# CHAPTER FOUR

# NATIONAL INVENTORY OF GREENHOUSE GASES

***The Convention requires Parties to make periodic reports on national inventory of greenhouse gases. Guyana utilized the IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories and considered carbon dioxide, methane, nitrous oxide, non-methane volatile organic compounds, carbon monoxide and nitrogen oxides in its inventory. 1994 was taken as the base year for Guyana.***

# 4.0 NATIONAL INVENTORY OF GREENHOUSE GASES

## 4.1 INTRODUCTION

In accordance with articles 4.1 (a) and 12.1 (a) of the United Nations Framework Convention on Climate Change (UNFCCC), all Parties to the Convention are obliged to report on and periodically update their national inventory of anthropogenic emissions by sources, and removals, by sinks, of greenhouse gases (GHG) to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of Parties (COP).

As a consequence, the Government of Guyana conducted an inventory of the following greenhouse gases: carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$). Other indirect greenhouse gases, for example non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and nitrogen oxides ($NO_x$) were also inventoried to the extent possible.

*The IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories, together with the accompanying software*, were used to generate the emissions balance. Default values for emission and other factors provided in the Workbook, were extensively used. Because the IPCC software requires land cover to be expressed in hectares (ha), this chapter utilizes hectare as the unit for aerial cover.

Inventories were done separately for the years 1990 through 1998, but the year 1994 was chosen as the base year for the inventory period in accordance with paragraph 14 of the annex to COP Decision 10/CP.2.

It should be noted that $CO_2$ emissions from **International Bunkers** and **Biomass** are not included in the national totals; they are reported separately as other sources of emissions under **Memo Items**.

The GHG **Inventory** was done on a sector basis for **Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste**. The **Solvents** sector was not considered since the IPCC methodology for this sector is not yet available.

## 4.2 ENERGY SECTOR

There is no primary/secondary fossil fuel production in the Co-operative Republic of Guyana. Secondary fuels, including gas oil/diesel, kerosene, jet kerosene, Liquefied Petroleum Gas (LPG), gasoline and heavy fuel oil, are imported for local consumption. Fuel imports for international aviation and marine bunkers represent a very small percentage of total imports.

Energy is produced through the combustion of these secondary fuels for use in the power-generating utilities, transport, agriculture/fishing, manufacturing, commercial, residential and tourism and international aviation and marine sectors.

Energy from biomass also accounts for part of the energy sources in Guyana. *Bagasse* is used in the sugar industry and *rice husk* in the rice industry for the co-generation of heat and electricity, while *wood (firewood and charcoal*) is used in the residential sector for cooking purposes.

***Methodology***

Both the aggregate **Reference Approach** (top-down) and the source categories **Sectoral Approach** (bottom-up) were used to calculate the GHG Inventory for the Energy sector.

Conversion factors derived from the " Latin American Energy Organisation (OLADE)" were used to convert local activity data on fossil fuels, which were expressed in 1,000's of barrels, to **Apparent Consumption** in terajoules (TJ).
**Biomass** fuels (in 1,000's kg) on the other hand, were converted to Apparent Consumption in TJ by using

the IPCC default values (refer to table 1-13, Vol.3 of the IPCC Guidelines).

In all cases, for lack of country-specific data, the **Default Values of the Conversion, Emission and Carbon Oxidation Factors** as furnished by the IPCC, when available, were used.

$CO_2$ emissions from fuel combustion for the years 1990 to 1993 were calculated using the **Reference Approach** only, since the relevant data was not available for the period 1990 to 1993 to do the **Sectoral Approach**.

For the years 1994 to 1998, both the top-down **Reference** and the bottom-up **Sectoral** approaches were used to calculate the emissions mainly to assess the effectiveness of the sectoral approach.

The Guyana Energy Agency (GEA) provided the relevant data to enable the use of the Sectoral Approach. This was based on data availability for some sectors (e.g. Energy Industries), and expert estimates for other sectors where specific consumption data were not available. This procedure allowed for obtaining the requisite data on 'sector fuel consumption'. Moreover, this method should give close emission estimates for the various sectors since Guyana's fuel consumption is limited to only six fuel types, and each fuel type is used in a particular sector (e.g. gasoline is used particularly in the **transport** sector). In addition, no fuel is allotted to manufactured items in which carbon is stored since all fuels imported is burnt and carbon storage in products is negligible.

Some differences exist when comparing $CO_2$ emissions for the **Reference** and **Sectoral** approaches. These differences, which vary from year to year, could have arisen from the procedures used to disaggregate the fuels, as explained above.

*Carbon Dioxide emissions/removal*

Combustion of fossil and biomass fuels are the two main sources for emissions of $CO_2$ in the Energy sector. Guyana does not produce cement, which is a very significant source of this gas through its production process. In addition, the country does not have metal producing industries and other industries that emit $CO_2$ through their production processes. Gold is being produced, but the production process (electrolysis) does not emit $CO_2$.

$CO_2$ is the major greenhouse gas being emitted from anthropogenic sources of which a major part is contributed by energy-related activities. For example, in 1994 it represented 96.5% or 1446 Gg (excluding $CO_2$ emissions from biomass) of the total emissions of $CO_2$, $CH_4$ and $N_2O$, the major GHG's. This percentage share is similar for the other years, 1995 to 1998 for which the sectoral approach was done.

*Figure 4.1: Proportion of $CO_2$ emissions by sub-sectors within Energy sector for 1994.*

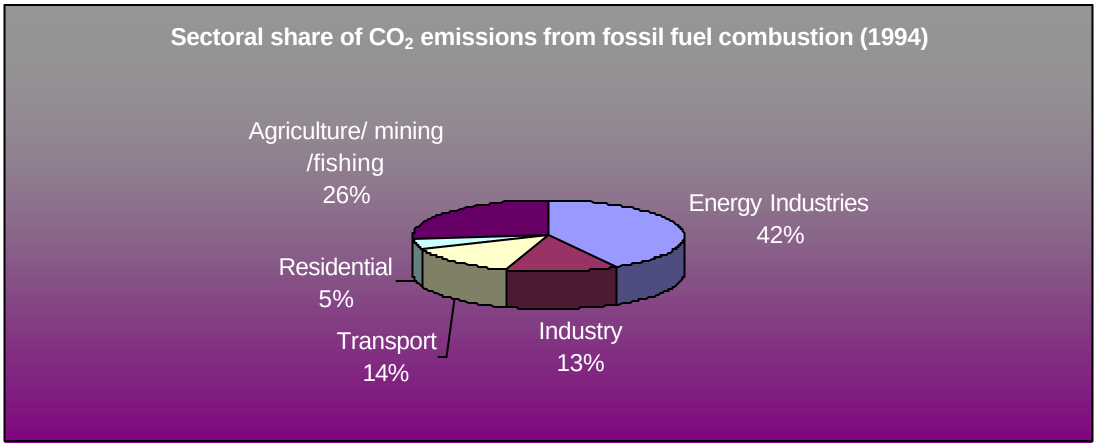



*Figure 4.2: Proportion of $CO_2$ emissions by sub-sectors within Energy sector for 1998.*

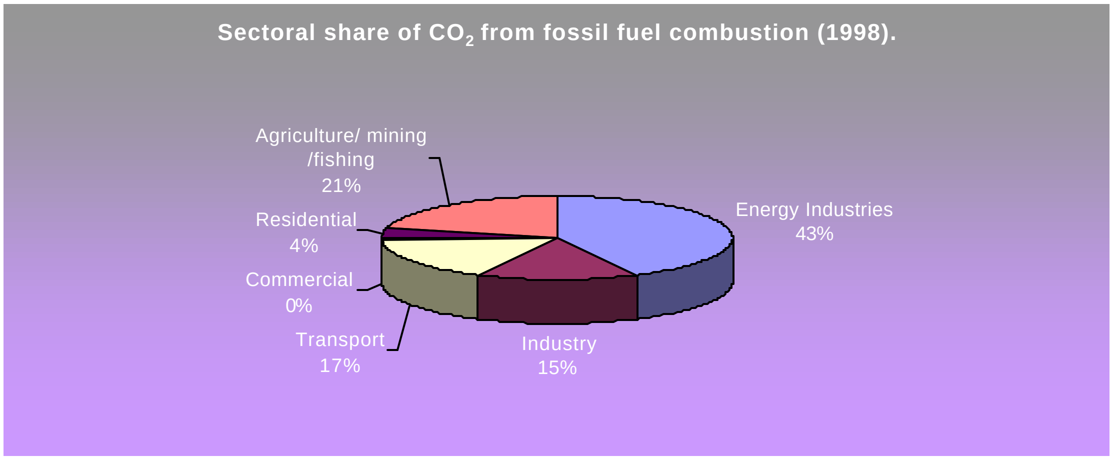



*Figure 4.3: $CO_2$ emissions (Gg) by sub-sectors within Energy sector for 1994 and 1998.*

