



The Male' Declaration Air Pollutant Emission Inventory Report

**National Environment Commission
Royal Government of Bhutan
July 2009**

Acknowledgement

The group would like to acknowledge work carried out under Second National Communication project management for allowing us to use same data.

Inventory team members

1. Mr. Tshewang Dorji, Project coordinator, Male Project, NEC
2. Mr. Rinzin Namgay, member, NEC
3. Mr. Karma Pemba, member, RSTA
4. Mrs. Pema Dekar, member, DRC
5. Mr. Phuntsho Wangdi, member, RSTA
6. Mr. Karma Jigme, member, DoF, MoA
7. Mr. Chukey Wangchuk, member, BTFEC
8. Mr. Krishna Bdr. Rai, member, BPCL
9. Mrs. Yeshey Dema, member, NSSC
10. Mr. Dago Tshering, member, RSPN
11. Mr. Gyembo Dorji, member, DoPH, MoH
12. Jigme Zangmo, member, NEC

Table of Contents

National Environment Commission	1
Royal Government of Bhutan	1
July 2009	1
1.0 Introduction	6
1.1 National Circumstances.....	6
1.2 Policy response.....	6
1.3 National standards	6
1.4 Emission load.....	8
2.0 Objective and the Scope of the Inventory	8
3.0 Methodology	9
3.1 Sector 1- 4 & 5: Fuel Combustion activities & Fugitive Emissions (non-combustion) for fuels	9
3.2 Sector 6: Industrial Process Emission	9
3.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry.....	10
4.0 Special Characteristics	12
4.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for Fuels	12
4.2 Sector 6: Industrial Process Emission	13
4.2.1 Cement Production	13
4.2.2 Lime Production	13
4.2.3 Asphalt Road Paving.....	13
4.2.4 Chemical and Metal Production Industry	13
4.2.5 Paper and Pulp:	14
4.2.6 Food and Drink Production:	14
4.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry.....	14
5.0 Result	16
5.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels	16
5.2 Sector 6: Industrial Process Emission	16
5.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry.....	16
6.0 Level of confidence	17
6.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels	17

6.2 Sector 6: Industrial Process Emission 17

6.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry..... 17

7.0. Recommendation 18

7.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for
fuels 18

7.2 Sector 6: Industrial Process Emission 18

7.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry..... 18

8.0 References/data sources 20

8.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels
..... 20

8.2 Sector 6: Industrial Process Emission 20

8.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry..... 20

ABBREVIATION

DoF	Department of Forest
DRC	Department of Revenue and Customs
DSC	Druk Seed Corporation
DOI	Department of Industry
DoPH	Department of public health
GHG	Green House Gases
IPCC	Inter-government Panel on Climate Change
LPG	Liquefied Petroleum Gas
LUCF	Land Use Change and Forestry
MoA	Ministry of Agriculture
MoEA	Ministry of Economic Affairs
MoH	Ministry of Health
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NCV	Net Calorific Value
RNR	Renewal Natural Resource
RSTA	Road Safety and Transport Authority
SNC	Second National Communication
UNFCCC	United National Framework for Climate Change

CHEMICAL SYMBOLS

NK	Nitrogen and Potassium
NPK	Nitrogen, Phosphorus, Potassium (commonly known as Suphala in Bhutan)
SO ₂	Sulphur dioxide
NO _x	Oxide of Nitrogen
CO	Carbon Monoxide
NMVOC	Non-Methane Volatile Organic Compound
NH ₃	Ammonia
PM ₁₀	Particulate Matter (less than 10 micro meter in diameter)
PM _{2.5}	Particulate Matter (Less than 2.5 micro meter in diameter)

MEASUREMENT UNITS

Kt	Kilotons
----	----------

1.0 Introduction

1.1 National Circumstances

Air pollution is an emerging issue in Bhutan. Although present levels of air pollution are not of much a concern, growing urbanization and industrialization might lead to problems in the future unless specific policies and action plans are put in place. Sources of air pollution can be attributed to forest fires, fuel wood burning in the households, industrial operations and vehicular emission. In the urban area, air pollution is due to wood burning in heating appliances and vehicular emission. Existing impacts of air pollution are not known because of lack of data. However, government has recognized air pollution as one of the priority environmental issues and is taking various measures to abate air pollution.

