Does Climate Change Matter in Pakistan?

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Working Paper Series # 58
2001

A publication of the Sustainable Development Policy Institute (SDPI).

Sustainable Development Policy Institute is an independent, non-profit research institute on sustainable development.

WP-058-002-060-2001-018

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List of Acronyms

CIDA	Canadian International Development Aid
CO_2	Carbon Dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organization
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GFDL	Geophysical Fluid Dynamics Laboratory
H_2S	Hydrogen Sulphide
MAF	Million Acre Feet
MELGRD	Ministry of Environment, Local Government and Rural Development
NCS	National Conservation Strategy
NO_x	Oxides of Nitrogen
SDPI	Sustainable Development Policy Institute
SO_2	Sulphur Dioxide
SO_x	Oxides of Sulphur
TOE	Tonnes of Oil Equivalent
UNEP	United Nations Environment Program
UKMO	United Kingdom Meteorological Office
WB	World Bank
WHO	World Health Organization

Does Climate Change Matter in Pakistan?

Shaheen Rafi Khan

Pakistan is both energy deficient and energy profligate. These aspects define the energy-environment nexus and establish its national versus global context. Energy inefficiency tends to have direct and adverse environmental consequences. To the extent that Pakistan is energy deficient, -- and this is almost a tautology -- it falls in that category of developing countries which contribute relatively little to global warming but are vulnerable to the effects of climate change. Such vulnerability, however, is primarily rooted in socio-economic factors, with potential climate change impacts -- either harmful or benign -- being incremental in character. While this is true of secular impacts, extreme events (droughts, floods, storms) are presumed to have more far-reaching impacts and should be researched.

The paper has three related parts. The first part reviews patterns of energy consumption in Pakistan and the ensuing direct environmental impacts. The macro-indicators of energy consumption are examined and separated by their constituent elements, namely, by fuel source. The second part presents forecasts of energy demand. Collateral emissions are also estimated, reflecting global concerns. The third part examines biophysical and socio-economic impacts of climate change in Pakistan, with a focus on the three related sectors of water, agriculture and forestry. Socio-economic vulnerabilities are juxtaposed with climate change impacts for a more holistic view of the problem.

The paper concludes with some observations on the North-South debate on climate change. In particular, it re-visits the issue of national versus global guilt and concludes that over the next half century the potential impacts of climate change on the economy will largely be governed by national policies affecting Pakistan's demography, agriculture, infrastructure, forest resources and health.

1. National Energy Demand Patterns

The Macro Picture

The national energy system in Pakistan is and has been traditionally demand based, with supply deficiencies being addressed variously through imports, rationing and price equilibration -- the last a relatively recent recourse. The level, structure and evolution of this demand are derived from socio-economic variables; population growth, economic activity and the efficiency of energy use at the sector level. On a cross-country comparison basis, Pakistan is shown to be both 'energy deficient' and 'energy profligate.' The respective measurement indices are per capita energy consumption and energy intensity. Both are defined in terms of final energy consumption and are presented, respectively, in Figures 1 and 2.

With initial and end values of 0.26 TOE and 0.32 TOE, per capita energy consumption is low compared to the European Union countries where, by contrast, consumption rose from an average 3.5 TOE to 4.2 TOE over the same period. The relatively low level of consumption and its flat time profile has a three-fold and related explanation. It reflects: a) the low level of development; b) the absence of energy infrastructure in the rural areas where the bulk of the population resides and; c) reliance on traditional fuels, which both substitutes for and defers investment in such infrastructure.

