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CLIMATE CHANGE: EMISSIONS AND SINKS OF GREENHOUSE GASES IN PAKISTAN

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ABSTRACT:

This study presents the emissions and sinks of Greenhouse Gases (GHGs) in Pakistan during July 2007 to June 2008 (Fiscal year). The emissions of GHGs including CO_2, N_2O, CH_4 and Halocarbons were estimated for various potential contributing sectors in Pakistan. The emissions were estimated by adopting the revised guidelines for national greenhouse gas inventories (1996) of Intergovernmental Panel on Climate Change (IPCC).

The net estimated emissions of CO_2, CH_4 and N_2O are 1,04,939.3, 5,132.3 and 193.1 Giga grams (Gg) respectively. The contribution of various sectors for the emission of CO_2 were; energy (74.3 %), industrial processes (16.0 %) and land-use & forestry (9.7 %). The major emitters of CH_4 are energy (16.0 %), agriculture (74.4 %) and waste (9.2 %). The estimated percentage contribution to the emission of N_2O from energy sector, industrial processes, agriculture and waste were 0.4, 0.6, 94.8 and 4.2. Other gases' estimates were as NO_x (628.1 Gg), CO (1,322.8 Gg), NMVOCs (1,599.8 Gg), SO_2 (1,226.3 Gg) and Halocarbons (2.4 Gg). The only sink of CO_2 is forestry with CO_2 sequestration of 87,284 Gg. The study revealed that the per capita CO_2 emission remained 0.65 tonne from July 2007 to June 2008 in Pakistan. This estimated value is lower than the neighboring countries like India and China where per capita emissions are 1.5 and 5.3 tonnes respectively.

KEYWORDS: GHGs; Emissions; Per capita; Pakistan; IPCC guidelines.

1. AIM OF WORK:

According to United Nations Framework Convention on Climate Change (UNFCCC), countries are classified in two categories i.e Annex-I and Non-Annex-I. Annex-I include developed countries like USA, Russia etc. and their mandate is to reduce the emission of GHGs in a specific quantity. Non-Annex-I countries are mostly developing/under developed countries and Pakistan lies in this category. According to Copenhagen Accord, December 2009 (UNITED NATIONS Draft decision -/CP.15 ***Copenhagen Accord***), Non-Annex-I countries are mandated to submit their national GHGs inventory after every two years. Pakistan's last GHGs inventory was developed for 1993-94 and submitted to UNFCCC in 2005. So, the need was felt to up-date the emissions of GHGs.

2. INTRODUCTION:

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons).

There are also several gases that do not have a direct global warming effect but indirectly affect terrestrial and/or solar radiation absorption by influencing the formation or destruction of greenhouse gases, including tropospheric and stratospheric ozone. These gases include carbon monoxide (CO), oxides of nitrogen (NO_x), and non-CH_4 volatile organic compounds (NMVOCs). Aerosols, which are extremely small particles or liquid droplets, such as those produced by sulfur dioxide (SO_2) or elemental carbon emissions, can also affect the absorptive characteristics of the atmosphere.

Although the direct greenhouse gases CO_2, CH_4, and N_2O occur naturally in the atmosphere, human activities have changed their atmospheric concentrations. From the pre-industrial era (i.e., ending about 1750) to 2005, concentrations of these greenhouse gases have increased globally by 36, 148, and 18 percent, respectively (IPCC 2007).

Beginning in the 1950s, the use of CFCs and other stratospheric ozone depleting substances (ODS) increased by nearly 10 percent per year until the mid-1980s, when international concern about ozone depletion led to the entry into force of the Montreal Protocol. Since then, the production of ODS is being phased out. In recent years, use of ODS substitutes such as HFCs and PFCs has grown as they begin to be phased in as replacements for CFCs and HCFCs. Accordingly, atmospheric concentrations of these substitutes have been growing (IPCC 2007).

3. IMPACTS OF GLOBAL WARMING/CLIMATE CHANGE ON PAKISTAN:

GHGs are directly related to global warming/climate change and some of its impacts on Pakistan are as below:

Rise in Sea level

Rising sea levels will put hundreds of millions of people at risk for being flooded each year. About 15 to 40 percent of all species could face extinction as a result of global warming. The tsunami in Southeast Asia and the further convulsions that followed are said to be the result of climatic changes. Coastal areas bordering the Arabian Sea in the south of Pakistan will be at greatest risk due to increased flooding from the sea and in some cases, the rivers.

GDP decrease

Global warming would cost about one percent of the annual global GDP by 2050 in Pakistan. Global warming of two degrees Celsius above pre-industrial temperatures could result in permanent reductions in GDP of four to five percent for South Asia.

