Country Case Study on Sources and Sinks of Greenhouse Gases in Costa Rica

Final Report

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PREFACE

In accordance with Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC), all Parties are required to develop, periodically update, publish and make available to the Conference of the Parties, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol using comparable methodologies to be agreed upon by the Conference of the Parties.

A methodology for conducting such inventories was developed by the OECD Environment Directorate, the International Energy Agency (IEA), and the IPCC Working Group I Technical Support Unit and was proposed as the standard methodology as required under the Convention.

In order to test and further refine the method, the UNEP Atmosphere Unit, working in collaboration with the UNEP Global Environment Facility (GEF), implemented a series of nine complementary national studies using these "IPCC Guidelines for National Greenhouse Gas Inventories".

This report is one of the nine technical reports resulting from this effort. Based partly on this study and on a series of regional workshops sponsored by UNEP under the GEF funded programme and with the assistance of experts from a number of countries, an improved version of the IPCC Guidelines was prepared and approved at the Tenth Plenary Session of the IPCC in Nairobi (November 1994).

The First Conference of the Parties to the UNFCCC (Berlin, April 1995) also adopted the IPCC methodology as the recommended standard to be employed by all Parties in making their inventories in accordance with Article 4.

It is hoped that this report will assist other country study teams in the development and updating of future inventories of greenhouse gases.

E. Dowdeswell

Elizabeth Dowdeswell
Executive Director
United Nations Environment Programme

THE REPUBLIC OF COSTA RICA

NATIONAL INVENTORY OF SOURCES AND SINKS OF GREENHOUSE GASES IN COSTA RICA

PROJECT GF/4102-92-42 (PP/3011)

FINAL REPORT

Ministry of Natural Resources, Energy and Mines
National Meteorological Institute
P. O. Box 7 - 3350 - 1000
San Jose, Costa Rica

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Costa Rica National Inventory of Greenhouse Gases Emissions by Sources and Sinks

Instituto Meteorológico Nacional
Ministerio de Recursos Naturales Energía y Minas
UNEP

(Project GF 4102/92/42)
(Subproject XII)

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NATIONAL TEAM

The technical team responsible for the evaluation of the inventory was integrated by the following members:

COORDINATION, EVALUATION AND EDITION

M. Sc. Patricia Ramírez Obando	Meteorologist, National Meteorological Institutel
Eng. Ana Rita Chacón Araya	Chemical Engineer

ENERGY

Eng. Alexandra Hernández	Civil Engineer Sectorial Direction for Energy
Eng. Hanzel Rodríguez	Mechanical Engineer Sectorial Direction for Energy
Eng. Paula Chaves Alfaro	Chemical Engineer
Eng. José Joaquín Hernández	Chemical Engineer

INDUSTRIAL PROCESSES

Eng. Ana Rita Chacón Araya	Chemical Engineer

AGRICULTURE AND WASTE MANAGEMENT

M. Sc. Fernando José Mojica	Agronomical Engineer, Ministry of Agriculture
Eng. Carlos Ramírez	Agronomical Engineer

LAND USE CHANGE AND FORESTRY

Evaluation of Forested areas

Eng. Edwin Syrus S.	Forestry Engineer, General Direction on Forestry
Eng. Damaris Garita	Forestry Engineer, General Direction on Forestry
Eng. José Joaquín Matarrita	Forestry Engineer, General Direction on Forestry

Evaluation of Land Use Changes

Lic. Rodolfo Méndez Chinchilla	Geographer, Ministry of Agriculture
Lic. Vera Salazar	Geographer, Ministry of Agriculture
Lic. Christian Asch	Geographer, National Geographic Institute

Analysis and interpretation of Satellite Pictures

Lic. Mercedes Artavia Rodríguez	Geographer
B. A. Gisselle Flores Villalobos	Geographer
B. A. Marta Aguilar Varela	Geographer

Bibliographical Research

Hannia Delgado S.	Library Sc. Student.

