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## SECTOR WISE FOSSIL FUEL CONSUMPTION AND CARBON DIOXIDE EMISSION IN BANGLADESH

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## SECTOR WISE FOSSIL FUEL CONSUMPTION AND CARBON DIOXIDE EMISSION IN BANGLADESH

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### ABSTRACT

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This study was carried out to estimate the amount of CO<sub>2</sub> emission due to combustion of fossil fuel from five different sectors viz. domestic, industrial, commercial, transport and agriculture during 1988 to 2004. IPCC guidelines for national greenhouse gas inventories were followed for estimation of CO<sub>2</sub> emission. It was observed that consumption of fossil fuels and CO<sub>2</sub> emission showed increasing trend over the period of investigation. Total consumption of fossil fuel was calculated to be 2849 thousand tons in the year of 1988-1989 while the amount increased 5 times during the period of 2004-2005. In 1988-1989, CO<sub>2</sub> emitted from industrial, domestic, commercial, transportation and agricultural sectors were 768.2, 667.5, 148.1, 508.4 and 318.1 kilo tons respectively while the values were, for industrial, commercial, transportation and agricultural sectors were 4313.7, 2978.6, 350.7, 6330.5, 2930.6 kilo tons respectively in the year 2004-2005. The total emission of CO<sub>2</sub> from these five sectors was 2410.3 kilo ton in the year of 1988-1989 and it increased to 16906.3 kilo ton in the year of 2003-2004 due to increased fossil fuel consumption.

**Key words:** carbon dioxide, consumption, emission, fossil fuel

### INTRODUCTION

Emission of carbon dioxide (CO<sub>2</sub>) from fossil fuel has long been considered problematic in the industrialist nations of the West. It has now become one of the major causes of environmental degradation in the developing countries as well. At present, as consequences of rapid urbanization and industrialization, the world is experiencing dramatic levels of increases air pollution (Liu and Diamond, 2005). Bangladesh relies heavily on fossil fuel and coal as source of energy. Fossil fuels contain high percentages of carbon and include coal, petroleum, and natural gas. Combustion of fossil fuels alone produces around 21.3 billion tons (21.3 gigatons) of CO<sub>2</sub> per year and it has been estimated that natural processes can utilize about half of this amount. Therefore, there is a net increase of 10.65 billion tons of atmospheric carbon dioxide per year. This indicates that increase in amount of carbon dioxide in the atmosphere due to burning of fossil fuels can be regarded as major cause of rise in the earth's average. Rapid rise of temperature of the earth's surface and atmosphere are partly due to continual increase in emission of greenhouse gases such as carbon dioxide, methane, nitrous oxide etc. (Kabir and Halim, 2011). It was estimated in 2003 that Bangladesh was responsible for emission of about one tenth of the world's CO<sub>2</sub>. The country has a population of 160 million with contribution of 0.14 percent to the world's emission of carbon dioxide (Gunter 2010). This low CO<sub>2</sub> emission could be attributed to the country's low energy consumption (Azad *et al.* 2006). The future magnitude of CO<sub>2</sub> emissions from human activities such as fossil fuel burning has been predicted as one of the largest uncertainties in projections of atmospheric CO<sub>2</sub> concentrations. While there has been a great deal of emphasis in carbon cycle science on natural sources and sinks of carbon, the fossil fuel component of the carbon budget remains uncertain, particularly at increasingly smaller spatial and temporal scales (Wofsy and Harris, 2002). The study was carried out to determine the amount for emissions of carbon dioxide in different year from different sources and put insights into the trends of carbon dioxide emissions in Bangladesh.

### MATERIALS AND METHODS

As the present study was carried out to determine the total amount of CO<sub>2</sub> emission from different sectors of energy consumption in Bangladesh due to combustion of fossil fuel, The study area belonged to Bangladesh extending from 20°34'N to 26°38'N latitude and from 88°01'E to 92°41'E longitude.

The data on the amount of fossil fuel consumption in different sectors of Bangladesh were collected from Bangladesh Bureau of Statistics, Statistical year book of Bangladesh and these data were processed according to the guidelines of International Panel for Climate Change (IPCC 1995) and carbon dioxide emission was calculated from fossil fuel conversion and a tool was developed.

The emission of CO<sub>2</sub> from fossil fuel combustion was calculated based on the quantity of fuel combustion and its properties. The tool provided procedures to calculate CO<sub>2</sub> emissions from combustion of fossil fuels. Methodologies used in the tool specified the combustion process, which was designated as *j*.