Figure 1: Energy Consumption Per Capita

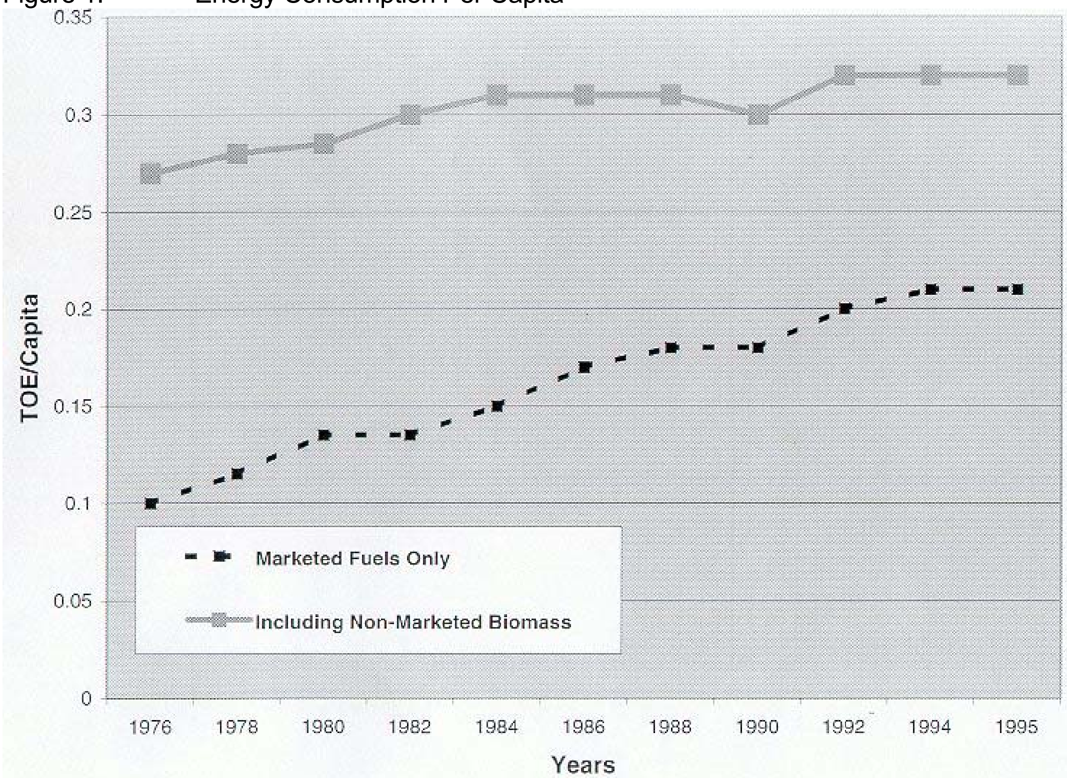
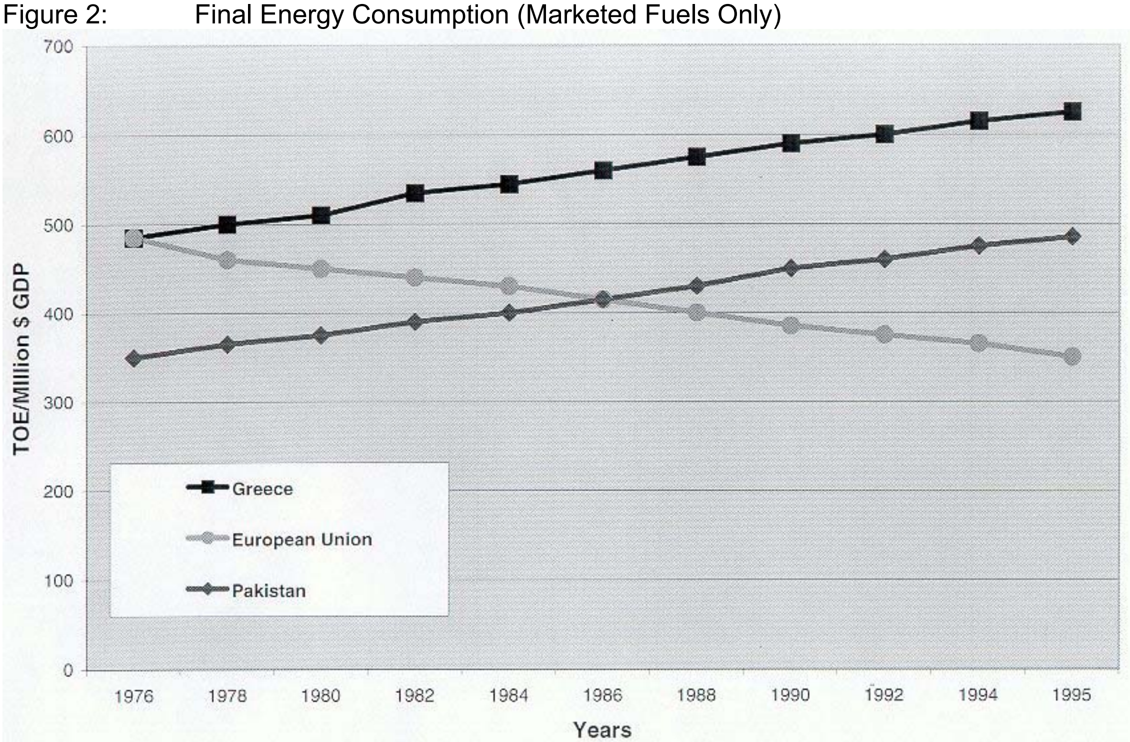


Figure 2: Final Energy Consumption (Marketed Fuels Only)



By contrast, energy intensity levels converged to the European average in 1985, with the comparison becoming distinctly unfavourable for Pakistan in 1995. It may be argued that one can not compare two entities in different stages of development; that as a result of having emission controls in place, European countries are well into the declining portion of the curve, which Pakistan has not yet even begun to approach. However, this is a conjecture based upon a statistically determined relationship and the subject of considerable.[1] controversy. In fact, there is good reason to decry such deterministic outcomes; there is no reason for developing countries not to internalise both technology and institutional precedents. By this token, the indicated levels of energy inefficiency are a source of concern. Some of the factors contributing to high-energy intensities are:

- transmission and distribution losses in power generation (an average 25% over the past 20 years)
- tariff concessions on imported, second-hand machinery
- fuel price subsidies on diesel
- an ageing vehicle fleet (50% over 10 years old), which is primarily diesel powered (75%)
- indigenisation and relative inefficiency of vehicle production
- rapid penetration of new appliances (air conditioners, refrigerators, heaters) in private homes

Energy Consumption Patterns

Low per capita energy consumption illustrates that Pakistan does not contribute substantively to global warming. This level falls even lower (Figure 1) with the exclusion of biomass, as emissions from combusting biomass are estimated net of replacement of sinks. On the other hand, rising energy intensity has direct and adverse environmental impacts. Inter-fuel substitution trends compound the problem. The increase in the consumption of petroleum products over past years is larger than for all other fuel types (see Figure 3). Also, petroleum products have overtaken natural gas as a fuel source in thermal energy production (shown in Figure 4). Further, the share of thermal-based relative to hydel-based power generation has gone up over time (see Figure 5). The future scenario is not encouraging either. The major planned investments in power generation are in the private sector and the two main fuel sources envisaged are imported oil and the high-sulphur coal reserves, recently discovered in the Thar Desert in Sindh.