EXECUTIVE SUMMARY

Earth's atmosphere has been in constant change through time but nevertheless the faster pace of more recent times has been alarming: the atmosphere's composition has changed with an acceleration unknown in any other stage of human history.

The sustained increase of greenhouse gases in the atmosphere, caused by human activities, is the main cause of alarm since we know with certitude that the affected radiative balance of the atmosphere will produce global climate changes.

In June, 1992, in Rio de Janeiro, Brazil, 155 countries signed a Framework Convention on Climate Change, which main objective was to attain the stabilization of greenhouse effect gases concentrations in the atmosphere, at such a level to stop the dangerous anthropogenic interferences in the climate system. The signatory countries at the Convention got involved, among other objectives, in the performance of national inventories on the emissions of greenhouse effect gases and in the implementation of national programs aiming to provide measures towards the mitigation of climatic change.

Costa Rica ratified the Convention on June 13, 1994 and as part of its compromise and as part of the National Program on Climate Change, the first inventory of emissions of greenhouse effect gases in the country was implemented.

In order to make the results of the inventory able to be compared with those from other countries, it was carried out by following the "Guidelines for the Elaboration of National Inventories on Greenhouse gases" as proposed by the IPCC/OECD (1994) and the reference year was 1990.

The National Inventory on Emissions of Greenhouse Effect Gases for Costa Rica, was elaborated as part of a larger project: " Country Studies, by sources and sinks of greenhouse gases emissions". (GF/4102-92-42), implemented by the Climate Unit of the United Nations Program for the Environment (UNEP) and sponsored by the Global Environmental Fund (GEF).

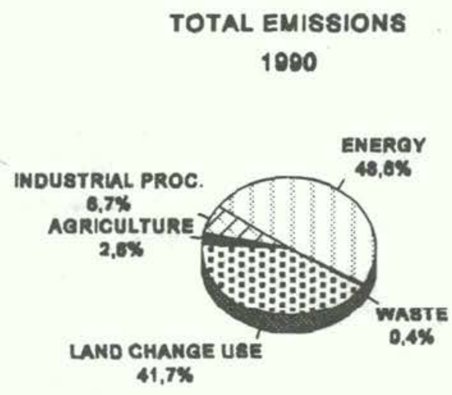
The evaluation was charged to the National Meteorology Institute, which in turn coordinated a team of professionals and technicians from various institutions.

The inventory included six gases: Carbon Dioxide (CO_2), Carbon Monoxide (CO), nitrous oxide (N_2O), methane (CH_4), nitrogen oxides (NOx), and Non-Methane Volatile Organic Compounds (NMVOC), in five economic activity areas: Energy, Industrial Processing, Agriculture, Changes in Land Usage and Forestry and Waste Management.

The total emissions for greenhouse gases in Costa Rica for the year 1990 were estimated to be 5479.3 Gg, which is equivalent to 5 479 300 tons. To this total, the Energy Sector contributed with 2665.6 Gg (2 665 600 tons), Industrial Processes with 367.9 Gg (367 900 tons), Agriculture with 139.81 Gg (139 810 tons), Changes in Land Usage 2 285 450 tons), and Waste Management with 20.5 Gg (20 500 tons).

The Percentage Distribution for each one of the aforementioned sectors appears in figure 1.

FIGURE 1



A resume of the results by sector follows herein:

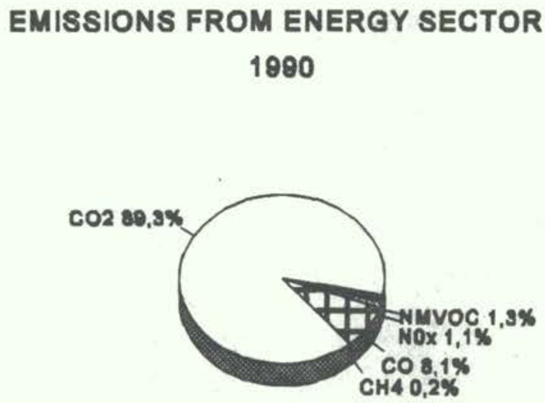
1. ENERGY

The production, transformation, management and energy consumption activities are known to generate important amounts of greenhouse gases. In this section the emissions produced by the consumption of fossil fuel, by the usage of the biomass as fuel and by the fugitive emissions due to storage and transportation of hydrocarbons were evaluated.