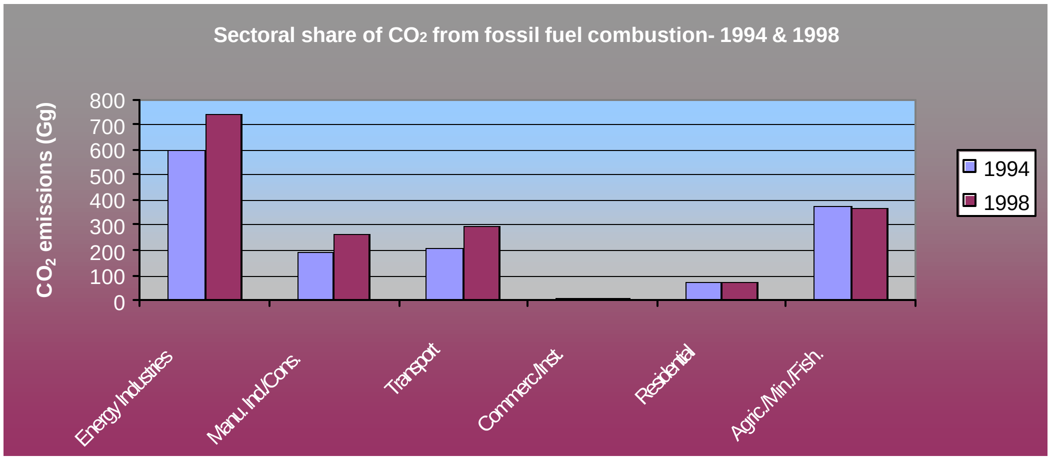



***Table 4.1. $CO_2$ emissions (Gg) from fossil fuel combustion according to the Reference and Sectoral***

***Approaches.***

| Year | 1990 | 1991 | 1992 | 1993 | **1994** | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Reference Approach | 1198 | 1218 | 1266 | 1320 | **1414** | 1511 | 1559 | 1701 | 1728 |
| Sectoral Approach | _ | _ | _ | _ | **1446** | 1469 | 1538 | 1663 | 1749 |
| % Change from 1994 (RA) base value. | - 15 | - 14 | - 10 | - 7 | | 7 | 9 | 20 | 22 |
| Difference between (RA) & (SA) – in (Gg). | | | | | **-32** | +42 | +21 | +38 | -21 |
| % difference between (RA) & (SA) | | | | | **-2.3** | 2.8 | 1.3 | 2.2 | -1.2 |

KEY:
1. (RA) – Reference Approach
2. (SA) – Sectoral Approach
3. For Reference Approach data for 1994, see Annex 4.A.

Data analysis of $CO_2$ emissions for Guyana for the years 1990 to 1998, using both the **Reference** and **Sectoral** approaches show that for the reference year **1994**, $CO_2$ emissions totaled **1414 Gg** (Reference) and **1446** Gg (Sectoral), a difference of 2.3 %, which is acceptable. However**, the differences are greater for the years, 1995 and less for 1996, 1997 and 1998**, for which both calculations are done, this most likely being due to the estimation of the fuels allocation to the different sub-sectors. ***Also, $CO_2$ emissions increase by about 15 %, from 1990 to 1994**, **and by a further 21 % from 1994 to 1998***, reflecting an increase in use of fossil fuels through economic growth and expansion (See Table 4.1.)

***Table 4.2. $CO_2$ emissions by sub-sectors within the Energy sector in 1994 –1998***

| **Fuel combustion activities** | **1994** | | **1995** | | **1996** | | **1997** | | **1998** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gg | % | Gg | % | Gg | % | Gg | % | Gg | % |
| Energy Industries | 602 | 42% | 561 | 38 | 587 | 38.3 | 713 | 42.9 | 742 | 42.4 |
| Manufacturing Indus./Cons. | 191 | 13 | 178 | 12 | 202 | 13.2 | 187 | 11.2 | 264 | 15.1 |
| Transport | 203 | 14 | 204 | 14 | 253 | 16.4 | 257 | 15.5 | 296 | 16.9 |
| Commercial/Institutional | 4 | 0.3 | 4 | 0.3 | 4.5 | 0.3 | 5 | 0.3 | 5 | 0.3 |
| Residential | 72.8 | 5 | 85.2 | 5.7 | 79 | 5.1 | 92 | 5.5 | 74.3 | 4.3 |
| Agriculture/Mining/Fishing | 373 | 25.7 | 437 | 30 | 413 | 26.7 | 409 | 24.6 | 367 | 21 |
| **Total emissions** | **1446** | **100** | **1469** | **100** | **1538** | **100** | **1663** | **100** | **1748** | **100** |

N.B. Energy Industries include both auto and public generation of electricity

Furthermore, within the **Energy sector**, **$CO_2$ emissions from *energy industries*** totaled ***602 Gg of $CO_2$ in 1994***, which accounts for ***42 %*** of the total $CO_2$ emissions. This figure is consistent from 1994 to 1998. Next in line are $CO_2$ emissions from ***agriculture, mining and fishing*** that accounted for ***373 Gg of $CO_2$ (25.7 %)***

***in 1994*** and ***437 Gg $CO_2$ (30 %) in 1995***. Other important emitters of $CO_2$ in the Energy sector are the ***manufacturing industries*** sub-sector that accounted for ***191 Gg of $CO_2$ (13 %) in 1994*** and ***264 Gg of $CO_2$ (15.1 %) in 1998*** while the ***transport*** sub-sector emitted ***203 Gg of $CO_2$ (14 %) in 1994*** and ***296 Gg of $CO_2$ (16.9 %) in 1998***. See Table 4.2 and Figures 4.1,4.2 and 4.3.

**Memo Items**

Under the current IPCC methodology, countries are not required to incorporate **Memo Items** including **international aviation and international marine bunkers** and the **burning of biomass** in their total emissions or removals of $CO_2$. However, countries are obliged to report these items separately.

The Guyana Sugar Corporation uses bagasse for the co-generation of steam and electricity, but these emissions are reported under **Biomass Emissions.** This is because, according to the IPCC, the $CO_2$ emitted is reabsorbed in the next growing season of sugar cane. This justification applies for all biomass fuels, which are used as a source of energy. Emissions from biomass are therefore reported for information purposes only.

*Carbon Dioxide emissions from international bunkers*

Emissions from **international bunkers** are very minimal. This is because most of the vessels engaged in international air and marine transport purchased their fuel outside of Guyana. The Guyana Airways Corporation (previously state-owned and presently privatized) was the main consumer of bunker fuel (aviation / jet kerosene).

***Table 4.3: $CO_2$ emissions ( Gg ) from Memo Items : 1994 to 1998.***

| Memo Items | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|
| International Aviation Bunkers | 24 | 26 | 23 | 22 | 14 |
| International Marine Bunkers | 4 | 4 | 5 | 9 | 7 |
| Total | 28 | 30 | 28 | 31 | 21 |

$CO_2$ emissions for the reference year 1994 and more recently for 1998 from **international bunkers** show a sharp reduction in emissions. In 1994, *international air transport* accounted for *24 Gg* of $CO_2$ emissions while the figure in 1998 was only *14 Gg*. The reduction of $CO_2$ emissions in 1998 was due to the fact that the national airline, Guyana Airways Corporation, had reduced operations in that year (See Table 4.3).

On the other hand, *international marine transport* showed an increase of $CO_2$ emissions from only *4 Gg* in 1994 to *7 Gg* in 1998 (See Table 4.3).

*$CO_2$ emissions from biomass fuels*

In Guyana the biomass fuels that are burned for energy are primarily firewood, charcoal, bagasse and rice husks.

Table 4.4 gives **total biomass fuel consumption** (metric tonnes) for firewood, charcoal, rice husk and bagasse for the years 1994 to 1998.

***Table 4.4 Biomass fuel consumption by types (metric tonnes).***

| | Year | | | | |
|---|---|---|---|---|---|
| **Consumption (boe)** | **1994** | **1995** | **1996** | **1997** | **1998** |
| *Firewood* | 82436.0 | 83200.0 | 85591.0 | 87352.0 | 87011.0 |
| *Charcoal* | 1691.0 | 1448.0 | 1081.0 | 587.0 | 601.0 |
| *Bagasse* | 1132938.0 | 1418432.9 | 1199591.0 | 1516676.2 | 1090084.0 |
| *Rice husk* | 40000.0 | 40000.0 | 45000.0 | 54000.0 | 60000.0 |
| **Total** | **1257065.0** | **1543080.9** | **1331263.0** | **1658615.2** | **1237696.0** |
| Source: Guyana Energy Agency. | | | | | |

For the reference year, 1994, the largest amounts of $CO_2$ emissions derive from **bagasse** combustion (983.7 Gg) in the **energy industry** sub-sector. Smaller amounts derive from the combustion of wood and wood wastes in the **residential** (98.48 Gg), **manufacturing** (45.73 Gg) and **rice husk** in the **manufacturing** (62.52 Gg) sub-sectors. **Charcoal** combustion in the **residential** sector only accounts for 5.32 Gg of $CO_2$ emissions (See Table 4.5 for details).

