die prematurely every year in Pakistan due the exposure to air pollution, and associated economic losses range at about USD 250-350 million. The loss to the national exchequer is large when compared to the costs of pollution abatement (Harijan et al, 2007). Failure in the incorporation of these factors in economic policies leads to losses in GDP and creates serious health and environmental problems. This heavy burden of environmental degradation is adversely affecting every sector of the national economy.

Implementation costs of emission control measures have been calculated with the GAINS model for the different scenarios and compared with the GDP. By 2020, the costs of implementing air pollution control measures prescribed in the current legislation are estimated at 1 percent of GDP, and this share would increase to 1.5 percent in 2030.Application of the BAT scenario would lead to substantially higher costs.

Table 4.5: Implementation costs of emission controls (MEuro/year) (LCS … low control scenario application, CLE … current legislation scenario, BAT … application of best available technology)

	2000	2010	2020	2030
LCS	33.3	253	323.2	486
CLE	33.3	269.4	1410.2	3948.4
BAT	33.3	269.4	8530.5	12270.3

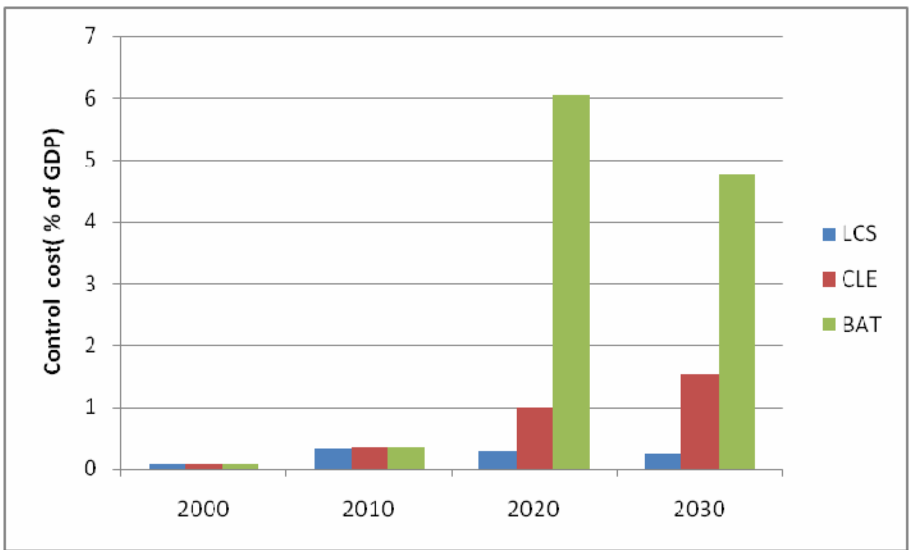

Fig 4.13 Implementation cost of emission controls in terms of percentage of GDP

(LCS … low control scenario application, CLE … current legislation scenario, BAT … application of best available technology)

4.3 Health impacts

The GAINS model also quantifies health impacts from the exposure to fine particulate matter in terms of years of life loss (YOLLS). Figure 4.14 compare ambient PM2.5 concentrations computed with GAINS for the year 2020. Large parts of Pakistan would experience annual mean concentrations of PM2.5 in outdoor air of significantly more than 50 $\mu g/m^3$. For comparison, the World Health Organization established a guideline value of 10 $\mu g/m^3$ as a recommended level for PM2.5.