For the Energy Sector, we estimated separately, the emissions of CO_2 and the emissions for all other gases (CO, NOx, N_2O, CH_4 and NMVOC).

The total emissions in 1990 accounted for 2665.6 Gg, amount that represents 48.6% of the total emissions. The percentage contribution from each one of the gases is represented in figure 2.

FIGURE 2



CO_2 EMISSIONS

The estimations of CO_2 were done over the total imports and production of fuels and the final usage of fuels. They were calculated upon the basis of an apparent consumption of 35177 TJ, for 1990.

The apparent consumption of solid biomass in 1990 was 31029 TJ, nonetheless, the CO_2 emissions for such usage were not accounted for, since the biomass comes mainly from pruning and agricultural residues in renewable systems (since the plants grow the following year), reason for which the emitted CO_2 was considered fixed again in the vegetation.

CO_2 emissions in Costa Rica for 1990 were estimated in 2381.4 Gigagrams (Gg) that represents a 43.5% of the total emission of greenhouse gases.

EMISSIONS FROM OTHER GASES

The calculations for other gases different from CO_2, were divided in four sections: Mobile sources; stationary sources; burning of biomass and fugitive sources.

EMISSIONS FROM MOBILE SOURCES

The estimation of emissions from mobile sources included CO, CH_4, NOx, N_2O, and NMVOC, was calculated over the average consumption of fuel, estimated over the number of vehicles in the country, average mileage by vehicle and type of fuel.

The total emissions from mobile sources were estimated in 233.15 Gg, amount that is divided in 200.3 Gg (85.9%), from gasoline motor vehicles and 32.85 Gg (14.1%), for Diesel fuel vehicles.

In the estimated emissions from gasoline vehicles, 80.05 Gg (50%) are carbon monoxide produced by automobiles, followed by light trucks and pick ups with 25% (40.66 Gg) and motorcycles with 13% (21.32 Gg).

As for the methane emissions, automobiles contributed with 35% of the emissions, followed by four-wheel traction cars and motorcycles with a percentage of 29% each.

Likely, automobiles contributed with 54% of the NOx emissions, followed by light trucks with a 31%.

N_2O emissions in automobiles and light trucks were equally distributed with 50% each, respectively.

Finally, a 43% of the NMVOC emissions were provided by automobiles, 27% by light trucks and 20% by motorcycles.

The emissions for diesel fuel consumption were basically produced by heavy trucks, which contribute with 80.4% of all carbon monoxide emissions, followed by light trucks responsible for a 9.9% of the emissions for diesel consumption. These vehicles were responsible for NOx, N_2O, and NMVOC emissions, in the same proportions as those for CO above.

Of the total emissions corresponding to mobile sources using diesel fuel, three gases were encountered to be the most important: NOx with a 56%, CO with 32% and NMVOC with 12%.

EMISSIONS FROM STATIONARY SOURCES

Emissions from stationary sources for 1990, have been classified in various sectors, according to the type of source: Industrial, Residential, Commercial, Public, Agriculture and Transformation.

The Agriculture and Industrial Sectors include the energy consumption of manufacturing and agricultural industries, as well as the agricultural consumption by itself.

The Transformation Sector includes consumption related to the production of electricity by means of thermal plants and the transformation of primary sources into secondary sources, as in the case of oil refineries.