1.2 Policy response

In Bhutan, over recent years, the combination of growing industrialization and urbanization together with rapid growth in the number of vehicles has led to increasing air pollution in the urban areas. This has resulted in many measures being taken to curb pollution from transport, industrial and domestic sources through specific acts, rules, regulations and standards. This includes National Environment Protection Act 2007, Environment Assessment Act 2000 and its regulation, Road Safety and Transport Act 1999 and its regulation. Besides, the Government has taken initiatives to import improved fuel quality, better infrastructure, environmentally sound industrial development and the promotion of electrical appliances to replace bukharis (domestic wood stoves).

1.3 National standards

Since 2002, Bhutan established vehicular emission standard and subsequently revised it in 2007, to respond to the increasing level of vehicular air pollution due to number of vehicle population in the country. The table below shows the vehicle emission standards.

Table 1 Vehicle Emission Standard 2002-2007

Fuel Type	Emission Standard (%)
Petrol (%CO)	5
Diesel (HSU)	80

Table 2.1 Vehicle Emission Standard, 2008

Fuel Type	Vehicles registered prior to 1 Jan 2005	Vehicles registered after 1 Jan 2005
Petrol (% CO)	4.5	4
Diesel (HSU)	75	70

All New vehicles imported into the country must meet euro-II and above type approval

The vehicle emission standards 2008 upholds ban on the importation of two-stroke engines, and enhanced type approval as Euro II and above.

Bhutan also established industrial discharge standards since 2004. The emission standard was further revised in 2007, based on realistic scenario of the air pollution in Bhutan. The table shows the Emission standards adopted in 2007.

National Standards for

Ambient Air Quality, Industrial Emission, Workplace Emissions and Noise levels for Bhutan, 2007

Ambient Air Quality Standards (Maximum permissible Limits in $\mu\text{g}/\text{m}^3$)

Parameter	Industrial Area	Mixed Area*	Sensitive Area**
<i>Total Suspended Particulate Matter</i>			
24 Hour Average	500	200	100
Yearly Average	360	140	70
<i>Respirable Particulate Matter (PM 10)</i>			
24 Hour Average	200	100	75
Yearly Average	120	60	50
<i>Sulfur Dioxide</i>			
24 Hour Average	120	80	30
Yearly Average	80	60	15
<i>Nitrogen Oxides</i>			
24 Hour Average	120	80	30
Yearly Average	80	60	15
<i>Carbon Monoxide</i>			
8 Hour Average	5000	2000	1000
1 hour Average	10,000	4000	2000

* **Mixed Area** means area where residential, commercial or both activities take place,

** **Sensitive Area** means area where sensitive targets are in place like hospitals, schools, sensitive ecosystems.

Industrial Emissions: Maximum Limits for Pollutants (mg/Nm^3)

Industrial Type by Technology	Maximum Limits for Pollutants (mg/Nm^3)			
	SPM	SO ₂	NO _x	CO
Lime Kilns	150	100	100	50
Arc Furnace, Induction Furnace	150	100	100	50
Tapping Fume Stack	150	-	-	-
Coal fired, Oil fired and Wood fired Boiler	150	100	100	50
Horizontal/Rotary Kiln, Vertical Shaft Kiln and other Kilns	150	100	100	50
Other Technologies: for sectors that are not covered in the above sections	150	100	100	50

Workplace Emissions for 8 hour average

Parameter	Standard
Total Suspended Particulate	10 mg/m^3
Respirable Particulate Matter	5 mg/m^3
Sulfur Dioxide	1 mg/m^3
Nitrogen Oxides	1 mg/m^3
Carbon Monoxide	5 mg/m^3

Noise Level Limits

Industrial Area		Mixed Area		Sensitive Area	
Day*	Night*	Day	Night	Day	Night
75 dB(A)	65 dB(A)	65 dB(A)	55 dB(A)	55 dB(A)	45 dB(A)

Note: All the values are maximum values

* Day time is from 0600 hours to 2200 hours (human activities)

** Night time is from 2200 hours to 0600 hours (no human activities)

Maximum value allowed in workplace in any point of time is 75 dB(A).