***Table 4.5: $CO_2$ emissions from biomass ( Gg ) in 1994.***

| Biomass Type | Energy Sub-sector | Residential Sub-sector | Manufacturing Sub-sector | Commercial Sub-sector | Totals ( Gg) |
|---|---|---|---|---|---|
| Wood/waste | _ | 98.48 | 45.73 | 4.32 | 148.52 |
| Bagasse | 983.7 | _ | _ | _ | 983.72 |
| Rice husk | _ | _ | 62.52 | _ | 62.52 |
| Charcoal | _ | 5.32 | _ | _ | 5.32 |
| Total | | | | | **1 200.08** |

Total $CO_2$ emissions (Gg) from biomass fuels, namely firewood, charcoal, rice husk and bagasse for the years 1994 to 1998 are relatively stable and consistent being **1200 Gg in 1994**, the reference year, and rising to 1270 Gg in 1996 ( See Table 4.6 ).

***Table 4.6: $CO_2$ emissions from biomass fuel (1994 – 1998) Gg.***

| Years | Total Emissions (Gg) |
|---|---|
| **1994** | 1200 |
| **1995** | 1157 |
| **1996** | 1270 |
| **1997** | 1248 |
| **1998** | 1199 |

*Non-Carbon Dioxide ($CO_2$) emissions*

Non-$CO_2$ emissions of **methane** ($CH_4$), **nitrous Oxide** ($N_2O$), **nitrogen oxides** ($NO_x$), **carbon monoxide** (CO) and **non-methane volatile organic compounds** (NMVOC) are relatively small for the Energy sector in Guyana (See Table 4.7). Only **CO** emissions *(44.51 Gg in 1994 and 49.96 Gg in 1998)*, **NOx** emissions *(10.66 Gg in 1994 and 11.91 Gg in 1998)* and **NMVOC** emissions *(6.27 Gg in 1994 and 7.15 Gg in 1998)* seem significant. For instance, in 1994, **CO** emissions derived mainly from fuel combustion in the road transport *(22.4 Gg)* and energy industries *(9.18 Gg)* sub-sectors. **NOx** emissions in 1994 on the other hand, are produced by the mobile fishing *(5.51 Gg)*, energy industries *(2.51 Gg)* and road transport *(1.68 Gg)* sub-sectors.

***Table 4.7. Non- $CO_2$ emissions (Gg) from fuel combustion (fossil & biomass) by source category: 1994 – 1998.***

| Non-$CO_2$ GHG | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|
| $CH_4$ | 0,72 | 0.71 | 0.75 | 0.75 | 0,74 |
| $N_2O$ | 0,06 | 0.05 | 0.06 | 0.06 | 0,06 |
| $NO_X$ | 10.66 | 11.47 | 11.69 | 11.96 | 11.91 |
| CO | 44.51 | 44.35 | 47.62 | 48.61 | 49.96 |
| NMVOC | 6.27 | 6.30 | 6.74 | 6.89 | 7.15 |

*Fugitive emissions* are considered to be zero in Guyana. This is because the country is not involved in activities from which fugitive emissions arise.

## 4.3 INDUSTRIAL SECTOR

In spite of its geographical size and vast natural resources, Guyana does not have a strong Manufacturing or Industrial sector so that GHG emissions from light manufacturing or heavy industries are minimal. GHG emissions in this sector are limited to **NMVOC** emissions from the **food and beverage industry** and from **asphalt** used in road paving.

***Methodology***

**NMVOC** emissions derived from *bitumen used in road paving with asphalt*, and the *manufacture of alcoholic beverages* (rum, beer and stout, shandy and wine) and *food production* (bread, biscuits, meat, fish and poultry, sugar, margarines and stockfeed). All activity data are country-specific and were obtained from the Bureau of Statistics, Guyana. However, all emission factors were taken as Default Values from the IPCC Workbooks.

An average emission factor of (0.057) was used to estimate NMVOC from wine production since production figures were not separated as white and red wine.

*NMVOC Emissions*

For the inventory year 1994, **NMVOC** emissions from **road paving with asphalt** was **9.60 Gg**, from the manufacture of **alcoholic beverages** it was **3.87 Gg** and from **food production** it was **2.77 Gg** (See Table 4.8)

*Table 4.8: NMVOC emissions (Gg) from the Industrial Processes sector in 1990 to 1998.*

| Activity | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Road Paving Asphalt | N.E. | N.E. | N.E. | N.E. | **9.60** | N.E. | N.E. | N.E | N.E. |
| Alcoholic Beverages | 2.75 | 2.45 | 3.28 | 3.79 | **3.87** | 3.39 | 3.59 | 3.5 | 3.31 |
| Food Production | 1.49 | 1.80 | 2.65 | 2.66 | **2.77** | 2.75 | 3.01 | 2.97 | 2.77 |
| **Total** | **4.24** | **4.25** | **5.93** | **6.45** | **16.24** | **6.14** | **6.6** | **6.47** | **6.08** |

Total NMVOC emissions in 1994, the reference year, were relatively high compared to the other years. This was because emissions from *road paving with asphalt* were not estimated for the other years (data not available).

*Halocarbon emissions* from the consumption, use and disposal of products containing halocarbons, such as refrigerants and air conditioners are not included in the *Inventory*, since these are substances controlled under the Montreal Protocol.

## 4.4 AGRICULTURE SECTOR

Agriculture is one of the key sectors of the Guyanese economy, accounting for more than 25 % of GDP in 1994. Methane ($CH_4$) is one of the most important non-$CO_2$ GHG emitted by the Agriculture sector. **$CH_4$** emissions are derived from *rice cultivation*, *field burning of agricultural residues*, *prescribed burning of savannahs, and enteric fermentation and manure management* in the rearing of livestock. **CO** and **$NO_x$** emissions on the other hand are derived exclusively from the *field burning of agricultural residues* and to a lesser extent from *prescribed burning of savannahs*. **$N_2O$** emissions however, which are very small, resulted from a number of sources, including *enteric fermentation and manure management, field burning of agricultural residues, prescribed burning of savannahs* and a variety of soil processes (including synthetic nitrogenous fertilizer application).

***Methodology***

Domestic livestock, rice cultivation, field burning of agricultural residues and agricultural soils

Activity data on rice cultivation, production of crops, and animal population according to species, are country-specific to some extent. Where no data was available locally, estimates from the Food and Agricultural Organisation (FAO) Statistical Yearbook were used. However, emission factors and other default values were taken from the Revised 1996 IPCC Workbook.

For field burning of crop residue, the most important crops for Guyana are rice and sugar cane. Other crops are considered insignificant. Default values for maize were used for sugar cane to do the emissions estimates, while an estimated 70% of the residue in the field is burned.

*Derivation of enteric fermentation emission factor for poultry*

The IPCC Revised 1996 Workbook does not have an emission factor for the enteric fermentation of poultry. Also, it was not possible for any other reference to be identified and used. It was therefore decided to obtain the emission factor by consideration of the factor for swine, which has been given in the IPCC Workbook.

The ratio of the emission factor for poultry (0.023) to that of swine (2.0) is (0.0115). This value was then assumed to be the ratio of the enteric fermentation for poultry to that of swine. The enteric fermentation for swine was (1.0) which was obtained from the IPCC Revised 1996 Workbook. Therefore, the enteric fermentation emission factor for poultry was calculated to be (0.012) using the values and the assumptions above.

*Prescribed burning of savannahs*

Two categories of savannah lands were identified: dry and wet savannahs. No data on total savannah area burnt annually was available. As such, the default approach of using the total savannah area and a fraction of what is burnt annually was used to estimate GHG emissions from this source.

Discussions with officials revealed that some spontaneous burning occurs annually. Also, there is some amount of planned burning for agricultural purposes but monitoring of this situation is inadequate. It was determined that the total area burnt annually however, represents a very small percentage of the total savannah area. Within the foregoing context, the default fraction (0.50) for savannah burnt annually in Tropical Region in the IPCC Workbook, significantly overstates the total area of savannah burnt annually in Guyana. A decision was therefore taken to use the value (0.065) in our inventory, which fell in the range of default values for the Sahel Zone, shown in the IPCC GHG Inventory Workbook.

*$CH_4$, CO, $N_2O$ and $NO_x$ Emissions*

In 1994, the reference year, **$CH_4$** emissions in the Agriculture sector amounted to **40.95 Gg**. Of this total, emissions from *domestic livestock* amounted to *14.35 Gg*, with *95.5 %* coming from *enteric fermentation (13. 66 Gg)*, and the remainder coming from *manure management (0. 69 Gg)*. *Rice cultivation* is the other major source of $CH_4$, amounting to *22.33 Gg (44 % of total)* in 1994. A smaller amount, *3.20 Gg* of $CH_4$, is emitted from the *field burning of agricultural residues* and *1.07 Gg* from *prescribed burning of savannahs* (See Table 4.9).

**CO** is emitted exclusively from the *field burning of agricultural residues* and *prescribed burning of savannahs*, amounting to **95.27 Gg** in 1994 from the Agriculture sector (See Table 4.9).

**$N_2O$**, on the other hand, is emitted from **all agricultural activities** listed in Table 4.9, except *rice cultivation*. However, the amount was **1.16 Gg** in 1994.

**$NO_x$** emissions are derived exclusively from the *field burning of agricultural residues*. In 1994, a relatively small amount (**4.04 Gg**) was emitted from the Agriculture sector (See Table 4.9).