1 The formal term for this posited relationship is the Envrionmental Kuznets Curve.

Figure 3: Final Energy Consumption by Fuel Type (including non-marketed biomass)

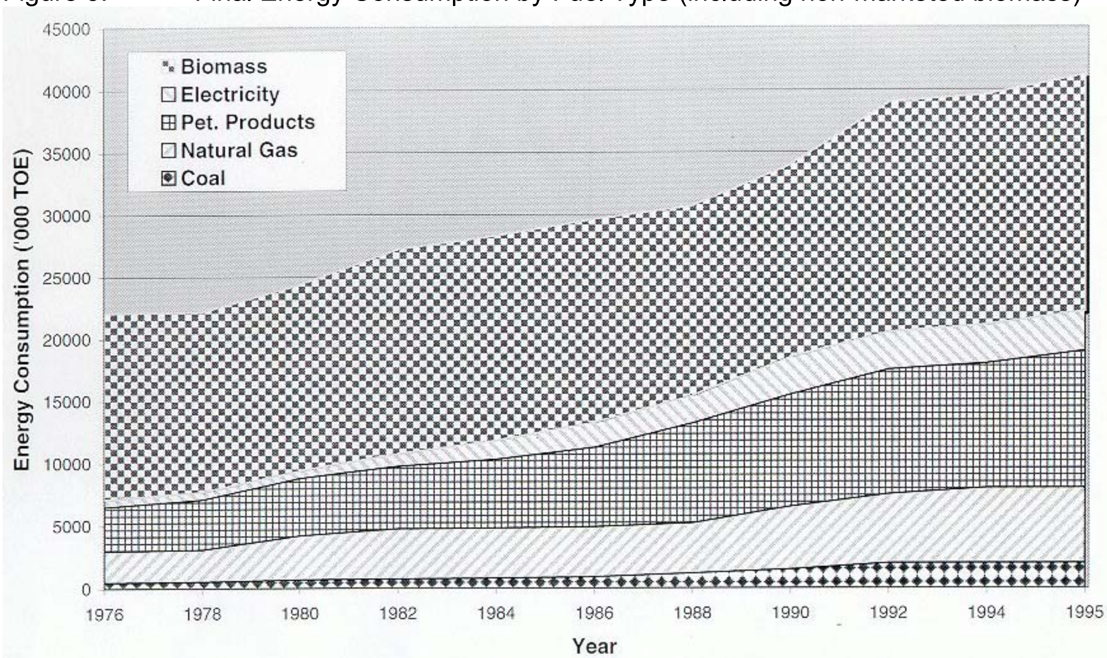


Figure 4: Thermal Power Generation by Fuel Source

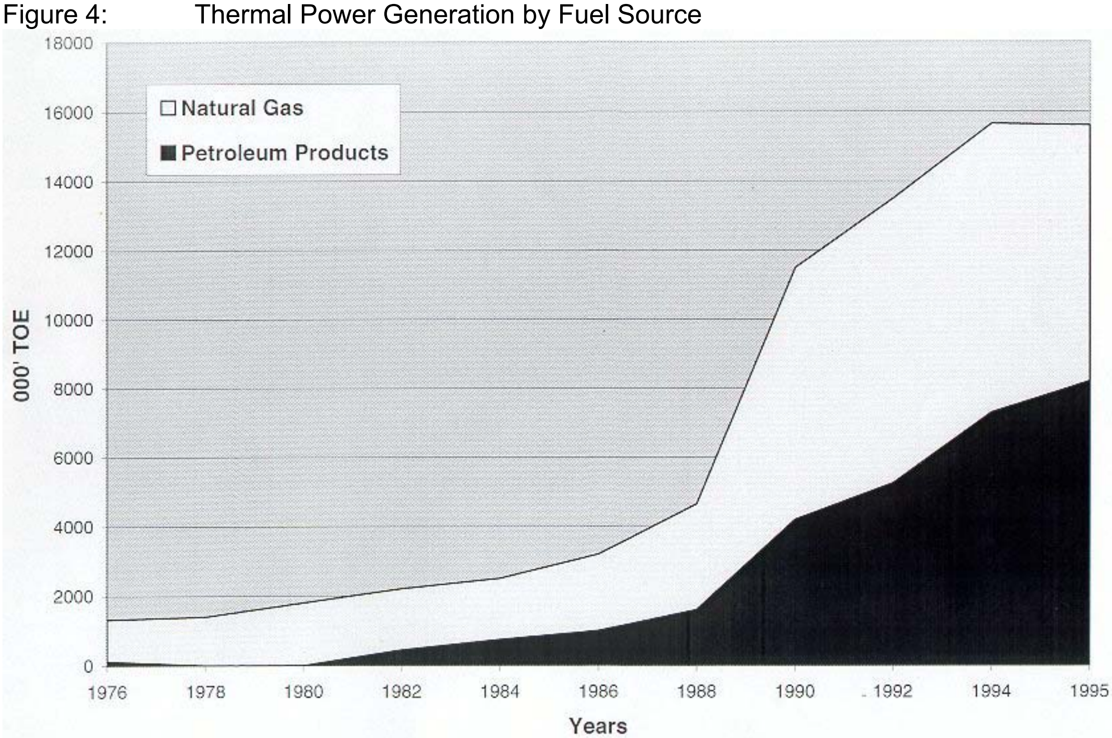
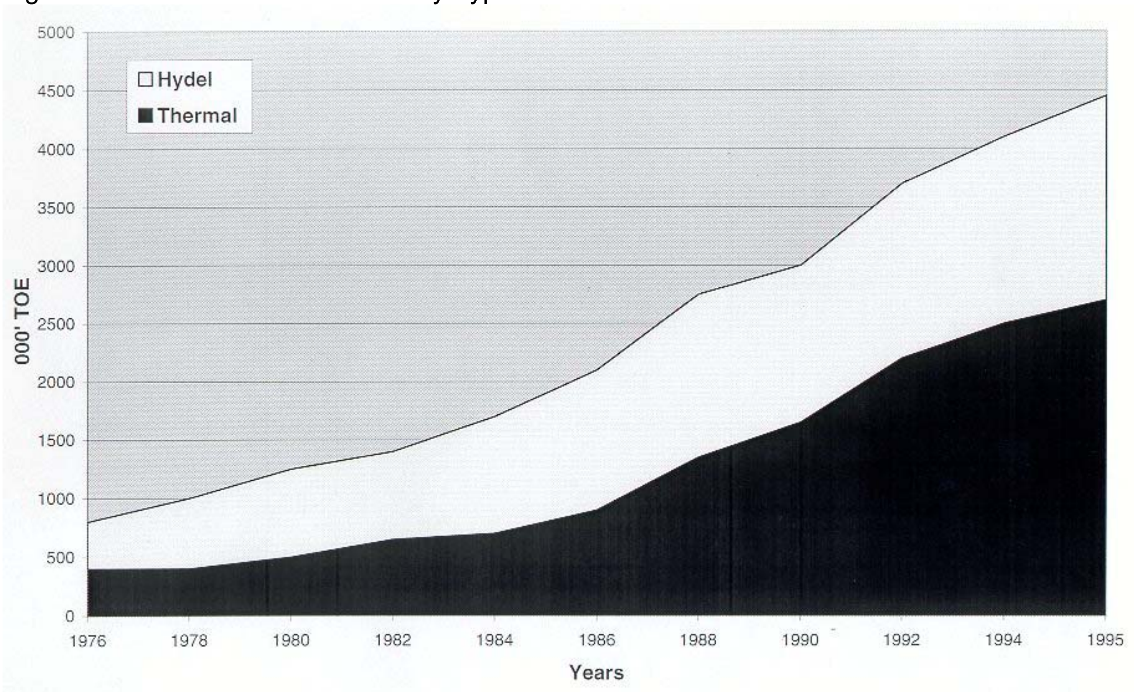


Figure 5: Power Generation by Type



Direct Environmental Impacts

Key environmental impacts due to fuel emissions are fairly heterogeneous, as shown below:

Table 1: Environmental Impacts of the Development and Use of Energy

Energy sub-sector	Activity	Associated Impacts
Coal	Mining	Land disturbance; resettling of residents; dust emissions; river pollution; destruction of habitat
Electricity	Thermal generation (coal)	SO_2, NO_x, CO_2 Emissions
	Hydel power generation	Flooding; displacement of people; effects on natural aquatic and riverine habitat; ecological impacts, including loss of wildlife habitat, erosion and watershed disturbance
Oil & Gas Development	Production	Water pollution from oil, brine and oil spills, H_2S Emissions
	Automobile fuel use	Urban air pollution, including lead and carbon monoxide; respiratory diseases, lead poisoning
Fuelwood	Domestic use	Indoor air pollution and health effects, deforestation; ecological impacts, including loss of wildlife habitat, soil erosion and watershed disturbance