1.4 Emission load

Under phase III of the Male Declaration on Control and Prevention of Air Pollution & Its likely Tran-boundary Effects for South Asia, Bhutan has continued monitoring air pollution level for particulate matter, SO_x, NO_x and ozone through network of passive sampling and manual Respirable Dust Sampler (RDS) stations. Under the arrangement of Male Declaration, passive samples are continuously being sent to Stockholm Environment Institute in Sweden for analysis, while the particulate matter concentrations are analyzed in Bhutan. The result shows that gaseous pollutants are still observed below detectable level, while PM concentration remains within national standards.

The Government has complimented air quality monitoring programme under Male declaration by establishing and enforcing point source emission of industries. Under this, industries are required to comply with the prescribed emission standards, thereby helping to preserve Bhutan's pristine air quality.

2.0 Objective and the Scope of the Inventory

The national inventory for the air pollutants under Male Declaration on Control and Prevention of Air Pollution & Its Likely Tran-boundary Effects for South Asia focuses on air pollutants that have direct impact on local and regional scale. Unlike most Green House Gases (GHG), air pollutant such as PM₁₀ and PM_{2.5}, SO_x and NO_x has direct implications on public health. Therefore, it is important to understand the concentration of such pollutants at the base year, and monitor its changes thereafter. Some of the specific objectives of the inventories are as follows:

- Understand the total emission of air pollutants in 2000;
- Understand the major sectors contributing the emission;
- Provide baseline emission information for future inventories;
- Monitor any changes in emission concentration and its sources;
- Provide guidance in policy formulation

The scope of the inventory covers emission from energy related activities, industrial processes, agriculture, vegetation fires and forestry and treatment and disposal of wastes. It does not include emission from solvent and other products use, and emission from large point source (LPS), as these activities are either not relevant to Bhutan or the data are not available.

3.0 Methodology

3.1 Sector 1- 4 & 5: Fuel Combustion activities & Fugitive Emissions (non-combustion) for fuels

The Primary data for fuel combustion activities of sector concerning 1-4 was collected from 15 manufacturing industries (Annex I), by circulating survey questionnaires and personal communication. The data collected for Second National Communication (SNC) under UNFCCC is also used in this inventory. The data are verified by personal communication with concerned industries as there is no authenticated published source. However, the data for diesel, petrol, kerosene, LPG and coal has been sourced from the Bhutan Trade Statistics 2000, Department of Revenue and Customs, Ministry of Finance.

The emission estimations are carried out as per the methodology prescribed in Draft Version 2.3 of the Male' Declaration Air Pollutant Emissions Inventory Manual. Default Net calorific value (NCV), given in the draft manual is used for the emission estimation. As suggested, the reference is also made to the IPCC Guidelines 1996 and the NCV value for India is used, except for Lignite.

The sector 5 on fugitive emission from fuels (non combustion) is not included in this inventory, as Bhutan has no such facilities and hence irrelevant.

3.2 Sector 6: Industrial Process Emission

The data for the inventory was collected from industries established before 2000, and screened based on the industrial establishment lists maintained with Department of Industry, Ministry of Economic Affairs. Following category of Industry are scoped for data collection.

- a. Cement Production;
- b. Lime production;
- c. Asphalt Road paving;
- d. Metal production;
- e. Pulp and paper; and
- f. Food and drink production

A survey questionnaire was developed for cement industries, lime production industries, paper and pulp, and food and drink industries (Annexure II). A template was prepared based on data requirements in the worksheets and sent to the industries for information submission from the period 1995 - 2005. However only the information supplied for year 2000 is used for the inventory purposes. For Asphalt road paving, the published data on the import of the asphalts was used from the Bhutan Trade Statistics, 2000.