***Table 4.9: $CH_4$, CO, $N_2O$ and $NO_x$ emissions (Gg) in the Agriculture sector for 1994.***

| Activity | $CH_4$ | CO | $N_2O$ | NOx |
|---|---|---|---|---|
| Enteric Fermentation and Manure Management. | 14.35 | _ | 0.01 | _ |
| Flooded Rice Cultivation | 22.33 | _ | _ | _ |
| Field Burning of Agricultural Residues | 3.20 | 67.21 | R.E. | 3.56 |
| Direct Nitrous Oxide Emission from Agricultural Fields | _ | _ | 0.39 | _ |
| Nitrous Oxide Soil Emissions From Grazing Animals | _ | _ | 0.41 | _ |
| Indirect Nitrous Oxide Emissions from Leaching and atmospheric deposition | _ | _ | 0.34 | _ |
| Prescribed burning of savannah | 1.07 | 28.06 | 0.01 | 0.48 |
| **Totals** | 40.95 | 95.27 | 1.16 | 4.04 |

R.E. –reported elsewhere (under agricultural fields)

## 4.5 LAND USE CHANGE AND FORESTRY

Of Guyana's total area of 21.5 million hectares, three quarters of its land surface, representing over 16 million hectares, are covered mainly by tropical moist evergreen rainforests, containing over 1,000 known species.

Available data and expert estimations from the Guyana Forestry Commission place Guyana's forested area (total **area: 16.45 million hectares**), which is **impacted by anthropogenic activities at an estimated 2.273 million hectares** (1998). This total disturbed forest area is based to a large extent on a percentage of the total forest area that is allocated to logging, an anthropogenic activity that disturb/impact on the forest biomass stocks. It includes the categories **Wood Cutting Leases, Timber Sales Agreements (TSA) and State Forest Production (SFP) conversion areas (Total forest area impacted from logging: 2,182,152 ha).** The disturbed forest area from **mining activities (40,000 ha) and from land allocated to Amerindian communities (51,000 ha)** were also crudely estimated and used in the inventory. This estimated disturbed-forest area acts as a sink for $CO_2$ through natural regeneration.

***Methodology***

*Changes in forest and other woody biomass stocks & Forest Conversion*

Activity data on **species and areas** (hectares) of forest/biomass stocks of forests and on **commercial harvest** from the forest ( $m^3$ ) are country-specific and were obtained from the **Guyana Forestry Commission** and to a limited extent from the **FAO Statistical Yearbook.** However, **annual growth rate (tdm/ha), conversion** and **emission** factors relating to **carbon fraction**, **biomass conversion/expansion** and **fraction of biomass oxidized** were taken as **default** values from the **IPCC Workbooks**. Furthermore, where published data was lacking, as for instance the fraction of biomass burned on-site and off-site, these were estimated, based on expert judgement, from comparisons with other countries in the region (eg. Costa Rica).

Because of a lack of data locally on forest conversion, the estimates for the rate of conversion of forest as provided in the Revised 1996 IPCC GHG Inventory Workbook (1980-1990 period) was used in this inventory as default.

_Abandonment of Managed Lands_

No data is available for the Abandonment of Managed Lands in Guyana. However, based on expert judgement, this value is insignificant.

*$CO_2$ Emissions / Removals*

**$CO_2$ emissions** and **removals** from **the Land Use Change and Forestry** sector are derived from anthropogenic depletion in forest and other woody biomass stocks leading to **removal** of $CO_2$ from carbon uptake, as a result of biomass regrowth from the conversion of forests and grasslands, and **emissions** from forest and grassland conversion due to burning and decaying of biomass.

The Land Use and Forestry data analyzed for the reference year, 1994, show a **gross removal (-29,195.35 Gg)** of $CO_2$ due to growth **changes in forest and other woody biomass stocks.**

This apparently large annual sink is due to two reasons:

(1) *Uncertainties in acquiring and using activity data:* The absence of country-specific activity data, particularly the annual growth rate of the forest led to the use of the IPCC default value, which may be unreliable. The IPCC Guideline was also not clear on the definition of a "managed forest", and further, the managed area of which was crudely estimated.

(2) *Inadequacy of the IPCC Methodology:* The calculation of $CO_2$ uptake is dealt with on a yearly basis. Hence, the emission from forestry production (3-year average) for the inventory year (under the assumption that all biomass extracted from the forest is oxidised in the year of production) is subtracted from the carbon uptake resulting from regrowth of the forest. The large resulting uptake of $CO_2$ is as a consequence of regrowth of the total managed forest area as at the year of calculation (estimated), that is, it included regrowth of forest that was anthropogenically impacted prior to the inventory year.

On the other hand, **forest and grassland conversions** account for **2,530.88 Gg of $CO_2$** emitted through burning and decaying of biomass. This results in a **net removal/sink (-26,664.47 Gg) of $CO_2$ from Land Use Change and Forestry** in Guyana (See Table 4.10 and Figure 4.4).

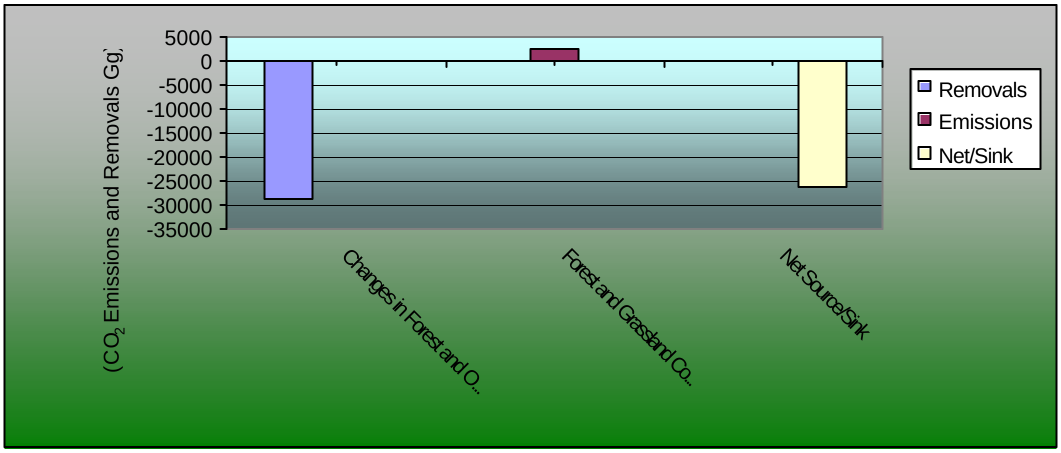
**Removal of $CO_2$** as a result of regrowth from the **abandonment of managed lands** is negligible in Guyana.

***Table 4.10: $CO_2$ emissions, removals and net sink (Gg) for Land Use and Forestry sector, 1994.***

| Activity | Removals | Emissions | Net / Sink |
|---|---|---|---|
| Changes in Forest and Other woody Biomass stocks | -29,195.35 | _ | _ |
| Forest and Grassland Conversion | _ | 2,530.88 | _ |
| Carbon Uptake from Abandonment of Managed Lands | N.E | N.E | N.E |
| Net Source / Sink | _ | _ | -26,664.47 |
| **Total** | **-29,195.35** | **2,530.88** | **-26,664.47** |

***N.E. (Not Estimated)***

*Figure 4.4: $CO_2$ emission, removals and net sink (Gg) from Land Use and Forestry sector, 1994.*




*Trace Gas Emissions*

Trace gases including **$CH_4$, CO, $N_2O$** and **$NO_x$** are also emitted from the **burning of cleared forests.**

Table 4.11 shows that the most important trace gas emitted from the **burning of cleared forests** is **CO (67.95 Gg)**, with smaller amounts of **$CH_4$ (7.77 Gg)**, **$NO_x$ (1.93 Gg)** and **$N_2O$ ( 0.05 Gg )**.

***Table 4.11: Trace gas emissions from forest burning ( Gg ), 1994***

| **Trace Gas** | **$CH_4$** | **CO** | **$N_2O$** | **$NO_x$** |
|---|---|---|---|---|
| **Emissions (Gg)** | **7.77** | **67.95** | **0.05** | **1.93** |

## 4.6 WASTE SECTOR

In the **Waste** sector, GHG emissions are limited to **methane ($CH_4$)** from **Solid Waste Disposal Sites (SWDS)** and to indirect **nitrous oxide ( $N_2O$ )** emissions from **human sewage**.

**Solid waste and wastewater handling**

*Solid Waste disposal on Land*

The solid waste disposal on land falls under the categories 'open-dump' and 'sanitary landfill'. Sanitary landfill (managed site), which is described as the trench-method, is particularly practiced in the capital city, Georgetown. The other urban areas practice 'open dumping' (unmanaged sites) where waste is burnt regularly. However, all the urban areas were considered in the inventory.

The rural population, which is about 66% of the total population (782,427: 1998 data), does not have an organized collection and disposal system for solid waste. Most of the waste generated is scattered on the land while part is burnt/buried, rather than being placed at specific locations/sites. Thus, there is little or no methane emission from rural locations.

***Methodology***

Activity data pertaining to Municipal Solid Waste (MSW) disposed to SWDS's are country-specific with the estimate on urban population obtained from the Bureau of Statistics, Guyana. However, the **IPCC Default** values for **Methane Correction** factor, **Fraction of Degradable Organic Compounds (DOC)** in (MSW), **Fraction of DOC which degrades** and **Fraction of Carbon Released** as methane were used for the estimation of **methane** emissions from solid waste disposal systems. Default values for **India** were used for the estimation of methane emissions from solid waste.