Plant, animal residues and wastes	Domestic fuel	Loss of organic matter soils; local air pollution

Source: George Green and Doug Walters, Environmental Impacts of Energy Development and Use in Pakistan, mimeo, CIDA, Islamabad, 1989.

Arguably, the most critical concern is air pollution and its resulting health effects. As the following table shows, combined emissions from different sectors are growing rapidly.

Table 2: Estimated Air Pollutants by Sector

(thousand tonnes)

Sector	1977/78		1987/88		1997/98	
	CO_2	SO_2	CO_2	SO_2	CO_2	SO_2
Industry	12,308	19	26,680	423	53,429	982
Transport	7,068	52	10,254	57	18,987	105
Power	3,640	4	11,216	95	53,062	996
Domestic	16,601	5	24,054	16	39,980	40
Agriculture	845	5	4,490	28	6,368	40
Commercial	1,726	11	2,587	13	4,261	25

Source: National Conservation Strategy (NCS), 1992

Furthermore, the truly dangerous pollutants to human health arise from **non-stationary** sources in urban areas. The average Pakistani vehicle emits 20 times as much hydrocarbons, 25 times as much carbon monoxide and 3.6 times as much nitrous oxide in grams per kilometre as the average vehicle in the US. Carbon monoxide levels in the range of 8-30 parts per million (ppm) and 6-40 ppm have been recorded for Lahore and Karachi, respectively. Ambient lead levels in Karachi have been measured at between 0.024 and 0.13 micrograms per cubic meter, which is high, by WHO/WB criteria (NCS, 1992: 84).