The emissions of pollutants from this sector is estimated by multiplying activity rate and default emission factor, provided in the Male Emission Inventory Manual draft version 2.3

3.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

Primary information on quantity of fertilizer and manure consumption in 2000 is obtained from published source of Renewal Natural Resource (RNR) Journals and verified through personal communication with relevant person in the sector. For data collection, the team visited Druk Seed Corporation (DSC) in Paro and Phuentsholing, which is the only fertilizer importing agent.

The data on Cattle population was collected from the RNR Statistics 2000. Similarly, data on vegetation fires and forestry were collected from Land Cover Atlas 1997 and Land Cover Assessment 2005. As the data were gathered from the published sources, verification was not felt necessary.

For estimating the Nitrous Oxide (NO) emission from the fertilizer use, the default fraction of 0.7% (value given in Male Inventory Manual Draft Version 2.3) of the total weight of the mineral -N applied is used to convert to NO. For the conversion of N into NH₃-N, the default emission factor for Region- A from Table 6-2 of Male Inventory Manual Draft Version 2.3 is used, since Bhutan falls under the climatic type of Region A (i.e. Mean spring temperature > 13°C).

For emission estimation from vegetation fires, the data for annual area burnt is taken as the average for two years (1999 & 2001) as the data for 2000 appears in both 1999 –2000 and 2000–2001 years (Forest Fire Record, Fire Incidence and Area Burnt 1992-2008, Department of Forest, MoA).

The default biomass consumption and emission factors for sub-tropical forest and temperate forest are being used from table 7-1 of Male Inventory Manual Draft Version 2.3

For the emission estimation of the amount of SO_x, NO_x, CO, NH₃, PM₁₀, PM_{2.5}, and NMVOC methodology prescribed in Male Inventory Manual Draft Version 2.3 is adopted.

1.5 Sector 10: Waste

Literature reviews on several publications were carried out viz. Enhancing Municipal Solid Waste Management with 3Rs Option by Penjor, Y., 2007 and Conference Proceedings of the National Conference on Solid Waste Management (DUDES, 2008) Ministry of Work & Human Settlement. Informal group meetings and focal person consultation was also carried out.

The total emission from combustion of the MSW was estimated by total amount of MSW generated by the urban population and its per capacity production in year 2005. Taking into account the per capita of solid waste generation at 0.533 kg/day (DUDES 2008), the waste generation of the total population is estimated for the base year 2000. Although the ten towns' population projection rate varies between 1.3 to 11.11 %, the projected rate of total population has been considered to be 1.3%. The table shows the population growth for the urban centers. For the Municipal Solid Waste, ten urban areas (DUDES 2008) were taken to consideration as they have wastes disposal facilities.

Population of 2005 and projection projects 2000-2007

Urban area	2000* *	2001* *	2002* *	2003* *	2004* *	2005*	2006* *	2007* *	Projection rate%
Thimphu	43970	49460	55635	62582	70395	79185	87975	97740	11.1
Phuentsholing	11404	12828	14429	16231	18257	20537	22817	25349	11.1
Samtse	2766	3111	3500	3937	4428	4981	5534	6148	11.1
Paro	1828	1924	2025	2132	2244	2362	2624	2915	11.1
Gelephu	7118	7493	7887	8302	8739	9199	9659	10142	5
Damphu	1289	1357	1428	1504	1583	1666	1749	1837	5
Samdrupjongkhar	5547	5626	5705	5787	5869	5952	6035	6120	1.4
Bumthang	2512	2644	2783	2930	3084	3246	3408	3579	5
Trashigang	2221	2252	2284	2317	2350	2383	2648	2685	1.4
Mongar	3264	3310	3357	3405	3453	3502	3891	3945	1.4
Total urban pop.	81917	90004	99034	109124	120402	133013	146339	160460	
National Population	594767	602601	610538	618580	626727	634,982	643237	643287	1.3