The procedures used and the parameters determined are listed as follows:

Parameter	SI Unit	Description
PE <sub>FC, j,y</sub>	(t CO <sub>2</sub> /yr )	Emissions from fossil fuel combustion in process <i>j</i> during the year <i>y</i>

CO<sub>2</sub> emissions from fossil fuel combustion in process *j* are calculated based on the quantity of fuels combusted and the CO<sub>2</sub> emission coefficient of those fuels, as follows:

$$PE_{FC,j,y} = \sum FC_{i,j,y} \times COEF_{i,y}$$

Where,

- $PE_{FC,j,y}$  : the CO<sub>2</sub> emissions from fossil fuel combustion in process *j* during the year *y* (t CO<sub>2</sub>/yr)  
 $FC_{i,j,y}$  : the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr)  
 $COEF_{i,y}$  : the CO<sub>2</sub> emission coefficient of fuel type *i* in year *y* (t CO<sub>2</sub>/mass or volume unit)  
*i* : the fuel types combusted in process *j* during the year *y*

The CO<sub>2</sub> emission coefficient  $COEF_{i,y}$  can be calculated using following equation, depending on the availability of data on the fossil fuel type *i*, as follows :

$$COEF_{i,y} = NCV_{i,y} \times EFCO_{2,i,y}$$

Where,

- $COEF_{i,y}$  : the CO<sub>2</sub> emission coefficient of fuel type *i* in year *y* (t CO<sub>2</sub>/mass or volume unit)  
 $NCV_{i,y}$  : the weighted average net calorific value of the fuel type *i* in year *y* (GJ/mass or volume unit)  
 $EFCO_{2,i,y}$  : the weighted average CO<sub>2</sub> emission factor of fuel type *I* in year *y* (t CO<sub>2</sub>/GJ)  
*i* : the fuel types combusted in process *j* during the year

## RESULTS AND DISCUSSION

In the present study, the emission of CO<sub>2</sub> was calculated from five sectors, *viz.* domestic, industrial, commercial, transport and agriculture. The study accounted for data from 1988-1989 to 2004-2005. Finally, the total emission CO<sub>2</sub> in each year was estimated.

### CO<sub>2</sub> emission from domestic source

The release of CO<sub>2</sub> from domestic sources due to fossil fuel consumption was shown in Table 1. During the year of 1988-1989, the amount of CO<sub>2</sub> emitted from domestic sources was about 667.5 kilo ton. The change in CO<sub>2</sub> emission remained till 1996-1997. However, the value approximately doubled in the period of 1997-1998 and increased 5 times in the beginning of 21<sup>st</sup> century and six times in the year of 2004-2005 respectively. Uses of coal for both cooking and lighting purposes in rural and urban households are common in developing countries and similar observation was found in Bangladesh as population increased over this period of time. This finding was in good agreement of Berkhout *et al.* (2006) who showed 26% of fossil fuel was used for domestic purposes in Bangladesh and some other developing countries.

Table 1. CO<sub>2</sub> emission from domestic source

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	789	667494	667.5
1989-1990	42.3	20	831	703026	703
1990-1991	28.2	25.8	777	565314	565.3
1991-1992	28.2	25.8	749	544942	545
1992-1993	28.2	25.8	903	656986	657
1993-1994	28.2	25.8	1011	735563	735.6
1994-1995	28.2	25.8	1148	835238	835.2
1995-1996	28.2	25.8	1021	742838	742.8
1996-1997	28.2	25.8	1060	771213	771.2
1997-1998	28.2	25.8	1751	1273957	1274
1998-1999	28.2	25.8	2856	2077911	2078
1999-2000	28.2	25.8	3563	2592296	2592.2
2000-2001	28.2	25.8	4203	3057934	3057.9
2001-2002	28.2	25.8	4655	3386791	3386.8
2002-2003	28.2	25.8	5469	3979025	3979
2003-2004	28.2	25.8	5826	4238764	4238.8
2004-2005	28.2	25.8	5929	4313703	4313.7

\*From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

### CO<sub>2</sub> emission from industries

It was shown from Table 2 that the emission of CO<sub>2</sub> was 768.2 kilo ton during the period of 1988-1989. The increment of CO<sub>2</sub> emission remained static till 1996-1997. After this period, the trend of CO<sub>2</sub> showed increasing

pattern and started to rise at the end of 20<sup>th</sup> century. It was found that from 1997-1998 to 2004-2005, the increase of CO<sub>2</sub> emission was noteworthy. The emission almost doubled during the period of 1998-1999 and increased four times during the period of 2000-2001 and five times during the period of 2004-2005 respectively. According to the reports by Fernandez (2008), the construction industry could be accounted responsible for a large proportion of this emission of CO<sub>2</sub>, one of the major greenhouse gases and was amounted upto 40% of the greenhouse gas emission.