Sulphur dioxide, a precursor to acid rain, is an irritant to the eyes, nose and throat as well as to the lungs. It is also phytotoxic. Exposure to carbon monoxide for an eight-hour period at identified levels is known to cause temporary impairment of nervous system functions, including eyesight sharpness. Hydrocarbons are an important source of particulate air pollution in Pakistan's major cities and also an eye and lung irritant. Lead, the most dangerous of vehicle- related emissions, when ingested by children are known to cause a reduction in intelligence quotient (NCS, 1992).

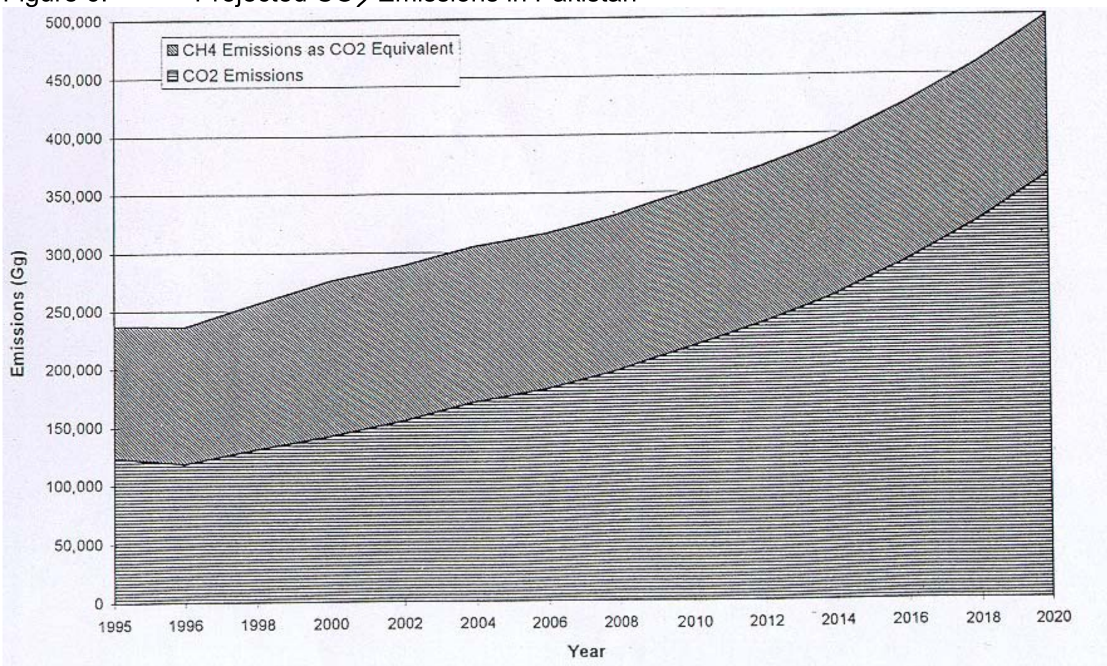
2. Energy Demand and Emission Forecasts

Pakistan,presently not a major contributor to global warming, is not likely to become one in the foreseeable future either. The emissions derived from energy demand forecasts are presented below (Figure 6).

Two points are of note. First, beginning from a low base, the emissions reach a figure of 475 million tons of CO_2 in the year 2020. This, in a relative sense, is low, both in absolute and in per capita terms. However, the more alarming implications from a national and global perspective are demonstrated by the exponential growth of emissions over this period. This trend is based on a number of developments: first, depleting natural gas reserves have begun to induce a switch to oil based products, particularly in private power generation; second, the large, high-sulphur, coal deposits in the Thar desert are likely to be tapped as oil imports become difficult to sustain; third, there will be considerable expansion of rural energy infrastructure; fourth, appliance use will intensify and; fifth, selective subsidies for highly emitting fuels, such as diesel, will continue to remain politically intractable.

Clearly, the visuals replicate the situation in countries, which Pakistan seeks to imitate -- where development is accompanied by high levels of pollution. The combined global environmental consequences are likely to be disastrous and, as such, Pakistan has an obligation to adopt pre-emptive measures to lower emissions.

Figure 6: Projected CO_2 Emissions in Pakistan



3. The Impacts of Climate Change: Adaptation Strategies

It is tempting to subscribe to popular rhetoric that Northern depredations, as manifested by its untrammelled emissions, will irrevocably harm Pakistan: that, as a result, forests will shrink; water resources will be depleted, agriculture will fall victim to droughts and floods, people will be displaced, coastal areas will suffer salt water intrusion and human health will suffer. None of this can be dismissed completely. But, it is equally true that climate change impacts and possible adaptations can not be addressed in isolation from the underlying socio-economic conditions. Pakistan, like many developing countries, is a society in transition from agriculture to a modern industrial economy. The transition entails high population growth, rapid urbanisation, infrastructure degradation, soil erosion, water and air pollution, increased morbidity etc. Many of these processes create conditions very similar to those caused by climate change. For instance, sea level rise results in salt-water intrusion, but this can also be caused by diversion of fresh water outflows to meet the needs of agriculture, human consumption and sanitation. Or, climate change can erode watersheds and cause flooding but this can also be the result of deforestation. When socio-economic factors and natural elements combine in this manner, existing vulnerabilities tend to be exacerbated. It follows, also, that adaptive responses need not necessarily be climate specific, and that climate change may reinforce or alleviate them. A corollary is that policy sustainability becomes both an imperative and a possibility.