The results obtained for these gases showed that the Industrial and the Transformation Sectors are the major contributors with 1.6 Gg and 0.455 Gg, accordingly.

EMISSIONS FROM BURNING THE BIOMASS

We considered two types of biomass: the liquid and the solid biomass. CO_2 emissions coming from biomass utilized as fuel, did not account herein since this usage of the biomass is considered to be a sustainable one.

The liquid biomass comprehends the production of ethanol. In 1990 the production of ethanol was estimated in 487 TJ. Notwithstanding the large amount, the alcohol produced was not used as an energy source: it was utilized entirely in the pharmaceutical industries and the production of alcoholic beverages.

The solid biomass includes firewood, coffee peelings or husks, "bagazo" (dried sugar cane stalks) and other agricultural residue. This type of biomass causes the emission of other gases, of which methane represents 19.4% and carbon monoxide gets a 78.4%, of the total emissions for that gas in the Energy Sector.

EMISSIONS FROM FUGITIVE SOURCES

Fugitive emissions are the ones produced by volatile hydrocarbons which escape during the manipulation of fuels. In Costa Rica this gas sources are very scarce, since the country does not count with natural oil nor gas wells. The only emissions found are those from the storage and refining of crude oil.

Methane emissions in this division were estimated to be 1.55 E-2 Gg of methane, which corresponds to 0.3% of the total emissions for this gas in the Energy Sector.

The emissions for other gases in the Energy Sector totalized 284.2 Gg, which contributes with

5.2% to the total emission in the Energy Sector.

SECTION 2: INDUSTRIAL PROCESSES

Industrial processing and production, which always include some type of chemical of physical transformation of some materials, do cause emissions of greenhouse gases.

In the case of Costa Rica we considered the emissions generated solely by the cement production industry, since the IPCC methodology has not yet developed guidelines for other types of industrial processes.

Cement production in 1990 was 738000 tons, which in turn generated 367.9 Gg, that is 367900 tons of CO2, amount that represents a 7.5% of total emissions for that gas.

SECTION 3: AGRICULTURE

Gas emissions due to agricultural activities are related to diverse processes of production and handling, in which methane, carbon monoxide and nitrous oxide are released.

The Agriculture Section was subdivided, for evaluation purposes, in five subsections:

- Emissions from cattle and other farm animals.
- Emissions from rice production.
- Emissions from burning of Savannahs.
- Emissions from burning of agricultural residues.
- Emissions from agricultural soil.

CATTLE AND OTHER FARM ANIMALS

The subsection of cattle and farm animals includes the methane emissions caused by enteric fermentation and by the handling of manure.

The estimation of the emissions was done taking into account the population of cattle and farm animals in the country for 1990, the information available on feeding and managing systems and the emission factors for each specie.

In order to estimate the emissions from manure handling and disposal, the number of animals which are kept in confinement and whose manure is handled in closed systems was taken into account, as well as, emissions from animals managed in pastures were taking into account using diferents emission factors..

The emissions for enteric fermentation accounted for 111.66 Gg of methane and the emissions for manure handling were 3.5 Gg, which represented a total of 115.2 Gg.

RICE PRODUCTION

In the flooded soils used in rice plantations, methane is produced by the reduction of carbon dioxide with hydrogen, and this reaction depends on the amount of hydrogen-donating agents and on the type of soil. The production of flooded-field rice produce methane emissions due to the anaerobic decomposition of organic matter that remains under water.

In Costa Rica in 1990, 12000 hectares were cultivated with flooded rice and over this area was estimated the emission of methane accounted 8.67 Gg.

BURNING OF SAVANNAS

The seasonal burning of pastures and savannahs generates emissions of CO_2, CO, CH_4, N_2O and NOx. In the estimation the emissions of CO_2 were considerated to be null (0), since the following year growth of the vegetation replaces the burned biomass and fixes the gas again but the emissions of all the other gases, were considered net emissions.