Un-seasonal rains

Un-seasonal rains in Pakistan are being attributed to climatic changes. Precipitation has decreased 10 to 15 percent in the coastal belt and hyper arid plains over the last 40 years while there is an increase in summer and winter rains in northern Pakistan. Pakistan is the 12th most vulnerable country.

Temperature rise

Although Pakistan contributes least to global warming—135th of the world's average of carbon dioxide emissions—temperatures in the country's coastal areas have risen since the early 1900s from 0.6 to 1 degree centigrade.

Decrease in crop yield

Being a predominantly agriculture economy, climate change is estimated to decrease crop yields in Pakistan which in turn will affect livelihoods and food production. Combining the decreased yields with the current rapid population growth and urbanization in the country, the risk of hunger and food security will remain high. If global warming goes unchecked, all regions of the world will be affected, but the most vulnerable — South Asia and Sub-Saharan Africa — will be hit hardest by fall in crop yields, according to the report, prepared by the International Food Policy Research Institute (IFPRI) for the World Bank and Asian Development Bank. Wheat yields could fall by more than 30 percent in developing countries. Wheat prices could rise by 170 percent — 194 per cent by the middle of this century. Rice prices are projected to rise by 121 percent.

Diseases

Endemic morbidity and mortality due to diseases primarily associated with floods and droughts are expected to rise. Increases in coastal water temperatures would exacerbate the abundance of cholera.

Social inequalities

The impact of climate change will also aggravate the existing social inequalities of resource use and intensify social factors leading to instability, conflicts, displacement of people and changes in migration patterns.

Glacier melting

The Glacier melting is a four-pronged danger. Data about % Depleted Snow-cover Area of some glaciers of Pakistan is as:

Name of Glacier	% Depleted Snow-cover Area	Study Period
Batura	15	1992-2001
Biafo	9.0	1992-2000
Yazghil	5.0	1992-2007
Jutmau	28	1992-2007
Passu	7.0	1992-2008
Ghulkin	12	1992-2008

4. METHODOLOGY:

This inventory has been prepared using the common reporting and documentation framework prescribed by the IPCC (Revised 1996 IPCC Guidelines for National GHG Inventories). The guidelines cover five significant GHG source categories, i.e., the energy, industrial processes, livestock and agriculture, forestry and land-use change, and waste sectors. Solvents and other product use, the sixth GHG source category identified by the IPCC, has been excluded from this inventory because of data deficiencies, i.e., absence of activity and emission data on solvents used in dry cleaning, printing, metal degreasing, painting, and industrial and household uses. The IPCC guidelines use specific terms for certain fuels, which may or may not correspond with terms used in Pakistan.

5. RESULTS AND DISCUSSION:

5.1. Energy:

Emissions from the energy sector are divided into two main categories, i.e., emissions from fuel combustion and fugitive emissions from a) coal mining and handling and b) oil and natural gas activities. In inventory preparation emissions from the energy sector using two approaches, the Reference Approach and the Source Categories Approach were used. The Reference Approach reports the inventory of CO_2 emissions by type of fossil fuel. On the other hand, the Source Categories Approach calculates CO_2 emissions at the levels of specific end-use activities, processes or technologies.

Total CO_2 emissions from fuel consumption, calculated by the Reference Approach were estimated at 1,42,900 Gg, with 40.8 percent of emissions resulting from the combustion of liquid fossil fuels, 44.0 percent from the combustion of natural gas and 15.2 percent from the combustion of solid fossil fuels.

The Source Categories Approach covers two broad classifications, i.e., emissions from fuel combustion and fugitive emissions from handling, processing and non-productive combustion of fuels. Emissions from fuel combustion are

estimated on a sector basis and the sectors considered include energy industries, manufacturing industries and construction, transport, the commercial and residential sectors and agriculture and forestry. Fugitive emissions are estimated for coal mining and handling activities and oil and gas activities including oil refining.

Emissions from energy industries amounted to 41,247Gg of CO_2 in 2007-08.Emissions from plants run on gas turbines contributed 48.3 percent of total emissions from power generation, while diesel operated generation stations accounted for 51.0 percent of emissions.

CO_2 emissions from manufacturing industries and construction were estimated at 44,900 Gg in 2007-08.Of the fuels used in manufacturing and construction, natural gas accounted for over 45.1 percent of all emissions while coal accounted for 47.6 percent, although it is used exclusively in the brick industry.