Our aim, then, is to show – quantitatively where possible – that Pakistan's key resources, its economy and society, are at risk; that such socio-economic pressures and imbalances establish vulnerability to climate change and; that potential climate change impacts are likely to be incremental in nature. Three key and inter-related sectors of Pakistan's economy are analysed; water resources, agriculture and forestry. Socio-economic vulnerabilities without and with climate change are identified in each sector -- quantitatively, where possible. The implications for adaptation are also considered.

Climate Change Scenarios

The following climate change scenarios are adopted for the sector analysis:

Table 3: Climate Change Scenarios

Scenario	2020	2050
Temperature	+ 0.9° C	+ 1.8° C
Precipitation	± 3.0%	± 6.0%

Source: Study on Climate Change Impact Assessment and Adaptation Strategies for Pakistan, 1998

A sea level rise of about 20 cms is predicted in 2020 and 30 cms by 2050. A number of models, such as CSIRO, GFDL AND UKMO predict increased frequency of extreme events. With a doubling of CO_2, average summer rainfall in South Asia will increase by, variously, 17% to 59%. This will be associated with a doubling in the frequency of high rainfall events. Variable monsoons, also anticipated, could mean more droughts, but this effect would be mitigated by higher snowmelt in the mountains.

The Sector Scenarios

Water Resources

Vulnerability is exhibited by the divergence between present and projected demand for water and the supply likely to be available. Demand is reflected in sectoral requirements and population growth, while supply has both quantitative and qualitative aspects. Seasonal imbalances, droughts and floods are other aspects of vulnerability. We focus on the water potential of the Indus Basin system, since it is pivotal to Pakistan's agriculture and for its sector needs as well, such as household consumption, energy, industry and coastal fisheries.

The water potential of the Indus Basin is limited. The mean value over 64 years of water availability at the rim stations (that is entering the Indus Basin within Pakistan) is about 146 million-acre feet (MAF). Of this, approximately, 104 MAF are diverted at the canal head. The 42 MAF or so that flows into the Arabian Sea, sustains Pakistan's coastal fisheries and prevents salt water intrusion. After accounting for losses in the canal system, in watercourses and in field applications, about 31 MAF is actually used by the crops. Ostensibly the loss rate is high; suggesting that higher uptake is possible through canal rehabilitation and lining. However, a significant proportion of this loss constitutes ground water recharge, which limits the scope for controlling seepage. Of the estimated total annual recharge of 46 MAF, about 41 MAF are already being used for crop cultivation. About 10 MAF represents the median value of the additional ground water that can be tapped (Khan, 1999).

With regard to surface water, new storage has become central to current policy dialogue and planning, although this issue continues to be surrounded by controversy. The political concern is with equitable water sharing. The environmental and social concerns relate to displacement of communities, biodiversity and species loss and disturbance of the coastal water balance. The evidence shows an increasing incidence of floods and associated damages over the past two decades. Supporting arguments, are less compelling. It is true that in the 20 years since its construction, Tarbela Dam has lost close to 30% (3.6 MAF) of its storage capacity due to sedimentation. However, this does not warrant the construction of yet another dam over the River Indus. Desilting Tarbela appears to be a far more cost-efficient alternative with equivalent outcomes, both in terms of energy production and additional water.[2] However, in view of the policy intent, the water supply forecasts factor in additional storage capacity of about 6 MAF coming on-stream in the year 2010 (SDPI, 1998).

Supply and demand forecasts, with and without climate change, are shown below. While supply is fairly easy to forecast, demand scenarios are relatively more difficult to generate. The least favourable supply scenario is considered where increased warming is accompanied by reduced precipitation.

Table 4: Demand-Supply Balances Without Climate Change

(MAF)

Year	2000	2010	2020	2050
Projected Irrigation Water Demand (with Kalabagh)	104.87	110.04	110.04	110.04
Households & Industry	5.90	8.70	12.00	20.00
Total Projected Demand:	110.77	118.74	122.04	130.04
Projected Supply:	104.87	110.04	110.04	110.04
Projected Deficit:	5.90	8.70	12.00	20.00

Demand-Supply Balances With Climate Change

(MAF)

Year	2000	2010	2020	2050
Projected Irrigation Water Demand (with Kalabagh)	104.87	110.04	110.04	110.04
Households &Industry	5.90	9.20	12.50	20.50
Total Projected Demand:	110.77	119.24	122.54	130.54
Projected Releases:	104.87	110.04	108.85	106.98
Projected Deficit:	5.90	9.20	13.69	23.56

Source: SDPI in-house calculations. Report of the Water Sector Team, 1998

In the supply projections, we have factored in increased uptake of 16 MAF over the projection horizon, assuming the construction of Kalabagh or alternative dams, and additional ground water exploitation. This is the sum total of water available for the agriculture, household, industry and energy sectors. It reflects competing uses as well as recycling, although we abstract from ground water quality deterioration.

The change in demand for irrigation water is synonymous with discrete additions to supply because, in the context of chronic under-irrigation, our concern is with demand that is actualised. Releases represent the continuous aspect of supply; the decline in these releases post climate change – and relative to supply – reflects the impact of climate change.