*$CH_4$ Emissions*

Data analyses using the above methodology provide **net annual methane emissions, from Solid Waste Disposal Sites, of 1.20 Gg** in 1994 for Guyana (See Table 4.12).

**Indirect Nitrous Oxide Emissions from Human Sewage**

Only part of the capital city, Georgetown, and the sub-urban district of Tucville have sewerage facilities, representing an estimated 10% of the population of Guyana. Out of the remaining 90% of the population, about 20-30% are estimated to use septic tanks and the remainder use pit latrines.

***Methodology***

**Nitrous oxide ($N_2O$)** emissions from **human sewage** was estimated from country-specific data on **population** as obtained from the Bureau of Statistics, Guyana.

However, the **IPCC default factors** for *fraction of nitrogen in protein* and *emission of $N_2O$* were used to estimate emissions from **human sewage**.

A factor of 25.8 was used for 'per capita protein consumption' (protein in kg/person/yr) to do the emissions estimates via human sewage. This factor is similar to that used by the Bahamas in their inventory study.

*$N_2O$ Emissions*

Based on the above analysis, **nitrous oxide ($N_2O$)** emissions in Guyana were estimated to be **0.05 Gg** in the year 1994. Thus, $N_2O$ emissions from this source are very low (See Table 4.12).

Other sources of $N_2O$ emissions are agricultural activities such as synthetic fertilizer usage and field burning of crop residues. Organic amendments to soil are done on a very small scale and this is particularly related to kitchen gardens. Thus, $N_2O$ emissions from these sources are insignificant.

***Table 4.12: $CH_4$ and $N_2O$ emissions (Gg) from the Waste sector for Guyana in 1994.***

| Activity | $CH_4$ Emissions | $N_2O$ Emissions |
|---|---|---|
| Solid Waste Disposal on Land | 1.20 | _ |
| Sewage | _ | 0.05 |

*Industrial Wastewater*

The state-owned Guyana Sugar Corporation, the privately owned beverages and fish processing factories, and the Omai Gold Mines Limited are essentially the companies where industrial wastewater is produced.

The wastewater from these sources is discharged into flowing rivers/the ocean, except Omai Gold Mines Limited where it undergoes a treatment process (both naturally and chemically) for the degradation/reduction of cyanide before discharging into the Essequibo river. There is no anaerobic treatment of industrial wastewater; hence no methane emission was calculated.

*Domestic Wastewater Handling*

There is no anaerobic treatment of wastewater; hence estimates of methane emissions from domestic wastewater have not been made.

**Waste Incineration**

A Waste Incinerator is located in the capital city, Georgetown. Primarily waste from the abattoir and hospitals is incinerated here. The IPCC Workbook does not have a methodology to estimate emissions from incinerators so such emissions were not calculated. However, emissions will be negligible since the bulk of solid waste in Guyana is placed in "open dumps/sanitary landfill sites" in the urban centres, and in rural areas where it is scattered on land, burnt/buried. Nevertheless, an attempt can be made to address this in future National Communications.

## 4.7 SUMMARY OF EMISSIONS AND REMOVALS

A Short Summary of the major emissions by sources and removals by sinks on a sector-by-sector basis for Guyana for the reference year 1994 is provided in Table 4.13 and Figure 4.5.

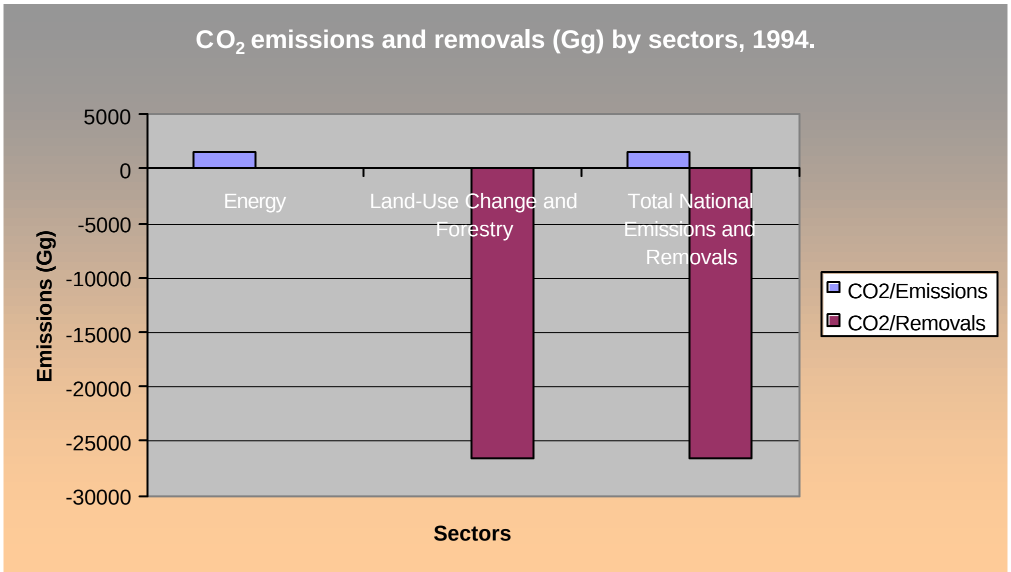
***Table 4.13: $CO_2$ emissions and removals ( Gg ) by sectors for Guyana, 1994..***

| **Greenhouse Gas Source and Sink Categories** | $C0_2$/Emissions | $C0_2$/Removals |
|---|---|---|
| | | |
| Energy | 1,446 | 0 |
| Industrial Processes | 0 | 0 |
| Agriculture | 0 | 0 |
| Land- Use Change and Forestry | (2530.88) | -26, 664.47* |
| Waste | N.E. | 0 |
| **Total National Emissions and Removals** | **1446** | **-26, 664.47*** |
| | | |
| **Memo Items** | | |
| International Bunkers | 28 | 0 |
| $C0_2$ Emissions from Biomass | 1200 | 0 |

KEY: 1. (N.E. – Not estimated)

2. ( ) - emissions value not counted because this source sector has net removals of $CO_2$ - IPCC.
3. (*) - value indicated net removal from this sector

*Figure 4.5. $CO_2$ Emissions and Removals ( Gg ) by Sectors, 1994.*




It is evident that the major emitter of $CO_2$ emissions in 1994 is from the Energy sector (1446 Gg), which virtually accounts for all of the $CO_2$ emissions, with the exception of Memo Items, biomass burning (1200 Gg) and international bunkers (28 Gg).

The Land Use Change and Forestry sector, which is also responsible for some amount of $CO_2$ emissions, through forest and grassland conversion (2,530.88 Gg), however is a net sink for $CO_2$ with a net removal of 26,664.47 Gg for 1994. This value derived from removal by growth *Changes in Forest and Other Woody Biomass Stock* **(-29,195.35 Gg of $CO_2$)** less emissions from *Forest/Grassland Conversion* - **2,530.88 Gg** (See Table 4.13 and Figure 4.5).

*Non- $CO_2$ emissions /removals*

Comparatively smaller amounts of non-$CO_2$ GHG's are emitted or removed in the year 1994 (See Table 4.14 and Figure 4.6).

**$CH_4$** emissions, which totaled 50.64 Gg, derived mainly from Agriculture (40.95 Gg) and Land Use Change and Forestry (7.77 Gg). Smaller amounts are derived from solid waste disposal in the Waste sector (1.20 Gg ), and Energy sector (0.72 Gg).

**$N_2O$** emissions on the other hand are restricted to emissions from the Agriculture sector, (1.16 Gg). Emissions from other sectors were negligible: human sewage (0.05 Gg $N_2O$) in the Waste sector, fuel combustion in the Energy sector (0.06 Gg), and conversion of forest in the Land Use Change and Forestry sector (0.05 Gg). This gives a total of **1.32 Gg** in the year 1994.

**NMVOC** emissions derive exclusively from *road paving with asphalt* and from *food and beverage production* in the Industrial Processes sector and Energy sector (6.27 Gg), totaling 22.51 Gg in 1994.