Total emissions from the transport sector amounted to 34,028 Gg, with road transport accounting for 96 percent of all emissions from the sector. Within road transport, gas/diesel oil was the most polluting fuel, accounting for almost 71.6 percent of total emissions from road transport. Emissions from air transport constitute the second largest group of emissions by sub-sector, but these constituted only 3.8 percent of total transport emissions. Rail transport and sea transport, which is extremely limited in Pakistan, did not cause significant emission levels.

Fuel consumption in the commercial sector resulted in emissions of 2,404 Gg of CO_2 in 2007-08. Over half of these emissions resulted from the use of gas, while a further 23 percent could be attributed to the use of LPG.

Emissions from residential, agriculture and other/ Govt. are 12,623, 351 and 1020 Gg respectively. Natural gas is very much the dominant fuel in the residential sector, accounting for 90 percent of total fuel consumption. Emissions from natural gas accounted for 88.7 percent of total CO_2 emissions from the residential sector, while emissions from LPG constituted 8.3 percent.

An analysis of emission factors for fuels shows that natural gas is the least polluting fuel with respect to magnitude of emissions per heat unit. Lignite is the most polluting fuel with considerable negative climate change impacts. Fuel oil and diesel have roughly similar emission effects. Residual fuel oil also had an emission factor that was slightly higher than the average for fuels in the energy sector. Gas/diesel oil, which in Pakistan is referred to as High Speed Diesel (HSD), has the highest polluting potential within the fuels used in the road transport sector. As diesel was also the dominant fuel in the road transport and railways sub-sectors in particular, and in transport in general, the relatively polluting nature of the fuel has particularly serious implications.

Methane emissions from coal mining and handling are calculated by multiplying coal production figures by the appropriate emission factor and then by a conversion factor of 0.67 which converts the emissions unit from million cubic meters to gigagrams (IPCC guidelines). Methane emissions from coal mining were

calculated as 73.4 Gg of CH_4 in 2007-08. The bulk of these emissions came from mining activities. Methane emissions from oil and gas activities were estimated to total 737.5 Gg in 2007-08. Over 99 percent of these emissions resulted from natural gas production and from transmission and distribution. Emissions from crude oil production, refining and storage remained negligible. Indirect GHG emissions from crude oil refining activities were negligible. Sulfur dioxide (SO_2) emissions from sulfur recovery plants amounted to almost 11.0 Gg in 2007-08. Non-methane volatile organic compound (NMVOC) emissions from storages in refineries also remained low (22.7 Gg).

5.2. Industrial processes:

Emissions from industrial processes are distinct from energy sector emissions as they result not from fuel combustion but from the physical and chemical transformation of materials during the production process. The IPCC guidelines specify methodologies to calculate emissions from a variety of industrial processes including cement and lime production, soda ash production and use and production of certain mineral products and chemicals. In addition, emissions from processes employed in industries such as the pulp and paper industry and the food and drink industries are also included in the inventory. Not all of these industrial processes are actually being used in Pakistan. Data availability is another problem in this sector as production from some processes, which are considered part of the informal sector, are largely un-documented. Data on industrial production in Pakistan tend to be patchy and publications such as the Economic Survey only publish production data for selected items.

Emissions from cement production were estimated at 11,335.4 Gg of CO_2. SO_2 emissions from the process were estimated at 6.8 Gg. CO_2 emissions can result from heating limestone and dolomite at high temperatures. Emissions from limestone and dolomite use amounted to 3,959 Gg of CO_2 in 2007-08.

Emissions of NMVOCs are likely to result from the use of asphalt in road paving. Emissions from road paving were estimated to amount to 1,372.4 Gg of NMVOCs. Emissions of GHGs and ozone precursors from glass production remained low. However, NMVOC emissions from glass production were estimated and were negligible at 1.0 Gg. Ammonia productions, which in Pakistan take place in fertilizer plants, is another potential source of GHG emissions. CO_2 emissions from ammonia production amounted to 436.8 Gg. SO_2 emissions from sulfuric acid production amounted to 1.6 Gg in 2007-08.

The IPCC guidelines recommend that emissions from metal production be estimated using information on the reducing agent used. If this information is not available, emissions can be estimated using data on metal production quantities. This is an area where considerable improvement in assessment methodologies is required, and where estimates are somewhat uncertain. The primary metals produced in Pakistan are iron and steel. A total of 14,860 Gg of CO_2 were estimated to have been emitted from the iron and steel production process in 2007-08, with a little over half of these emissions coming from the hot metal production process.

Emissions from the pulp and paper industry arise mainly during the pulping process. SO_2 emissions from the acid sulfite pulping process amounted to 3.1 Gg in 2007-08. The production of certain foods and beverages such as bread, edible oils and alcoholic beverages can be a potential source of NMVOCs emissions. Emissions from the food and drink industries considered remained largely negligible, with the sugar industry accounting for 35.3 Gg.