*Population and Housing Census Bhutan, 2005

**Urban population increase rate between 1.4% to 11.1% (MoWHS, 2008) Solid waste survey results

Total of 10 urban areas = 70% of total urban population

Waste generation (kg/day) applying 0.533 kg/day/person (DUDES, 2008) towards projected population

Urban area	2000	2001	2002	2003	2004	2005	2006	2007
Thimphu	23436	26362	29653	33356	37521	42206	46890	52095
Phuentsholing	6078	6837	7691	8651	9731	10946	12161	13511
Samtse	1474	1658	1865	2098	2360	2655	2950	3277
Paro	974	1025	1079	1136	1196	1259	1399	1554
Gelephu	3794	3994	4204	4425	4658	4903	5148	5406
Damphu	687	723	761	801	844	888	932	979
Samdrupjongkhar	2956	2998	3041	3084	3128	3172	3217	3262
Bumthang	1339	1409	1483	1561	1644	1730	1817	1907
Trashigang	1184	1200	1218	1235	1252	1270	1411	1431
Mongar	1740	1764	1789	1815	1840	1867	2074	2103
Total urban waste	43662	47972	52785	58163	64174	70896	77999	85525
Waste generation (kg/day) applying 0.533 kg/day/person (DUDES, 2008)								

Following the Male' Declaration Air Pollutant Emissions Inventory Manual Draft Version 2.3, the total emission from the wastes combustions is calculated based on the types of incinerators being used. However for Bhutan, most of this MSW are being transported to the landfills and buried or burnt in open environment. Following the default set in the workbook manual of considering 5 % of the total

MSW as burnt for developing countries, we have considered and accounted emissions from 2183 tonnes (5 % of 43662) of MSW under open burning incineration.

Although majority of the population is known for usage of pit latrines, this inventory could not compute the NH₃ emissions mainly due to inconsistent data withing the health sector.

4.0 Special Characteristics

4.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for Fuels

As Bhutan doesn't have the facilities for energy production industries that are using fuels specified in the worksheet 1.1.1 a, emission from such sources are not included in the inventory.. The term "Petrol" and "Motor Gasoline" was interpreted synonymously for the report. Therefore, the emission factor given for Motor Gasoline in the draft manual is used for the petrol consumption in Bhutan.

Further, total amount of petrol consumption in the country is assumed in Transport Sector only. While the diesel consumption is recorded in manufacturing and transport sectors

The quantity of Diesel consumed in manufacturing sector is arrived by subtracting total diesel import and the balance assumed to be consumed in the Transport Sector. While it was noted that certain quantity of diesels is being consumed in the mining sector for using the earth mover, excavators and other equipments, estimate amount could not be established. Therefore, the diesel usage in the mining sector is also reflected under the transport sector.

The LPG is predominantly consumed in residential sector only.

Kerosene is noted to be consumed in both residential and industrial sectors. The total quantity of residential sector consumption is arrived by calculating the difference between total import figure and consumption figure in the industrial sector.

The industrial and residential sector consumes notable quantity of wood. However, there is no data on quantity of wood consumption in residential sector. Therefore, the total wood is assumed to be consumed in industrial sector only. While computing the emission from the wood consumption, following assumptions were made:

1. All wood consumption was assumed to be used for industries since data for residential wood consumption was not available.
2. Wood density is taken to be *0.44 tons dry matter/cubic meter of fresh volume*.
3. 1 truck load of fuel wood was assumed to be 5.8 tonnes (Energy Data Directory 2005).
4. Air dried wood (20% moisture) has 15MJ/kg NCV. Total Fuelwood consumed in Bhutan in 2000 = 38.849.96 tdm X 15MJ/kg X 1000kg/t x TJ/1000000MJ = 582.75TJ (or 13915.96 toe).
5. 1 power tiller load of fuel wood was assumed to be 0.5 tonnes.
6. All fuel wood is assumed to be air dried wood

Since the production of coal in Bhutan is not classified into different types of coal, it has been put under sub-bituminous coal as the Bhutan Trade Statistics provides data on export of sub bituminous coal. All coal consumption is assumed to be in manufacturing and industries sector.