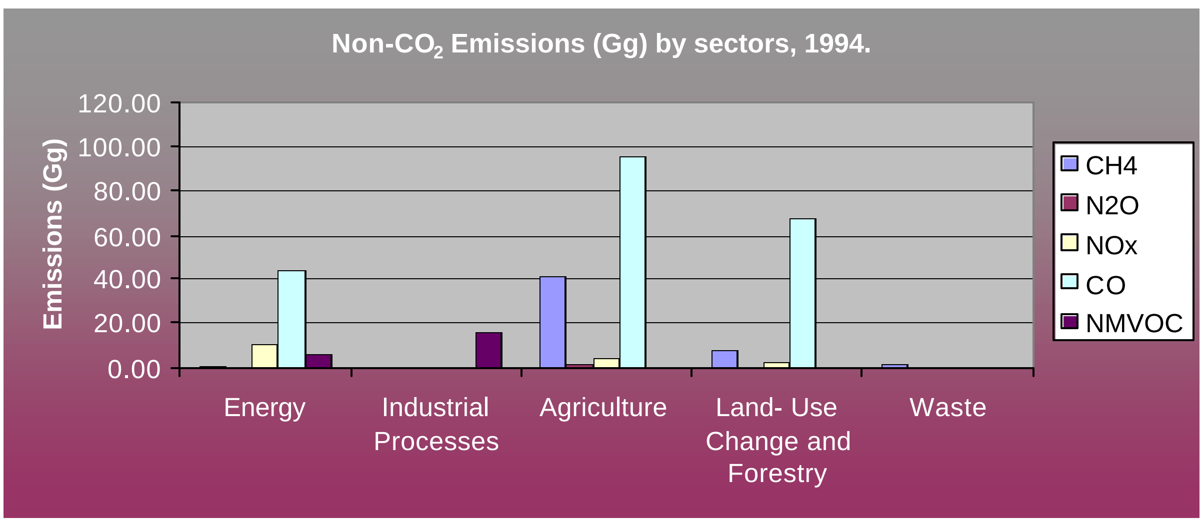
**$NO_x$** emissions derive from the Energy sector (10.66 Gg), the Agriculture sector (4.04 Gg) and from the Land Use and Forestry sector (1.93 Gg), totaling **16.63 Gg** in 1994.

**CO** is emitted in relatively large quantities from the Energy sector (44.51 Gg), from the Agriculture sector (95.27 Gg) and from the Land Use and Forestry sector (67.95 Gg) giving a total of **207.73 Gg** in 1994.

***Table 4.14: Non- $CO_2$ emissions (Gg) by sectors, 1994.***

| | Emissions (Gg) | | | | |
|---|---|---|---|---|---|
| **Greenhouse Gas Source and Sink Categories** | $CH_4$ | $N_2O$ | NOx | CO | NMVOC |
| | | | | | |
| Energy | 0.72 | 0.06 | 10.66 | 44.51 | 6.27 |
| Industrial Processes | 0 | 0 | 0 | 0 | 16.24 |
| Agriculture | 40.95 | 1.16 | 4.04 | 67.21 | 0 |
| Land- Use Change and Forestry | 7.77 | 0.05 | 1.93 | 95.27 | 0 |
| Waste | 1.20 | 0.05 | 0 | 0 | 0 |
| **Total National Emissions** | **50.64** | **1.32** | **16.63** | **207.73** | **22.51** |
| | | | | | |
| **Memo Items** | | | | | |
| International Bunkers | 0 | 0 | | | 0 |

*Figure 4.6: Non-$CO_2$ emissions and removals (Gg) by sectors.*




**Global Warming Potential**

Global Warming Potential (GWP) provides a simple measure of the relative radiative effects of the emissions of the different GHG's. The GWP index is defined as the cumulative radiative forcing between the present and some chosen time horizon, here taken as 20 and 100 years (see Table 4.15), caused by a unit mass of GHG emitted now, expressed relative to that of the reference GHG, namely $CO_2$.

The GWP of $CO_2$, $CH_4$, and $N_2O$ are provided in table 4.15. GWP's for $NO_x$, CO and NMVOC are not calculated because this is not currently possible on account of inadequate characterization of many of the atmospheric processes involved.

It is evident in table 4.15 that for Guyana, even taking GWP's into account, the removal of $CO_2$ mainly by forest sinks (-26,664.47) by far surpasses the $CO_2$-equivalent emissions (3,651.44 Gg over 20 years and 2,918.64 Gg over 100 years).

***Table 4.15: Global Warming Potentials, year 1994.***

| Greenhouse Gases (GHG) | Lifetime (Years) | Global Warming Potential (Time horizon) | | Total Emissions (Gg) | Total Emissions $CO_2$-Equivalent 20 years (Gg) | Total Emissions $CO_2$-Equivalent 100 years (Gg) |
|---|---|---|---|---|---|---|
| | | 20 years | 100 years | | | |
| Carbon Dioxide ($CO_2$) | Variable | 1 | 1 | 1446.00 | 1,446.00 | 1446.00 |
| Methane ($CH_4$) | 12(+)/(-)3 | 56 | 21 | 50.64 | 2,835.84 | 1,063.44 |
| Nitrous Oxide ($N_2O$) | 120 | 280 | 310 | 1.32 | 369.60 | 409.20 |
| Total Emissions ($CO_2$-Equivalent) | | | | **4,028.84** | **3,651.44** | **2,918.64** |
| Total Net Removals ($CO_2$- Equivalent) | | | | | **-26,664.47** | **-26,664.47** |

Source: IPCC, 1995.

## 4.8 BASELINE AND TRENDS

The year 1994 was used as the reference year to establish Guyana's emissions by sources and removals by sinks of greenhouse gases. However, for purposes of comparison and to establish trends in GHG emissions for Guyana, this section presents the results of GHG emissions from 1990 to 1998. In addition, trends are established according to the major GHG's, namely, $CO_2$, $CH_4$, $N_2O$ and the indirect GHG's NMVOC, CO and $NO_X$.

*$CO_2$ Emissions*

Table 4.16 and Figure 4.7 show the trend in emissions of $CO_2$ from fossil fuel combustion over the years 1990 to 1998. The indication is that there was a gradual increase from 1990 to 1993 and then an accelerated increase to 1998. Increases in the importation of diesel oil as a result of increased output of electricity and an increase of cultivated land (mainly for rice production) contributed mainly to the increases of $CO_2$ emissions.

*Table 4.16: Total carbon dioxide emissions and removal in 1990 – 1998 (Gg)*

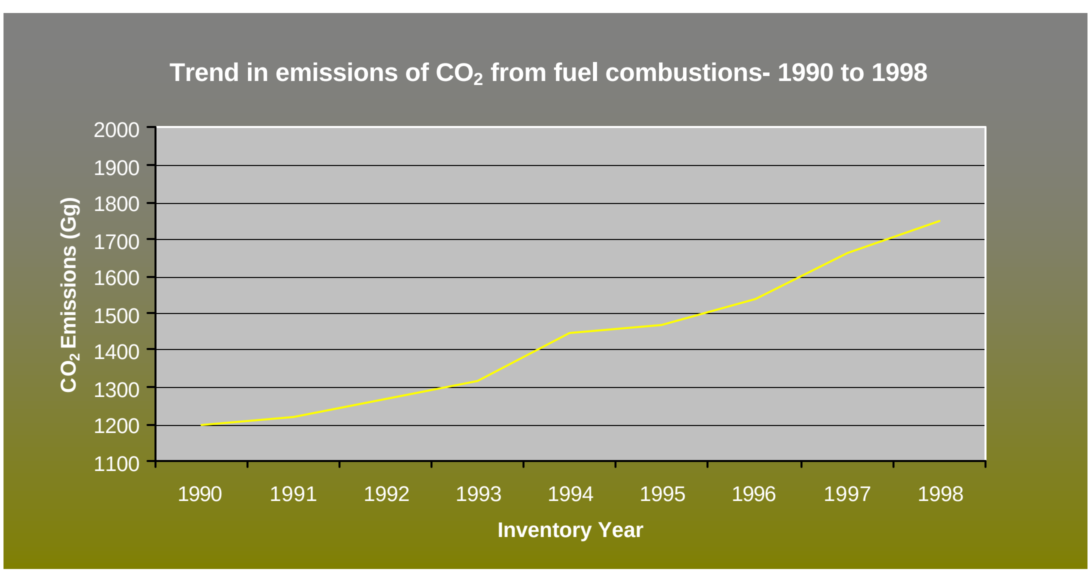
| | $CO_2$ emissions | | | | |
|---|---|---|---|---|---|
| | 1990* | 1991* | 1992* | 1993* | 1994 |
| Fuel combustion | 1198 | 1218 | 1266 | 1320 | 1446 |
| Industrial processes | N.O. | N.O. | N.O. | N.O. | N.O. |
| **Total CO2 emissions** | **1198** | **1218** | **1266** | **1320** | **1446** |
| | **$CO_2$ removal/emissions** | | | | |
| Changes in Forest/Woody Biomass | -26308 | -27149 | -27918 | -28597 | -29,195 |
| Forest/Grassland Conversion | 2531 | 2531 | 2531 | 2531 | 2531 |
| **Total $CO_2$ removal** | **-23,777** | **-24,618** | **-25,387** | **-26,066** | **-26,664** |
| | **Total national $CO_2$ emissions balance** | | | | |
| **Total emissions balance** | -22,579 | -23,400 | -24,121 | -24,746 | -25,218 |

| | $CO_2$ emissions | | | |
|---|---|---|---|---|
| | 1995 | 1996 | 1997 | 1998 |
| Fuel combustion | 1469 | 1538 | 1663 | 1749 |
| Industrial processes | N.O. | N.O. | N.O. | N.O. |
| **Total CO2 emissions** | **1469** | **1538** | **1663** | **1749** |
| | **$CO_2$ removal/emissions** | | | |
| Changes in Forest/Woody Biomass | -29990 | -30954 | -31788 | -33565 |
| Forest/Grassland Conversion | 2531 | 2531 | 2531 | 2531 |
| **Total $CO_2$ removal** | **-27459** | **-28423** | **-29257** | **-31034** |
| | **Total national $CO_2$ emissions balance** | | | |
| **Total emissions balance** | -25990 | -26885 | -27594 | -29285 |

*Determined by IPCC Reference Approach Methodology

**Note1:** Emissions from lubricants not included for the years 1990-1993 (data not available).
**Note 2:** Emissions from **biomass and international bunkers** are not included here.
**Note 3:** Negative values indicate removals.