Halocarbons are also potentially harmful as they have high global warming potentials and long atmospheric residence times. Applications of halocarbons include use in refrigeration and air-conditioning equipment, in aerosols and solvents and in foam blowing. Pakistan does not produce or export halocarbons. However, these chemicals are imported for use in refrigeration, in foam blowing and in fire protection equipment. Halocarbon emissions were estimated at 2.4 Gg in 2007-08.

5.3. Agriculture and livestock:

The agriculture and livestock sectors are potentially significant sources of methane (CH_4) and nitrous oxide (N_2O) emissions. Possible source sectors include enteric fermentation in domestic livestock, manure management practices, flooded rice fields, prescribed burning of savannas, field burning of agricultural residues and emissions from agricultural soils. This inventory calculates emissions from all these sources with the exception of emissions from burning of savannas. This module was excluded from the inventory because there is no prescribed burning of savannas in Pakistan.

Total CH_4 emissions from enteric fermentation and manure management amounted to 3,667.4 Gg in 2007-08. Fifty percent of these emissions came from the buffalo population alone, with cattle (both dairy and non-dairy) accounting for a further 28 percent. Emissions from poultry could not be estimated as no default emission factors were given. Methane emissions from paddy fields estimated at approximately 155.0 Gg. Emissions from field burning of agricultural residues remained low in 2007-08. Emissions were estimated at 12.9 Gg of CH_4, 361.1 Gg of CO, 0.34 Gg of N_2O and 12.3 Gg of NO_X.

Total direct emissions of N_2O from agricultural soils were obtained by adding direct soil emissions from agricultural fields (i.e., emissions from synthetic fertilizer, animal waste, nitrogen fixing crops and crop residue) and direct emissions from histosols. Thus total direct N_2O emissions were estimated at 51.8 Gg. Total indirect emissions, which included emissions from atmospheric deposition of NH_3 and NO_X as well as N_2O emissions from leaching amounted to 130.8 Gg of N_2O. Emissions from leaching constituted 97 percent of total indirect N_2O emissions.

5.4. Forestry and land-use change:

The IPCC methodology for estimating net emissions from the forestry sector rests on two basic themes. Firstly, the flux of CO_2 to or from the atmosphere is assumed to be equal to changes in carbon stocks in existing biomass and soils. Secondly, changes in carbon stocks can be estimated by first establishing rates of

change in land use and the practice used to bring about the change. The methodology covers three land use management practices that may result in net emissions, as well as changes in soil carbon. The practices considered include changes in forest and other woody biomass stocks, forest and grassland conversion and abandonment of managed lands. Of these, only emissions from changes in forest and other woody biomass stocks have been estimated in this inventory, as other emission source categories were judged not to be applicable to Pakistan. Total carbon uptake or increment was estimated at 87,284 Gg, while annual carbon release was estimated at 18,730 Gg. Net CO_2 up-take was 68,676 Gg.

5.5. Wastes:

Waste disposal and treatment is an important potential source of GHG emissions, particularly methane. Emissions from main categories which include land disposal of solid waste, methane emissions from wastewater handling in the domestic and industrial sectors and nitrous oxide emissions from human sewage were estimated in this inventory. The figure for Net Annual Methane Emissions was estimated at 472.5 Gg of CH_4. N_2O emissions from human sewage were 8.1 Gg in 2007-08.