Table 2. CO<sub>2</sub> emission from industries

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	908	768168	768.2
1989-1990	42.3	20	1275	1078650	1078.7
1990-1991	28.2	25.8	920	669355	669.4
1991-1992	28.2	25.8	1029	748659	748.7
1992-1993	28.2	25.8	836	608240	608.2
1993-1994	28.2	25.8	928	675175	675.2
1994-1995	28.2	25.8	1034	752297	752.3
1995-1996	28.2	25.8	997	725377	725.4
1996-1997	28.2	25.8	886	644618	644.6
1997-1998	28.2	25.8	1370	996757	996.8
1998-1999	28.2	25.8	1871	1361264	1361.3
1999-2000	28.2	25.8	2527	1838544	1838.5
2000-2001	28.2	25.8	3338	2428595	2428.6
2001-2002	28.2	25.8	3459	2516630	2516.6
2002-2003	28.2	25.8	3523	2563193	2563.2
2003-2004	28.2	25.8	3286	2390762	2390.8
2004-2005	28.2	25.8	4094	2978630	2978.6

\* From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

### CO<sub>2</sub> emission by commercial activities

The emission of CO<sub>2</sub> by commercial activities was about 148.1 kilo ton during the year of 1988-1989. Estimation showed that CO<sub>2</sub> emission remained same for five and ten year period after the initial study. However, the emission was double over fifteen year period. This gradual change of CO<sub>2</sub> emission from commercial sources was shown in Table 3. Brick fields are considered to be the largest contributor of greenhouse gas emissions in Bangladesh, the amount was calculated in the order of 3.0 million ton of CO<sub>2</sub> emission in an annual basis (Khusru and Noor, 2011).

Table 3. CO<sub>2</sub> emission from commercial sources

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	175	148050	148.1
1989-1990	42.3	20	151	127746	127.7
1990-1991	28.2	25.8	119	86579	86.6
1991-1992	28.2	25.8	111	80759	80.8
1992-1993	28.2	25.8	134	97493	97.5
1993-1994	28.2	25.8	126	91672	91.7
1994-1995	28.2	25.8	152	110589	110.6
1995-1996	28.2	25.8	159	115682	115.7
1996-1997	28.2	25.8	146	106223	106.2
1997-1998	28.2	25.8	182	132415	132.4
1998-1999	28.2	25.8	193	140419	140.4
1999-2000	28.2	25.8	203	147694	147.7
2000-2001	28.2	25.8	249	181162	181.2
2001-2002	28.2	25.8	262	190620	190.6
2002-2003	28.2	25.8	289	210264	210.3
2003-2004	28.2	25.8	317	230636	230.6
2004-2005	28.2	25.8	482	350683	350.7

\* From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

### CO<sub>2</sub> emission from transportation sector

The emission of CO<sub>2</sub> from domestic sources as a consequence of fossil fuel consumption was presented in Table 4. The amount was 508.4 kilo ton of CO<sub>2</sub> during the period of 1988-1989. The increment was negligible till the period of 1991-1992. Drastic increase in the amount of CO<sub>2</sub> emission was observed in the later stages of 20<sup>th</sup> century. It gradually increased following the period of 1997-1998 and during the period of 2000-2001, the

emission of CO<sub>2</sub> was nine times higher than the period of 1988-1989 and 12 times higher during the period of 2004-2005. CO<sub>2</sub> emissions from transport vehicles included the emissions from the combustion of fossil fuels from road, rail, air, and other forms of transportation, and agricultural vehicles (UNFCCC 2002). The transport sector is one of the main sources of CO<sub>2</sub> emission from combustion fuels in most Asian countries. Islam (2005) reported that road transport, automobiles and light trucks produce over 60% of CO<sub>2</sub> emission, but in developing countries, freight trucks and in some cases even buses consume more fuel and emit more CO<sub>2</sub> than the light duty vehicles.