*Fig. 4.7 Trend in emissions of carbon dioxide from fossil fuel combustion – 1990 to 1998 (Gg)*



*$CH_4$ Emissions*

The main source of $CH_4$ emissions in Guyana is from agricultural activities, that is, rice cultivation, and rearing of livestock (enteric fermentation & manure management). Methane is also produced from solid waste, combustion of fossil fuel, prescribed burning of savannahs, and forests/grassland conversion.

Methane emissions are very low when expressed in percentage of total emissions of the major greenhouse gases. For example, in 1994 and 1998 the combined total emissions of $CO_2$, $N_2O$ and $CH_4$ were 1501 Gg and 1809 Gg (excluding $CO_2$ emissions from biomass fuel) respectively. Out of these totals, only 3.59% (or 54 Gg) in 1994 and 3.26 % (or 59 Gg) in 1998 were represented as methane emissions.

Table 4.17 and Figure 4.8 provide estimates of methane emissions for the years 1990 to 1998. These show that $CH_4$ emissions rose from about 40 Gg in 1990 to about 60 Gg in 1998.

***Table 4.17: Methane emissions, 1990-1998 (Gg)***

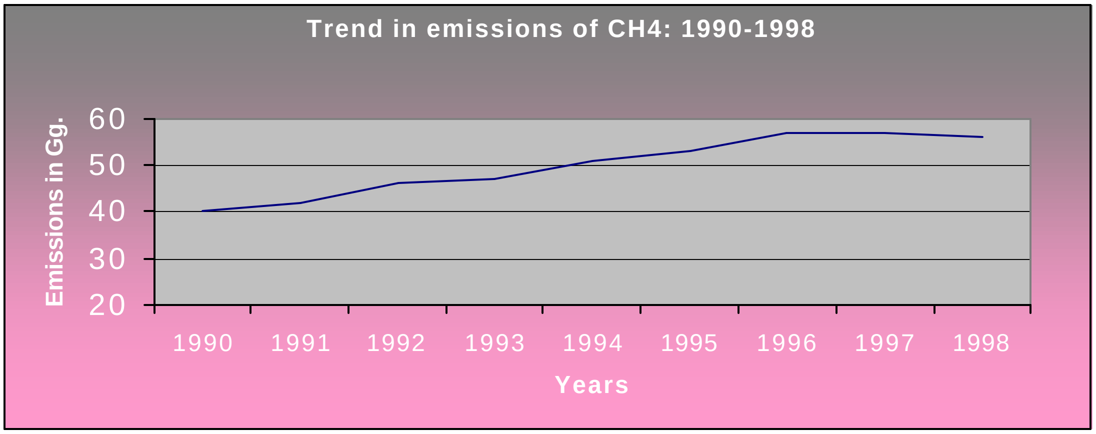
| | **1990** | **1991** | **1992** | **1993** | **1994** |
|---|---|---|---|---|---|
| **Fuel comb., total** | **N.E** | **N.E** | **N.E** | **N.E** | **1** |
| **Agriculture, total** | **31** | **33** | **37** | **39** | **41** |
| Rice Cultivation | 10 | 14 | 17 | 19 | 22 |
| Enteric Fermentation | 17 | 15 | 15 | 15 | 14 |
| other | 4 | 4 | 5 | 5 | 5 |
| **Forestry, total** | 8 | 8 | 8 | 8 | 8 |
| Forest Conversion | 8 | 8 | 8 | 8 | 8 |
| **Waste, total** | **1** | **1** | **1** | **1** | **1** |
| Solid waste disposal | 1 | 1 | 1 | 1 | 1 |
| **Total CH4 Emissions** | **40** | **42** | **46** | **48** | **51** |

| | **1995** | **1996** | **1997** | **1998** | |
|---|---|---|---|---|---|
| **Fuel comb. , total** | **1** | **1** | **1** | **1** | |
| **Agriculture, total** | **44** | **47** | **47** | **46** | 0 |
| Rice Cultivation | 25 | 27 | 27 | 26 | |
| Enteric Fermentation | 14 | 15 | 15 | 15 | |
| other | 5 | 5 | 5 | 5 | |
| **Forestry, total** | 8 | 8 | 8 | 8 | |
| Forest Conversion | 8 | 8 | 8 | 8 | |
| **Waste,total** | **1** | **1** | **1** | **1** | 0 |
| Solid waste disposal | 1 | 1 | 1 | 1 | |
| **Total CH4 Emissions** | **54** | **57** | **57** | **56** | **0** |

***Note***: 1. **Other** includes emissions from manure management, prescribed burning of savannahs and field burning of agricultural residues.

2. **(N.E.)** - not estimated (relevant data not available).

*Figure 4.8: Trend in emissions of $CH_4$ for the period 1990 to 1998.*




From Figure 4.8, it is evident that emissions rose gradually to the year 1996, then remained constant up to 1998. Generally, the increase in $CH_4$ over the period (1990-1998) was due mainly to the increase in land area cultivated for rice production, a main source for this gas from the anaerobic decomposition of organic material in flooded rice fields.

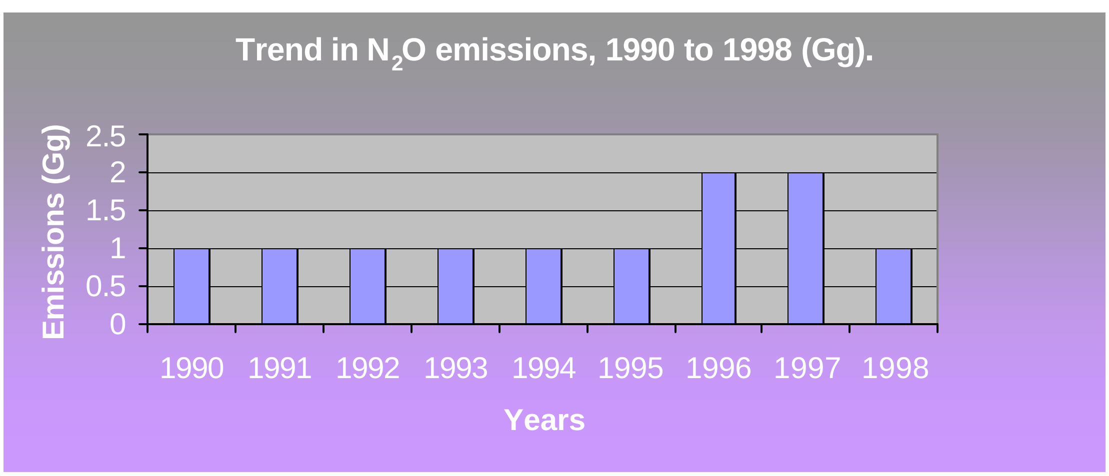
*$N_2O$ emissions*

Nitrous oxide emissions in Guyana were 1Gg in the years 1990,1991, 1992, 1993, 1994, 1995, and 1998. Emissions for the years 1996 and 1997 were 2 Gg.

The identified sources for this GHG are from agricultural activities (synthetic fertilizers usage; field burning of crop residues) and waste (human sewage). Organic amendments to soil are done on a very small scale and this is particularly related to kitchen gardens. Thus emissions are insignificant.

Figure 4.9 shows trend in $N_2O$ emissions (Gg), 1990 to 1998.

*Figure 4.9: Trend in $N_2O$ emissions, 1990-1998 (Gg).*



*Emissions of other indirect Greenhouse Gases*
*- NMVOC, CO, $NO_x$*

The source of NMVOC in Guyana is mainly from industrial processes: food and beverages production and road paving with asphalt. Carbon monoxide (CO) and nitrogen oxides ($NO_x$) are emitted from field burning of agricultural residue, fuel combustion (biomass & fossil fuel) and forest/grassland conversion.

Table 4.18 and Figure 4.10 provide emissions estimates (Gg) for these gases between 1990 and 1998.

The unusual increase of NMVOC emissions in 1994 was a result of emissions from road paving with asphalt, while emissions for the other years were not estimated (data not available). Emissions gradually increase over the years from **the other sources (i.e. production of alcoholic beverages and food items),** which arose from increased productions of these items.

CO shows a gradual increase from 1990 (136 Gg) to 1993 (161 Gg), but there was a jump to (208 Gg) in 1994. Emissions gradually increased from 1994 (208 Gg) to 1997 (216 Gg), then slightly dropped to 214 Gg in 1998.

$NO_x$ was more or less constant between 1990 and 1993, then increased suddenly to 17 Gg in 1994 and remained at that value up to 1998.