The Indian Net calorific value (NCV) for hard coal was used as NCV for coal produced in Bhutan.

The sector 5 on fugitive emission from fuels is not considered, as it is not relevant for Bhutan

4.2 Sector 6: Industrial Process Emission

4.2.1 Cement Production

Four cement industries were surveyed for their activity rate in year 2000. However, only three of them responded positively, of which two industries uses wet process consisting of vertical shaft kiln. Total cement production is assumed as the activity rate for the inventory. For the wet process kiln, there is no pollution control measure installed. However, the particulate matter emission from other component of the plant such as raw mill and cement mills are controlled by using fabric filter. Based on the survey information, part of the cement produced from the wet process kiln is assumed as the activity rate under "Wet process kiln (uncontrolled)", despite some measure of pollution control in the industry.

The survey result also suggests that significant quantity of the cement is produced by dry process with the help of rotatory kiln. The rotatory kiln is fitted with control technology of both ESP and fabric filter. However, for the purpose of inventory, it is assumed that the activity rate of cement production in the dry process is produced with pollution control equipment of fabric filter only.

Cement production is assumed as the activity rate for the emission estimation, although lot of emission occurs from the clinker production.

4.2.2 Lime Production

The only plant that which produces calcium carbide is considered for the inventory under the lime production category. Lime is produced as the initial products for production of carbide. The quantity of calcium carbide is assumed as the activity rate for lime production in emission estimation.

4.2.3 Asphalt Road Paving

The data for the Asphalt road paving is obtained from the Bhutan Trade Statistics, 2000. Under the Asphalt category, coal tar and bitumen are reported to be imported in 2000. For the purpose of inventory, it is assumed that both coal tar and bitumen are imported for road paving only and used by processing "Batch Mix Hot Mix (uncontrolled)". The default emission factor for NMVOC is used along with the activity rate of total import of the asphalt.

There was no asphalt plant in Bhutan.

4.2.4 Chemical and Metal Production Industry

There were no chemical and metal production industries.

4.2.5 Paper and Pulp:

Three traditional paper and pulp factories were operational in 2000. Since the production was micro scale operated based on the indigenous knowledge and practice, it fails to fit in any of the pulping process described under the Inventory Manuel. However, since production process uses soda, it is assumed that paper and pulp uses kraft process. Therefore emissions are estimated based on the default emission factor for kraft process.

4.2.6 Food and Drink Production:

Only bread and cakes/biscuits were found relevant for food industries, as we do not have other food industries, described in the Inventory Manuel. The survey report provides information on weight of the material used in the process of making the food item. It was assumed that the entire ingredient used for food productions are used in producing food products. In other words, it is assumed that there is no wastage of food ingredient in the production process.

For drink industry only brandy, whiskeys and unspecified spirits were found relevant. Whisky is assumed to be produced from malt. The detail conversion to hectoliter (HL) is

Conversion into HL:

i) For bottles:

1 bottle = 750ml = 0.75L

Since, 100L = 1HL as per the guide lines,

Therefore, 0.75L = 0.0075 HL.

This value was then multiplied with the quantity of alcoholic beverage produced.

ii) For cases:

1 case = 12 bottle = 12*750ml = 9000ml = 9L

Since 100L = 1HL,

Therefore, 9L = 0.09HL.

This value was then multiplied with the quantity of alcoholic beverage produced

4.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

Although, major portion of the data were collected for this inventory, the following aspects of the data computation is being reflected. In the *other cattle* cell, non-diary cattle (126954) and Yak (34,928) have been entered because there is no provision to enter these data. For the poultry data in the manure management section, only chicken has been entered as we do not have data for the ducks, geese etc.

In the Fertilizer type, since there is no option to enter bone meal (contains N and P) data, we have entered Bone Meal data in the Combined Ammonium Phosphate cell. Similarly, for other complex NK, NPK fertilizer cell, we have entered data for NPK (suphala) and KG-Mix. For entering the N-values of the fertilizers the following conversion has been adopted.