Table 4. CO<sub>2</sub> emission from transport sector

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	601	508446	508.4
1989-1990	42.3	20	637	538902	538.9
1990-1991	28.2	25.8	777	350683	350.7
1991-1992	28.2	25.8	790	574772	574.8
1992-1993	28.2	25.8	970	705733	705.7
1993-1994	28.2	25.8	985	716646	716.6
1994-1995	28.2	25.8	1162	845424	845.4
1995-1996	28.2	25.8	1039	755934	755.9
1996-1997	28.2	25.8	1062	772668	772.7
1997-1998	28.2	25.8	1898	1380908	1380.9
1998-1999	28.2	25.8	3271	2379848	2379.8
1999-2000	28.2	25.8	4791	3485739	3485.7
2000-2001	28.2	25.8	6579	4786617	4786.6
2001-2002	28.2	25.8	7205	5242069	5242.1
2002-2003	28.2	25.8	7738	5629859	5629.8
2003-2004	28.2	25.8	7929	5763002	5763
2004-2005	28.2	25.8	8701	6330499	6330.5

\* From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

#### **CO<sub>2</sub> emission from agricultural sector**

It was found that about 318.1 kilo ton of CO<sub>2</sub> emission occurred from agricultural sector during the period of 1988-1989 (Table 5). The emission was not considerable till the period of 1996-1997. This sector observed a major change in the emission pattern just after 10 years. The increment in emission was considerable in the early phases of 21<sup>st</sup> century. During the period of 2000-2001, the amount of CO<sub>2</sub> emission was 1707.6 kilo ton that was five times the emission for the period of 1988-1999. This increased up to nine times during the period of 2003-2004. As the economy of some country is agriculture based, various agricultural machineries are being used increasingly to boost up agricultural production for attaining food security. These agricultural machineries use fossil fuel facilitating increased CO<sub>2</sub> emission in the atmosphere. In addition, in the agricultural land mostly in rice fields CO<sub>2</sub> is also produced from oxidation of CH<sub>4</sub> to CO<sub>2</sub> under aerobic condition (Kabir and Halim, 2011).

Table 5. CO<sub>2</sub> emission by agriculture sector

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	376	318096	318.1
1989-1990	42.3	20	306	258876	258.9
1990-1991	28.2	25.8	277	201534	201.5
1991-1992	28.2	25.8	311	226271	226.3
1992-1993	28.2	25.8	275	200079	200.1
1993-1994	28.2	25.8	326	237184	237.2
1994-1995	28.2	25.8	495	360142	360.1
1995-1996	28.2	25.8	399	290296	290.3
1996-1997	28.2	25.8	407	296116	296.1
1997-1998	28.2	25.8	1311	953831	953.8
1998-1999	28.2	25.8	992	721739	721.7
1999-2000	28.2	25.8	1547	1125535	1125.5
2000-2001	28.2	25.8	2347	1707583	1707.6
2001-2002	28.2	25.8	2428	1766515	1766.5
2002-2003	28.2	25.8	3437	2500623	2500.6
2003-2004	28.2	25.8	4160	3026649	3026.6
2004-2005	28.2	25.8	4028	2930611	2930.6

\* From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

**Total CO<sub>2</sub> emission**

In Bangladesh, total CO<sub>2</sub> emission from fossil fuel was 2410.3 kilo ton during the year of 1988-1989. Fossil fuel consumption did not show a distinct pattern during the period of 1988-1989 to 1996-1997. After this period, CO<sub>2</sub> emission increased gradually as well as the fossil fuel consumption and in the period of 2002-2003 it reached up to 14882.9 kilo ton. In the period of 2004-2005, a sharp increase of fossil fuel consumption was observed and it amounted 23237 thousand ton of coal equivalent and it produced 16906.3 kilo ton of CO<sub>2</sub>. From Table 6 it was found that CO<sub>2</sub> emission increased gradually over time as well as the fossil fuel consumption. Azad *et al.* (2006) showed that the consumption of fossil fuels in Bangladesh experienced more than 5 percent growth per year during the period of 1977-1995 and it was estimated that the total CO<sub>2</sub> release from all primary fossil fuels used in Bangladesh was 5.07 million ton (Mt) in 1977 and 14.4 Mt in 1995, respectively.