**Generally, it can be seen from figure 4.10 that there was a sharp increase in emissions for these gases in the year 1994, then gradually increasing to the year 1998. The main reason for the sharp increases in the year 1994 towards 1998 was because no emissions were estimated for the period 1990 –1993 from a few sources since no data was available. Full details are given below for the increase:**

**NOTE: The unusual increase of NMVOC in the year 1994 is explained above.**

1. **Emissions of non- $CO_2$ gases from the combustion of fossil and biomass fuels for the period 1990-1993 were not estimated since the relevant data was not available.**
2. **Increased crop cultivation as a result of increased cropland prior to and in the year, 1994 (mainly for rice production) generated more residues in the fields, which are burnt and emit these gases in substantial amounts.**
3. **Increased number of vehicles imported into the country prior to and in the year 1994, caused increase in the use of fossil fuel in vehicles and other machines/equipment, which is responsible for emissions, to some extent, of these gases.**

***Table 4.18. Indirect GHG Emissions (Gg)***

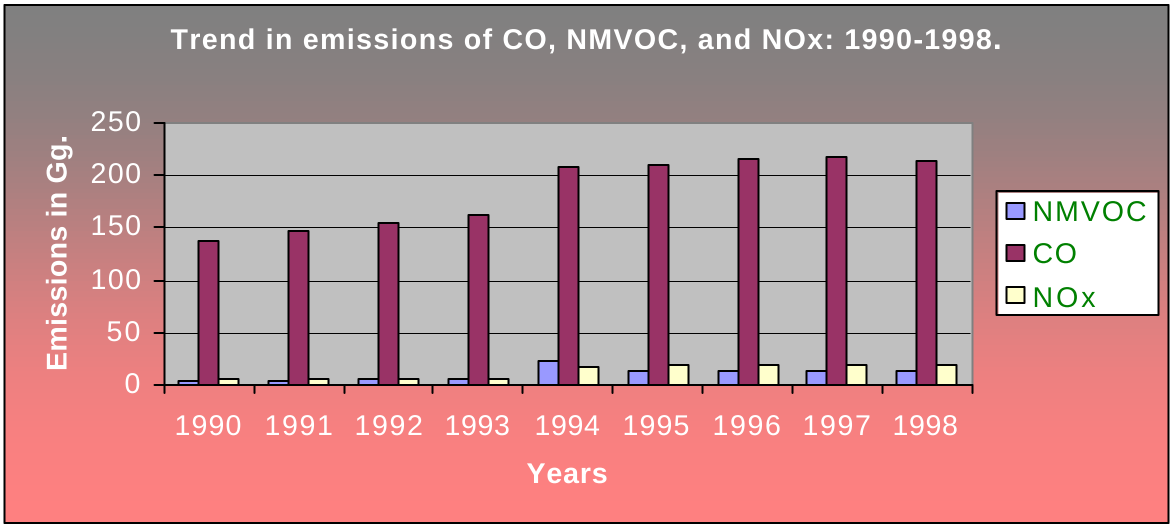
| | Emissions (Gg) | | | | |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 |
| NMVOC | 4 | 4 | 6 | 6 | 23 |
| CO | 136 | 146 | 155 | 161 | 208 |
| $NO_x$ | 5 | 5 | 6 | 6 | 17 |

| Year | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| NMVOC Emissions (Gg) | 12 | 13 | 13 | 13 |
| CO | 210 | 215 | 216 | 214 |
| $NO_x$ | 18 | 18 | 18 | 18 |

***Note:*** *1. Refer to summary tables for direct sources of emissions.*

*2. 1990 to 1993, emissions from fuel combustion not estimated – data not available.*

*Figure 4.10: Trend in emissions of the indirect greenhouse gases CO, NMVOC, and $NO_x$ for the period 1990 to 1998.*




## 4.9 SOURCES OF UNCERTAINTIES

It is evident that the calculations of sources and sinks of GHG's for the different sectors, as described above, incorporate several levels of uncertainty with respect to both the country activity data and the various conversion and emission factors. The ratings of these uncertainties are provided in Tables 4.B.1 to 4.B.4, which are found in appendix 4.B.

Energy Sector

The main source of uncertainty is the partitioning of the total fuels used in the different sub-sectors. This limits the results of the Sectoral Approach. However, for the Reference Approach, where the total fuels used are lumped together, there is lesser or very little uncertainty. Almost all activity data have been sourced locally from the Guyana Energy Agency.

Another source of uncertainty in the Energy Sector, regarding activity data, is with respect to the Memo items. For International Marine Bunkers, for instance, uncertainties exist since the data was partly estimated. Also, country statistics on charcoal and firewood (Biomass) burning were estimated. As for the emission factors for the various GHG's ($CO_2$, $CH_4$, $N_2O$, NOx, CO, NMVOC) the IPCC default values (mostly Tier 1) were used in all instances, since country–specific measurements are not available.

Industrial Sector

GHG emissions are restricted to NMVOC in the Road Paving and Alcoholic Beverages and Food Production industries. These two sources of emissions were the only ones relevant to Guyana. Activity data for these were obtained primarily from the Guyana Bureau of Statistics, so that uncertainties are minimal.

However the NMVOC emission factors are based on the IPCC default values, which may be somewhat unrepresentative based on the age and condition of the factories. Here again country specific conversion factors are not available.

Agriculture Sector

Several areas of uncertainty are encountered. FAO Statistical Yearbooks were used to obtain estimates of some animal population since national data did not address all types of livestocks. Also, data on the field burning of agricultural residues had to be derived from the IPCC methodology default values and expert estimates of the fraction of residues burnt in the field (locally) were used.

With regards to Prescribed Burning of Savannah, this is not a regular activity and may occur in small areas during the dry seasons. Actual data on savannah burnt annually were not available. However, the total area burnt annually represents a small percentage of the total savannah area. The IPCC default value (0.5) was not used. Rather, a factor of (0.065) was estimated to be relevant to Guyana. This is one area where uncertainty exists.

Land Use Change and Forestry

There are a number of uncertainties relating to GHG emissions and removals in this sector. There was a difficulty in assessing the fraction of the forested area which was anthropogenically impacted. In Guyana, selective logging is the criterion for timber extraction from an area. As such, to determine the actual area disturbed from logging operation was somewhat difficult. However, the Guyana Forestry Commission, based on it's Forestry Management Plan provided estimates. Areas being disturbed by mining activities and lands occupied/used by indigenous peoples were also estimated. There are uncertainties in the values assigned to these activities.

With regards to emission and conversion factors, the IPCC default values were used. Given the very general nature of these default values, country-specific values such as annual growth rate of forests may be quite different and introduce significant uncertainty in the GHG emissions and removals calculations.

Data on abandonment of managed lands was not available. However, initial assessment indicates that this will be insignificant. Hence, it was not considered in the inventory.

Waste Sector

The methodology utilizes population statistics for urban areas and this was used in the calculation of $CH_4$ emissions from solid waste disposal sites. The default values for India were used and the urban population statistics were also estimated. There is uncertainty here since the actual amount of waste deposited in disposal sites was not used since no data was available.

In the case of $N_2O$ emissions from human sewage, the IPCC default values were used. Also, the per capita protein consumption that was used was that for the Bahamas. This may not be applicable to Guyana and is a source of uncertainty.

Furthermore, although there are both domestic and industrial sources of wastewater in Guyana, $CH_4$ emissions were not calculated because there is no anaerobic treatment of wastewater.

Summary

In summary, the GHG emissions and removals for Guyana for the different sectors were calculated to the best of knowledge and ability. However, it must be cautioned that there are uncertainties in these estimates where the degree of uncertainty varies within each sectors.

The capacity of Guyanese Institutions to clear up these uncertainties is not there. The expertise to deal with these issues also needs to be addressed. However, with assistance from the UNFCCC, the capacity can be improved and studies can be attempted to address the uncertainties that have been highlighted.

## 4.10 SUMMARY AND CONCLUSIONS

Based on the inventory of GHG for Guyana for the reference year 1994, and the years preceding and following, it is evident that insofar as **$CO_2$ Emissions and Removals** are concerned, Guyana can be considered as a **Net Sink Country**, namely removals (**-26,664.47 Gg**) greatly exceed emissions (**1,446 Gg**) in 1994, resulting with a removal balance of (-25, 218 Gg) for $CO_2$.

Furthermore, $CO_2$ removals, which are largely due to absorption by its vast tracts of luxuriant tropical forests, are calculated based on the relatively small (13.8 % in 1998) anthropogenically-impacted fraction of the total forest area (16,450,000 ha). Guyana can increase its $CO_2$ sink capacity, through consideration of its total forest area, if it can justify the fact that its policies on forest conservation and preservation, whether or not with carbon sequestration in view, is an anthropogenic act.

As shown in the inventory, $CO_2$ emissions derived mainly from fuel combustion activities in the Energy sector. Any mitigation effort by Guyana can therefore focus on the activities in this sector.

Non-$CO_2$ emissions in Guyana are relatively small. **$CH_4$** emissions for instance derive mainly from rice cultivation and enteric fermentation in animals and manure in the **Agriculture** sector (**40.95 Gg in 1994**). **CO**, the only other non-$CO_2$ gas of note is emitted by the **Energy (45 Gg)**, **Land Use Change and Forestry (68 Gg)** and the **Agriculture (95 Gg)** sectors in 1994. Guyana's mitigation efforts can therefore be directed at the activities in these sectors.

The national inventory was calculated using rough estimations due to the lack of adequate activity data, and applying indirect default emission factors. Guyana needs to develop the capacity to prepare emission factors for local conditions so that uncertainties in future inventories may be reduced.