For this inventory, sheet 4.3 (Emissions from Agricultural Residue Burning) has been excluded since no data is available for the agricultural residue burning though the crop yield data for all the crops is available. In Bhutan, agricultural residue burning is almost non existent or is done on a very negligible scale if at all done.

Conversion Process

Fertilizer Type	Total Fertilizer (MT)	N%	Total Nitrogen
NPK (Suphala)	678.52	15.0	101.778
Urea	1415.1	46.0	650.946
Bone Meal	15.2	3.0	0.456
Calcium Ammonium Nitrate	14.75	26.0	3.835
KG-Mix	1.0	10.0	0.1

Fertilizer Data Source: DSC, Paro

For the Vegetation Fires and Forestry, the sub tropical forest has been considered as secondary forest because of frequent human interventions and the total area burnt is taken as the average for two years (1999&2001) as the data for 2000 appears in both 1999 –2000 and 2000–2001 years.

It would be important to note here that as per the Male inventory sheet, data is required for various vegetation types. However, in Bhutan information is unavailable for the various vegetation type prescribed in the Male worksheet. Considering, the data availability, it was only possible to derive two vegetation types, namely sub-tropical forest and other temperate forest. This classification of the forest was done based on data from fire record, fire incidence and area burnt 1992-2008, as this information segregates each Dzongkhag according to the fire occurrence and roughly each Dzongkhag can be grouped into these two forest types

1.1 Sector 10: Waste

The required data for municipal Solid waste and usage of latrine for whole country for the particular base year is unavailable. In addition, there is no local emission factor for respective pollutants.

Assumptions:

Based on the Population and Housing Census data of 2005 the population growth rate of 1.3 % has been assumed and applied throughout the projected year starting from 2000 to 2007.

Based on the DUDES survey report of 2008, the per capita waste generation value derived (0.533kgs/day) has been also assumed for the whole projection period covering 2000 – 2007.

5.0 Result

5.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels

The total emission of SO₂, NO_x, CO, NMVOC, NH₃, PM₁₀, and PM_{2.5} from Sector (1-4): combustion in manufacturing and construction sector, transport sector and other sectors is as shown in the table below.

Sub-sector	Total emissions (kilo tonnes pollutant per year (kt/yr))						
	SO ₂	NO _x	CO	NMVOC	NH ₃	PM ₁₀	PM _{2.5}
Non-ferrous metals	0.15	0.27	0.13	0.01	0.00	0.00	0.00
Civil Aviation (Detailed)	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Road transport (Simple--not used if Detailed used)	0.19	0.99	3.09	0.60	0.00	0.12	0.12
Residential	0.01	0.01	0.36	0.00	0.00	0.01	0.01
Total	0.35	1.28	3.59	0.61	0.00	0.13	0.13

5.2 Sector 6: Industrial Process Emission

The total emission of SO₂, NO_x, CO, NMVOC, NH₃, PM₁₀, and PM_{2.5} from Sector 6, Industrial Process is as shown in the table below

Subsector	Total Emission (Kilotonnes pollutants per year, (Kt/yr))						
	SO ₂	No _x	CO	NMVOC	MH ₃	PM ₁₀	PM _{2.5}
Mineral Products	0.09		0.00	0.00		1.27	0.30
Chemical Industry	NO	NO	NO	NO	NO	NO	NO
Metal	NO	NO	NO	NO	NO	NO	NO
Pulp and paper	0.00	0.00	0.00	0.00		0.00	0.00
Food and Drink				0.23		0.00	0.00
Major construction site activities	NE	NE	NE	NE	NE	NE	NE
Total	0.09	0.00	0.00	0.23	0.00	1.27	0.30

5.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

The total emission of SO₂, NO_x, CO, NMVOC, NH₃, NH₃, PM₁₀ and PM_{2.5} from agriculture; vegetation fires and forestry is presented in the following .