The emissions for other gases in the inventory were estimated over the number of hectares which are burned each year, and calculated over the information on fires and the evaluation of burned areas obtained after the analysis of Landsat TM images.

The emissions totalized for 2.77 Gg, of which 95% were carbon monoxide emissions.

BURNING OF AGRICULTURAL RESIDUES

Residues and waste produced in agricultural activities are either burned in the fields, left to decay and decompose or used as fuel. The burning of agricultural residues in the fields is considered a non-producer of net emissions of CO2, since this gas is re-absorbed in the next cultivation period but such burning does produce net emissions of other gases.

INTRODUCTION

In 1990, on its first evaluation report, the Intergoverment Panel on Climatic Change (IPCC) concluded that the increment of concentrations of greenhouse gases on the atmosphere, orginated by human activity, could warm the planet's surface and that if those gas emissions were to coontinue at the current rate, the average world temperature would increase during the next century at a rate of 0.3 °C each decade (with a gap of 0,2 a 0,5 ° C).

As an answer to the concern caused by the report, 155 countries were joined in Rio de Janeiro, Brazil, on June, 1992; signed a Framework Convention on Climatic Change, whose main objective was to attain an stabilization of greenhouse gases concentrations in the atmosphere, at a level low enough to stop dangerous anthropogenic interferences in the climatic system.

The signatory countries of the Convention committed themselves, among other objectives, towards the implementation of national programs containing measures to be taken in order to reduce climatic changes and in order to be prepared for the impacts of adapting to such changes. Likewise, they were compromised as for taking into account, inasmuch as possinle be, all considerations related to climatic changes on their policies, economic and social plans; to promote and support the development and diffusion of practical technologies and processes leading to the reduction or prevention of emissions, and to promote education, training and sensibilization of the general public on the subject.

The Convention was to be enforced since March, 19994 and its compromises became mandatory for the signatory countries. Costa Rica ratified the Convention on June 13, 1994 and in an effort to apply the policies and as part of the National Program for Climate Change, it implemented the first inventory on greenhouse gases emissions, by sources and sinks, in the country.

THE INVENTORY PROCESS

In order to meet the Convention specifications, on what concerns the inventories using comparative methods, the first inventory for Costa Rica was implemented following the guidelines for the elaboration of national inventories on greenhouse gases, provided by IPCC-OECD (1991). Following the guidelines stated in the agreement of the Negotiating Committee of the Framework Convention on the aforementioned year, the emisssions were evaluated for 1990, so that the inventory could be comparable with those elaborated by other countries.

Box 1

THE RADIATIVE FORCING

On yearly average of around one third of the radiation coming from the sun is reflected back into space; the rest is absorbed into the atmosphere, but most of that radiation is in turn absorbed by the terrestrial surface, the ocean and the ice layers. Solar radiation absorbed by the surface and the atmosphere (around 240 Watts/m^2) is compensated at the top atmospheric layers, by the radiation going out in infrared wave longitudes.

A change in the net radiation at the top of the troposphere (also known as tropopause), due to changes in either the solar radiation or the infrared radiation, is defined as the "*Radiation Forcing*". A radiative forcing alters the balance between the " in coming" radiation and the "out coming" radiation, and over a certain period of time, the climate responds to this alterations by trying to reestablish the radiation balance. A positive radiation forcing tends -on the average- to warm the surface, and a negative radiation forcing tends to cool off the surface.

The anthropogenic emissions of gases, such as CO_2, CH_4, N_2O, CFCs and other halocarbons, contribute to the increase of the "greenhouse effect". Some atmospheric minor constituent, such as nitrogen oxides and carbon monoxide, in despite of being non-greenhouse gases by themselves, may influence the concentration of other gases with positive greenhouse effect (particularly, the tropospheric ozone), through atmospheric chemistry. Contributions of this type are known as indirect radiative forcing.