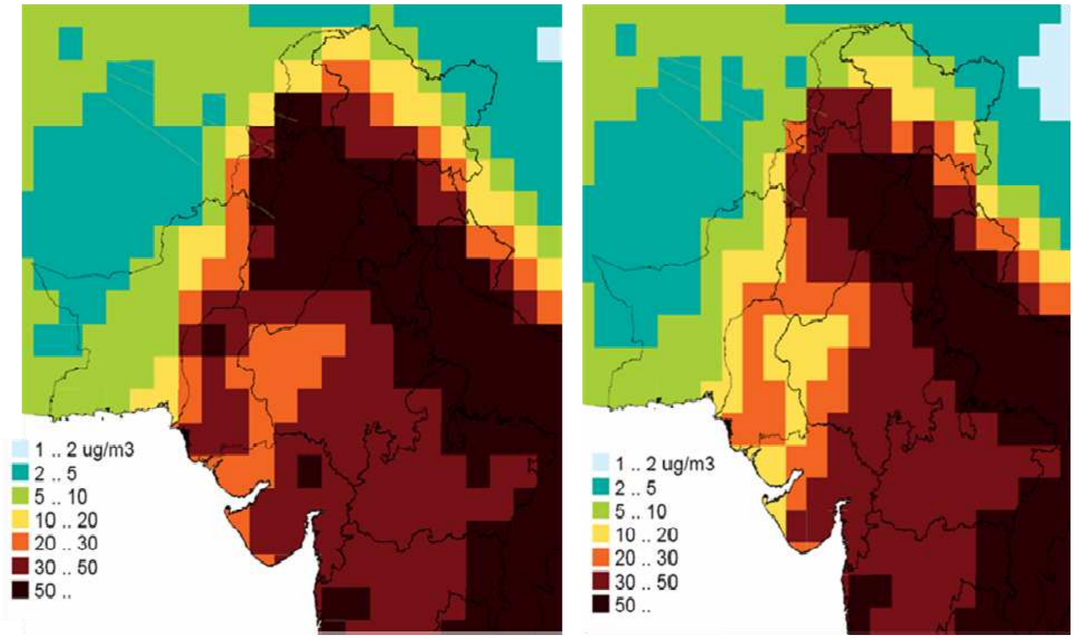

Figure 4.14 Ambient concentrations of PM2.5 in Pakistan for 2020 in the low control scenario (left panel) and the best available technology scenario for 2020 (right panel)

Not surprisingly, such high concentrations lead to significant health impacts. Figure 4.15 displays estimated loss in statistical life expectancy that could be envisaged from the concentrations displayed in Figure 4.12. While absolute health impacts are significant, there is a large difference between the two emission control scenarios. In the most polluted areas, life shortening would exceed 100 months on average in the LCS scenario, but remain around 60 months in the BAT case.

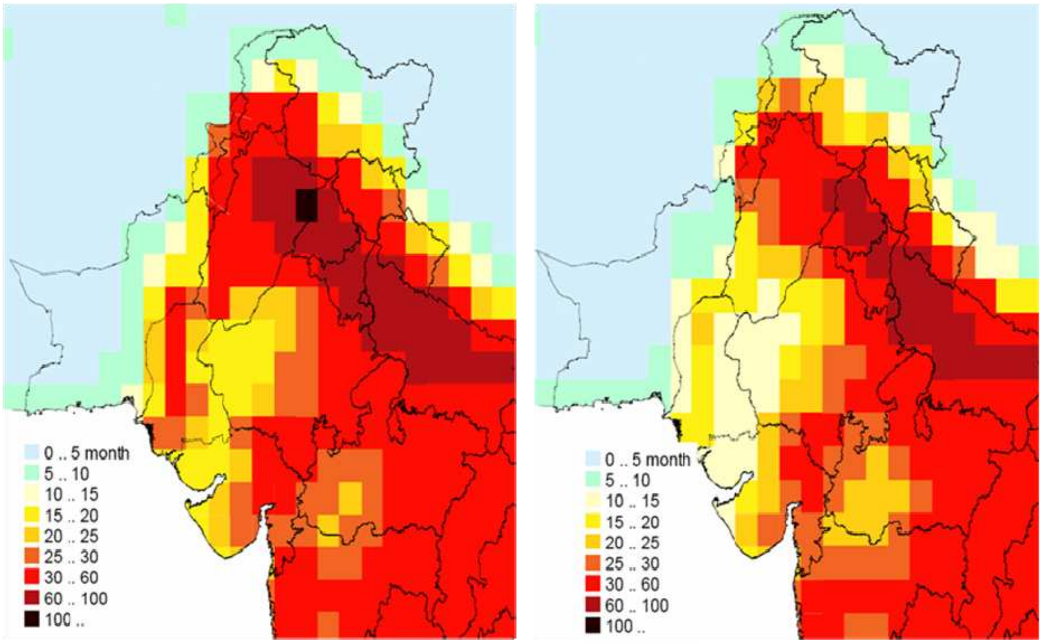

Figure 4.15 Health impacts due to ambient concentration of PM2.5 in Pakistan for 2020 in the low control scenario (left panel) and the best available technology scenario for 2020 (right panel)

5 Conclusions

Pakistan's attempt to raise the living standards of its citizens has meant that economic development has largely taken precedence over environmental issues. Uncontrolled use of hazardous chemicals, vehicle emissions, and industrial activities have contributed to a number of environmental and health hazards. Negative externalities emerge, inter alia, in the form of anthropogenic air pollution and increased rate of GHGs emissions.