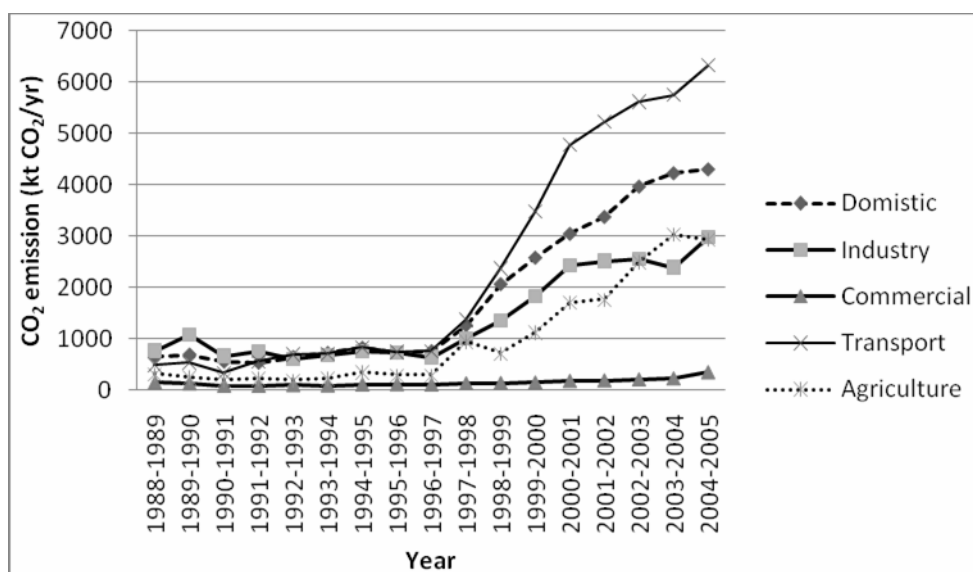
Table 6. Total CO<sub>2</sub> emission

Year	Net calorific value (TJ/Gg)	Carbon Emission Factor (t C/TJ)	Amount of fossil fuel* (BBS 2007)	Quantity of CO <sub>2</sub> emitted (t CO <sub>2</sub> /yr)	Quantity of CO <sub>2</sub> emitted (kt CO <sub>2</sub> /yr)
1988-1989	42.3	20	2849	2410254	2410.3
1989-1990	42.3	20	3200	2707200	2707.2
1990-1991	28.2	25.8	2870	2088097	2088.1
1991-1992	28.2	25.8	2990	2175404	2175.4
1992-1993	28.2	25.8	3118	2268532	2268.5
1993-1994	28.2	25.8	3376	2456242	2456.2
1994-1995	28.2	25.8	3992	2904419	2904.4
1995-1996	28.2	25.8	3615	2630129	2630.1
1996-1997	28.2	25.8	3661	2663597	2663.6
1997-1998	28.2	25.8	6512	4737870	4737.9
1998-1999	28.2	25.8	9183	6681183	6681.2
1999-2000	28.2	25.8	12631	9189810	9189.8
2000-2001	28.2	25.8	16716	12161892	12161.9
2001-2002	28.2	25.8	18009	13102628	13102.6
2002-2003	28.2	25.8	20456	14882967	14882.9
2003-2004	28.2	25.8	21510	25649815	15649.8
2004-2005	28.2	25.8	23237	16906311	16906.3

\* From the period of 1988-89 to 1989-90, figures are given in thousand tons of oil equivalents, except these all are coal equivalent

**Sector wise comparison of CO<sub>2</sub> emission**

Sector wise emission of CO<sub>2</sub> is shown in Fig. 1. During the period of 1988-1989 the emission of was found to be the highest from industrial sources and the lowest from commercial sources. The increments were almost parallel up to the period of 1996-1997. In case of commercial sources, the increase was found parallel up to the period of 2004-2005. However, differential pattern of CO<sub>2</sub> emission was found in the sources. The increment was the highest from transport sectors and the lowest share came from commercial sectors. However, the emissions of CO<sub>2</sub> showed decreasing trend over these periods.

Fig. 1. Sector wise comparison of CO<sub>2</sub> emission from fossil fuel consumption

## CONCLUSION

The present study summarizes CO<sub>2</sub> emission from different sectors as a result of combustion of fossil fuel. The global atmospheric concentration of CO<sub>2</sub> has been increasing, largely due to human activities, and likely to increase substantially in the future and contribute into increased earth's surface temperature. To reduce the total emission of CO<sub>2</sub> in Bangladesh the scientists and policy makers should adopt appropriate technology and ensure them for a clean environment.

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