The relative orders of magnitude are illustrative. The deficit increases to 20 MAF, due to the growing needs of agriculture, households, industry and energy. Supply, which is structurally constrained, is unable to meet this demand. The effect of climate change on this deficit is incremental – namely, increasing it by 3.56 MAF. Assumptions and abstractions notwithstanding, the message is clear. Climate change impacts act on the supply side and represent small increments to a large stock of usable water. A possible doubling of population, crop production, and industry size and energy production by the year 2050, on the other hand, represents socio-economic pressures. As such, they are the key drivers with respect to the

2 See TAMS-Wallingford, *Tarbela Dam Sediment Management Study: Final Report*, WAPDA, March 1998

water resource situation. Furthermore, as pointed out earlier, it is not easy to disentangle the impacts of climate change, deforestation and storage construction on, respectively, the increased frequency of floods and salt water intrusion in coastal areas.

Agriculture

Agriculture presently contributes 25% to Pakistan's national income, provides employment to 50% of the labour force and 60% of the country's exports are directly or indirectly based on agriculture. In the medium GDP growth scenario, agriculture's share in national income is projected to fall to 20% by the year 2020 and further to about 15% by the year 2050. However, agriculture will continue to remain a key sector by virtue of its role in:

- Food production to meet the needs of a growing population
- Diversification of the product mix and increase in livestock production, to meet milk and meat demands associated with rising incomes
- Sustaining exports and employment
- Providing inputs for agro-based industries
- Serving as a market for industrial goods

Constraints to growth in agricultural production fall into two categories; non-structural and structural. Non-structural constraints have traditionally been targeted by policies. The main problems are poor agronomic and post-harvest management practices, capital scarcity for small farmers, poor linkages between research and extension and input-output price distortions. In recent years, structural constraints have begun to emerge which, essentially, inhibit production increases at the extensive and intensive margins. These are:

Land Use Limits: Between 1947-52 and 1983-86, total cropped area, which includes area sown more than once, increased by 7.7 million hectares. Of this, 4.4 million hectares were due to the expansion of irrigated cropping areas and the rest due to an increase in double cropping. For the first 20 years, expansion was the main source of increase, accounting for 79% of the increase in cropped area. Since 1973-77, this ratio dropped to 33%, with intensification accounting for the bulk of the increase (MELGRD/UNEP/GEF, 1998: 26).

Unavailability of Water: Although limits to expansion at the extensive margin have been reached, production still remains well below its potential because of under-cropping. On the basis of just Class II irrigated soils, 12.2 million hectares of land and I are available for double cropping. This is almost 3 times the irrigated area that actually grows two crops per year. However, this potential is unutilised because of lack of water, a problem that we referred to earlier.

While the previous slack in policies could be afforded because additional land and water was available, this is a fast-iminishing luxury. In the supply projections below, we have made fairly heroic assumptions regarding policy implementation, which would result in both yield enhancements, as well as product diversification. Some of the anticipated policy changes are:

- Improvements in water use efficiency
- Canal and on-farm drainage improvements
- Rehabilitation of saline and waterlogged soils
- Input-output price rationalisation
- Agronomic improvements
- Organic replenishment of soils

- A livestock production strategy which focuses on herd improvements
- Increased institutional support to small farmers

However, even a more dynamic policy matrix may not be able to compensate for the pressures generated by additional demand. This is illustrated in the table below.

Table 5: Projected Demand-Supply Balances of Major Agricultural Commodities

(Million tonnes)

Commodities	YEARS								
	1995			2020			2050		
	S	D	G	S	D	G	S	D	G
Wheat	17.0	17.9	- 0.9	27.5	32.4	- 4.9	35.7	43.0	- 7.3
Rice	3.5	2.5	1.0	6.2	5.5	-0.70	7.9	10.0	- 2.1
Sugarcane	47.2	41.6	5.60	50.0	75.3	-25.3	60.0	100.0	-40.0
Cotton (million bales)	8.7	10.6	- 1.9	18.0	19.4	- 1.4	25.00	25.9	- 0.9
Fruits & Vegetables	9.8	9.6	0.2	26.0	26.0	0.0	35.0	34.5	0.5
Meat	2.1	2.1	0.0	5.7	5.7	0.0	7.6	7.6	0.0
Milk	15.3	15.3	0.0	41.5	41.5	0.0	55.0	55.0	0.0

Source: MELGRD/UNEP/GEF, 1998

Note: S = Supply, D = Demand, G = Gap

By the year 2050, the situation becomes critical. The wheat deficit increases seven-fold. The year 2020 becomes a milestone year -- in a negative sense -- when both rice and sugarcane surpluses are converted into deficits. Clearly, the primary concern becomes one of food security.

Cotton holds its own; in as much as it is linked with agro-processing, as opposed to income and population growth which determine demand in a supply-constrained situation for food crops. Growth in the livestock sector is premised on higher yields per animal as a result of breed and nutrition improvements.

Climate change impacts need to be viewed in the context of such deficits. In the modelled worst case scenario of increased warming and falling precipitation, growing season length reduces, especially in the arid areas where crops are already on the margin of stress. Increased heat and reduced soil moisture also causes accelerated growth early in the season and effects changes in the partitioning and quality of biomass. In combination these factors have yield reducing effects. This is offset by higher CO_2 levels, which have yield enhancing effects, especially on C3 and C4 crops like wheat, rice and maize. The net effects, therefore, are indeterminate. On the other hand, crops like rice and sugarcane would be hard hit by water scarcity. Spatial shifts in production are also predicted, especially in the crop zones dominated by wheat, rice, cotton and maize.