Sector	Sub-sector	Total emissions (kilotonnes pollutant per year (kt/yr))						
		SO ₂	NO _x	CO	NMVO C	NH ₃	PM ₁₀	PM _{2.5}
1.Agriculture	Manure management					6.30		
	Application of N-containing fertilizer		0.02			0.16		
	Burning of agriculture crop residues	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.Vegetation fires and forestry	On-site burning of forest and grasslands	0.07	0.32	7.50	0.41	0.10	1.22	0.90
Total Emission		0.07	0.34	7.5	0.41	6.56	1.22	0.90

1.1 Sector 10: Waste

The following table shows the result for waste sector

Sector	Sub-sector	Total emissions (kilotonnes pollutant per year (kt/yr))						
		SO ₂	NO _x	CO	NMVO C	NH ₃	PM ₁₀	PM _{2.5}
Waste	Waste incineration	0.00	0.01	0.00	0.01	0.00	0.04	0.04
	Human excreta					0.89		
Total		0.00	0.01	0.00	0.01	0.89	0.04	0.04

6.0 Level of confidence

6.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels

Since data for energy industries was missing, the level of confidence for the inventory is rated as medium (70%). The data for manufacturing and construction sector, transport sector and other sectors are from relevant sources.

6.2 Sector 6: Industrial Process Emission

The level of confidence is above 80% as data were obtained through survey and published documents/reports

6.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

The level of confidence in terms of data can be above 95% as most of our sources are published documents/reports. The data were further streamlined through consultation with relevant agencies and persons.

1.1 Sector 10: Waste

Since no proper record exists, the data has been adopted through survey results and questioners conducted by relevant sectors in 2008. It was then interpreted to the base year of 2000. Further, the default emission factors, which are provided for North America and European Countries, are adopted for our emission estimation, which is unlikely to reflect the true situation. Therefore, it is expected that the confidence level of the data is low.

7.0. Recommendation

7.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels

- Improve data capturing for proper data inventory;
- Develop a data recording system for fuel consumption in residential sectors;
- Need to explore the fuel consumption for energy production industries;

7.2 Sector 6: Industrial Process Emission

- The inventory worksheet needs to cover all the existing industries in the country;
- Streamline data collection and recording system;
- Develop national emission factors;
-

7.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

- Data for agricultural residue burning could be explored with the respective Dzongkhag Agricultural Officers (DAO) or could be included in the RNR Statistics.
- Some study by the relevant agency on the demarcation of different forest types of Bhutan has to be conducted.

1.2 Sector 10: Waste

- Annual consistent data on waste sector including figures and references.
- Coordination/networking to be strengthened between the various stakeholders

8.0 References/data sources

8.1 Sector 1- 4 & 5: Fuel Combustion activities and Sector, & Fugitive Emissions (non-combustion) for fuels

1. Bhutan Trade Statistics (BTS), DRC (1995-2005)
2. Bhutan Energy Data Directory 2005
3. *Survey of Energy Usage in Industries by Energy Working Group, GHG Inventory Task Force of the Second National Communication Project, December 2008.*
4. Statistical Yearbook of Bhutan 2000, CSO, Planning Commission
5. IPCC reference Manual
6. The Male' Declaration Air Pollutant Emissions Inventory Manual Draft Version 2.3

8.2 Sector 6: Industrial Process Emission

1. Bhutan Trade Statistics (1998,1999,2000)
2. Industrial License Database, Ministry of Economic Affairs as of July 2008
3. Survey data from individual industries
4. Male Inventory Manuel, Draft version 2.1

8.3 Sector 8 and 9: Agriculture & Vegetation Fires and Forestry

1. Fire Section, Department of Forest, MoA, Forest Fire Record, Fire Incidence and Area Burnt 1992-2008.
2. MoA, RGoB, Renewable Natural Resources Statistics 2000.
3. Druk Seed Corporation Paro and Phuentsholing. Fertilizer Data, 2000.
4. PPD, MoA, RGoB, Land Use and Land Cover Atlas of Bhutan-1997
5. PPD, MoA, RGoB, Bhutan Land Cover Assessment 2005 – Summary
6. UNEP RRC-AP/SACEP/SEI, The Male' Declaration Air Pollutant Emissions Inventory Manual, Draft Version 2.3, May 2007