Continuation of current practices in the implementation of emission control standards, paired with the progressing increase in energy consumption that accompanies the rapid economic development, will lead to a significant increase in air pollution levels throughout Pakistan.

This report presents a first analysis of potential implications of the current economic development plans of Pakistan on local and regional air pollution, and explores alternative approaches that could limit the envisaged deterioration of air quality.

Progressing economic growth paired with a continuation of current practices in implementing emission control measures would lead to a drastic increase in emissions and negative health and environmental impacts. For instance, the baseline energy projection with current implementation practices of air pollution control regulations would increase SO_2 and PM emissions by a factor of five up to 2030, and the volume of NO_x emissions would almost quadruple. CO_2 emissions would grow by more than 600 percent compared to 2000.

As a consequence of deteriorating air quality, serious health impacts are expected for Pakistan's population. Statistical life expectancy could shorten by more than 100 months due to air pollution, keeping all other factors constant. Therefore, without further air pollution control policies, negative impacts on human health and vegetation that are currently felt across Pakistan are expected to worsen in the coming decades.

Strict implementation of current legislation could alleviate these consequences to some extent. For instance, the growth in SO_2 emissions could be cut by half and PM emissions by 80 percent if existing legislation were fully implemented. However, even in this case air quality would deteriorate and cause higher premature mortality.

There is an array of policy interventions that could avoid such negative impacts of economic development. Measures are available that could provide clean air to Pakistan and increase well-being in physical terms, in addition to the expected increase in material welfare from the ongoing economic development. Such measures include selective replacement of the most polluting fuels by cleaner fuels, and effective implementation of dedicated emission control technologies.

A strategy that would promote the use of clean fuels could cut SO_2 emissions by 60 percent compared to the 2000 levels, and PM emissions by 80 percent. Application of world market technologies for reducing emissions of air pollutants could cut emissions further, however at considerable costs. Different portfolios of measures result in different levels of health benefits, and involve different levels of economic resources. The GAINS model can be used to identify emission control portfolios that reach effective health and environmental improvements while putting least burden on the economic development.

Annex 1: CO_2 emissions in different countries

In this section CO_2 emissions per capita in different countries are presented for the year of 2004. Emissions levels are high for developed countries like United States, Japan etc when compared with Pakistan (USDOE, 2004). Due to increasing population and industrial activities in Pakistan it is assumed that CO_2 emissions will increase in the coming years.

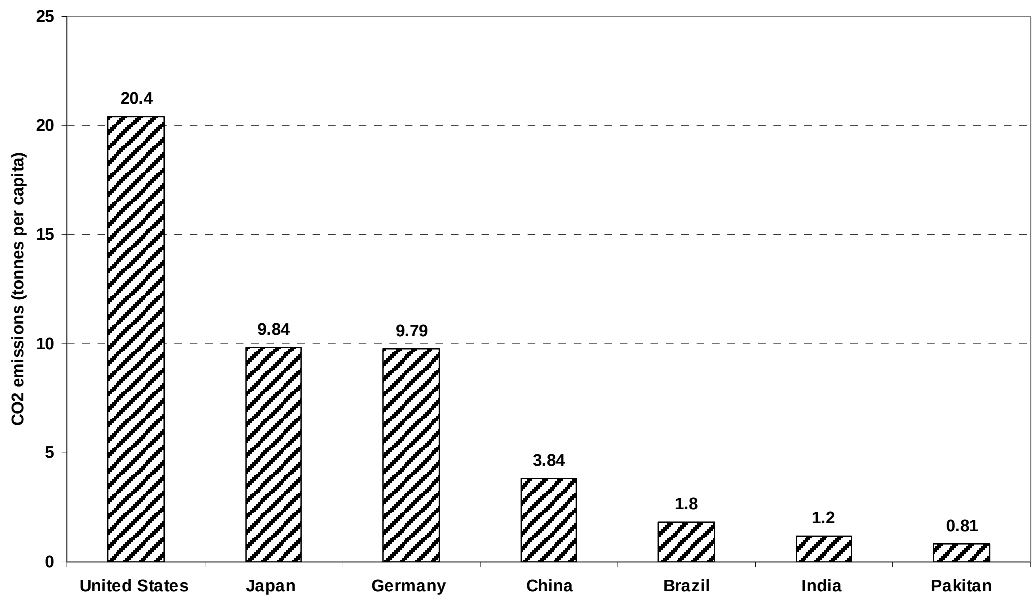

Fig 5.1 CO_2 Emission per capita in different countries

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