The most critical policy measures are those geared to enhancing yields, but these also address climate change impacts, especially in the case of sugarcane and rice. Climate specific adaptations involve research on heat-resistant cultivars. At the social level, alternative employment opportunities would need to be created for labour displaced by zonal shifts; women engaged in cotton picking and rice transplanting are an important target group.

Forestry

In the case of water resources and agriculture, we have attempted to show that future trends with regard to resource and crop balances will be driven primarily by economic pressures and by the structural characteristics in these sectors. Climate change impacts will reinforce or dampen these trends, but either way such impacts are likely to be incremental. This is illustrated vividly in the case of the forestry sector, where model simulations were carried out to assess the biophysical impacts of climate change.

Climate Change Impacts in the Forestry Sector

In the forestry sector, socio-economic pressures, especially with respect to coniferous forests and desertification reverse modelled climate change impacts.

Nine forest types were identified for the climate change impact assessment. The first-order impacts of increased atmospheric concentration; temperature and precipitation were evaluated with the help of BIOME 3 model simulations. Of the 9 biomes, 3 (alpine tundra, grassland/arid woodlands and deserts) showed **reduction** in their area; 5 biomes (cold conifer/mixed woodland, cold conifer/mixed forests, temperate conifer/mixed forests, and steppe/arid shrublands) showed **increase** in their area as a result of climate change. There was no change in the area of xerophrytic wood/scrubs in the simulations. Enhanced CO_2 concentration in the atmosphere appeared to have a pronounced effect on a biome's area increase, even in the case of high temperature and low precipitation scenarios.

These results are completely at variance with reality. In particular, it would be counterintuitive to expect deserts to shrink or conifer dominated areas to increase. The reality is that Pakistan's forests are under severe pressure. As little as 5% of Pakistan's total area is under forest, of which 30% is economically utilised, the rest being under protective cover. Both economic and environmental considerations suggest that the desirable range is 25% - 30%.

The annual rate of deforestation ranges between 7000 - 9000 hectares per annum, which is equal to about a 0.2% decline in forest cover. The factors contributing to this loss are:

- Logging for timber
- Cutting for fuel wood
- Land use changes (crop cultivation)
- Over grazing
- Poor quality planting stocks and low regeneration

Forestry Demand Projections

The two major sources of forest depletion are logging and cutting for fuel wood. Privately owned farmlands supply 50% of the demand for timber, imports 36% and state forests only 14%. On the basis of per capita income increases, the projected demand for timber in the year 2000 is 4.11 million cubic meters. State forests are expected to supply 1.0 million cubic meters and farm lands 2.0 million cubic meters, leaving a deficit of 1.11 million cubic meters. Since foreign exchange for imports will be scarce, this may put further pressure on depleting forest stocks.

As a result of population pressure, fuel wood demand is expected to rise by 55% in the year 2000. This will lead to further excessive cutting, unless alternative fuels (kerosene, natural gas) can be provided. The following table shows a four-fold increase in demand by the year 2050.

Table 6: Fuelwood Demand by Industry and Households

(Million metric tons)

Year	2000	2010	2020	2050
Households	605.94	910.53	1308.48	2209.99
Industry	14.08	17.41	21.54	40.77

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Socioeconomic Impacts

Deforestation also has adverse socio-economic impacts, which are likely to be exacerbated by climate change. Some of the critical problems are:

***Displacement of Communities**:* Land erosion and soil degradation caused by deforestation has displaced many rural communities in the Northern Areas, forcing them to migrate to crowded 'road towns' along the Karakorum Highway.

***Disruption of Communications, Energy Loss**:* Land slides in the Northern Areas, Azad Kashmir and the Murree Hill tracts frequently disrupt communications. In general, land erosion results in siltation of reservoirs and reduces hydropower generation capacity. More frequent and torrential rains are a possible outcome of climate change. The resultant sheet erosion could cause further gullying and landslides in exposed locations, with both forms of degradation affecting standing forests and regeneration.

***Loss of Agricultural Land**:* The loss of forest cover in the riverain areas has created flooding problems and, through soil erosion, reduced agricultural potential. Growing demand for fuelwood and continuing land use changes, thanks to population increase, will make the riverain areas even more vulnerable to the increased frequency of flooding.

***Damage to Coastal Infrastructure and Marine Habitat**:* The clearing of mangroves in the coastal areas has resulted in sea encroachment and in loss of habitat for many marine species that are a source of livelihood for coastal communities. If unchecked, the loss of this natural barrier could expose coastal infrastructure to the increased frequency of storm flooding. Sea level rise could further damage marine habitats.

4. Conclusion

Pakistan is not expected to be a major player in global warming, although its energy based emissions are a major source of pollution and environmental damage within the country. On the other hand, Pakistan is vulnerable to the consequences of climate change. The potential impacts have been identified in the water, agriculture and forestry sectors. However, such impacts are likely to be incremental and a function of the imbalances generated by socio-economic pressures and structural constraints. It follows that adaptations to climate change have their genesis in such imbalances. The three key adaptations, which have been identified, are increasing water-use efficiency, agricultural policies to enhance crop yields, and afforestation.

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