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

Source / GHGs	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2	Halocarbons (P)
Energy	**142900.0**	**NA**	**824.4**	**0.9**	**612.3**	**952.3**	**182.5**	**1205.3**	**NA**
A. *Fuel Combustion activities*	**142900.0**	**NA**	**13.5**	**0.9**	**611.6**	**951.3**	**175.1**	**1194.3**	NA
1. Energy industries	41,274	NA	1.2	0.2	112.5	11.5	3.2		NA
2. Manufacturing industries and construction	44,900	NA	4.2	0.4	131.5	45.4	6.6		NA
3. Transport	34,028	NA	6.5	0.24	346.7	876.3	164.0		NA
4. Other sectors	16,398	NA	1.6	0.035	15.4	18.1	1.3		NA
B. *Fugitive emissions from fuels*	**NA**	**NA**	**810.9**	**NA**	**0.7**	**1.0**	**7.4**	**11.0**	**NA**
1. Solid fuels	NA	NA	73.4	NA	NA	NA	NA	NA	NA
2. Oil & natural gas	NA	NA	737.5	NA	NA	NA	NA	NA	NA
3. Ozone precursors & SO_2 from refining	NA	NA	NA	NA	0.7	1.0	7.4	11.0	NA
Industrial processes	**30,593.3**	**NA**	**NA**	**1.1**	**3.5**	**9.4**	**1417.3**	**21.0**	**2.4**
A. Mineral products	15,294.3	NA	NA	NA	NA	NA	1,373.0	6.8	NA
B. Chemical industry	436.8	NA	NA	1.1	3.0	4.8	9.1	4.7	NA
C. Metal production	14,862.2	NA	NA	NA	0.5	4.6	0.5	9.5	2.0
D. Other production	NA	NA	NA	NA	NA	NA	35.3	NA	NA
E. Production of halocarbons & sulfur hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Consumption of halocarbons & sulfur hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	0.4
Solvent & other product use	-	-	-	-	-	-	-	-	-
Agriculture & Livestock	**NA**	**NA**	**3,835.4**	**183.0**	**12.3**	**361.1**	**NA**	**NA**	**NA**
A. Enteric fermentation	NA	NA	3,667.4	NA	0.02	NA	NA	NA	NA
B. Manure management									
C. Rice cultivation	NA	NA	155.0	NA	NA	NA	NA	NA	NA
D. Agricultural soils	NA	NA	NA	182.6	NA	NA	NA	NA	NA
E. Prescribed burning of savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field burning of agricultural residues	NA	NA	12.9	0.34	12.3	361.1	NA	NA	NA
Forestry & land use change	**18,730**	**87,284**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
A. Change in forest & other woody biomass stocks	18,730	87,284	NA	NA	NA	NA	NA	NA	NA

B. Forest and grassland conversion	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Abandonment of managed lands	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Emissions from soils	NA	NA	NA	NA	NA	NA	NA	NA	NA
Waste	**NA**	**NA**	**472.5**	**8.1**	**NA**	**NA**	**NA**	**NA**	**NA**
A. Solid waste disposal on land	NA	NA	447.5	NA	NA	NA	NA	NA	NA
B. Wastewater handling	NA	NA	25.0	NA	NA		NA	NA	NA
C. Waste incineration	-	-	-	-	-	-	-	-	-
D. Other (human sewage)	NA	NA	NA	8.1	NA	NA	NA	NA	NA
Net National Emissions	**1,04,939.3**		**5,132.3**	**193.1**	**628.1**	**1,322.8**	**1,599.8**	**1226.3**	**2.4**

SECTOR-WISE % AGE CONTRIBUTION OF VARIOUS GHGs

Source / GHGs	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2	Halocarbons
Energy	74.3	16.0	0.4	97.5	72.0	11.4	98.3	NA
Industrial processes	16.0	NA	0.6	0.5	0.7	88.6	1.7	100.0
Solvent & other product use	-	-	-	-	-	-	-	-
Agriculture	NA	74.4	94.8	2.0	27.3	NA	NA	NA
Forestry & land use change	9.7	NA	NA	NA	NA	NA	NA	NA
Waste	NA	9.2	4.2	NA	NA	NA	NA	NA

P = Potential emissions based on Tier 1 approach

NA = Not Applicable

\- = Not Available

6. RECOMMENDATIONS:

In order to reduce GHGs emissions and deal with the changing climate following steps should be taken**:**

1. Promotion of renewable energy sources**.**

   Pakistan lies in favorable zone with respect to solar energy as daily sun hours here are 5-6 and has a potential of 2.9 Million MW electricity generation from solar and wind.

2. Afforestation / Plantation.
3. Clean Development Mechanism (CDM) should be implemented.
4. Periodic tuning of vehicles.
5. Increasing access to high quality information about the impacts of climate change.
6. Improving technological responses by setting in place early warning systems and information systems to enhance disaster preparedness.
7. Practicing energy efficiency through changes in individual lifestyles and businesses.
8. Reducing the vulnerability to livelihoods to climate change through infra-structural changes.
9. Promoting good governance and responsible policy by integrating risk management and adaptation.
10. Developing new and innovative farm production practices, including new crop varieties and irrigation techniques.
11. Improving forest management and biodiversity conservation.
12. Empowering communities and local stakeholders so that they participate actively in vulnerability assessment and implementation of adaptation.
13. Mainstreaming climate change into development planning at all scales, levels and sectors.

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CONCLUSION:

GHGs is not the problem of a single country as gases have no boundaries, so Government of Pakistan should take the benefit of CDM in projects as many as possible. However, the per capita CO_2 emission of Pakistan is lower than

neighbouring / many other countries and its contribution towards global GHGs emissions is also very low.

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