Human activities have also produced an increase of the amount of aerosols in the atmosphere, originated mainly by the oxidizing of sulphur dioxide (SO_2) and the burning of the biomass, which cause a direct radiative forcing by the reflection and absorption of solar radiation. An indirect radiative forcing is believed to result from the influence of aerosols on the size of water drops in clouds, and subsequently, on its reflectivity. The radiative effect of aerosols is mainly negative and tends to cool off the surface.

Natural factors, such as the increment of aerosols in the atmosphere, produced by volcanic activity or by changes in the solar emissions, may also produce a radiative forcing.

The magnitude and the chronology of the climatic changes due to radiative forcing may depend on the concentration of greenhouse gases and aerosols, on their growth rate and on the specific responses of the climatic system.

Taken from: IPCC, 1994.

Box 2

THE GREENHOUSE EFFECT

The Earth absorbs solar radiation, mainly on its surface. The atmosphere and the oceans radiate this energy back as long wave radiation (thermal, terrestrial or infrared). In the atmosphere, part of this thermal radiation is absorbed by radiatively active gas (the greenhouse gases), mostly by water vapor but also by carbon dioxide, methane, fluorocarbons (CFCs), ozone and other gases. Absorbed energy is radiated back in all directions, both upwards and downwards, so that radiation which is eventually lost into space comes mostly from the colder and higher layers of the atmosphere. The result of all this is that the surface loses less heat into space than it would lose in the absence of such gases with a greenhouse effect and therefore keeps itself warmer. This phenomenon, which works as a blanket wrapped around the earth, is known as the greenhouse effect.
Taken from: IPCC, 1992.

The inventory was elaborated mainly as part of the project entitled "Country Studies of Greenhoiuse Gases Emissions by sources and sinks" (GF/4102-92-01), sponsored by the Climate Unit of the United Nations Environmental Program (UNEP) and financed by the Global Environmental Fund (GEF).

The evaluation of the inventory was charged to the NATIONAL METEOROLOGICAL INSTITUTE, which coordinated the work of a an experts team with specialists from many associated institutions working in the areas of energy, industrial processes, agriculture, land use and waste management.

The inventory included six gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO), nitrogen oxides (NOx) and other non methane volatile organic compounds (NMVOC). Fluorocarbons were not included since they are included in the Montreal Protocol and not in the Framework Climate Convention.

ORGANIZATION OF THE INVENTORY

According to the IPCC methodology, the inventory was divided into five main areas, corresponding to the five most important categories: Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste Management.

In the Energy Sector emissions were estimated of:
- CO_2 by combustion of fossil fuels
- Other gases, produced by combustion on mobile sources
- Other gases, produced by combustion on stationary sources
- Other gases, produced by combustion of biomass
- Methane from manipulation of hydrocarbons

On what concerns Industrial Processes, the inventory focused on the production of cement, as there is not a well defined methodology for the analysis of other industrial processes.

In Agriculture, the emissions of methane were calculated from:

- Enteric fermentation
- Manure disposal
- Rice production

The emissions of other gases, produced by burning other agricultural residues and savanna burning, as well as the emission of nitrous oxide (N_2O), produced by the utilization of fertilizers in agricultural soils were also calculated.

In the section Land Use Change and Forestry, the inventory included estimations of the emissions and absorptions of CO_2, for:

- Changes in forest and other woody biomass stocks
- Forest and Grasslands conversion
- Abandonment of managed lands

Moreover, for the emissions of other gases by burning of forests *in situ* were also accounted.

In the section Waste management, the emissions of methane in landfills and wastewater were accounted.

Box 3

INTERGOVERNMENTAL PANEL ON CLIMATIC CHANGE (IPCC)

The Inter-govermental Panel of Experts on Climatic Change (IPCC) was established by the World Meteorological Organization (OMM) and the United Nations for the Environmental Program (UNEP), in 1988 with the following objectives:

(i) Evaluation of scientific information related to various subjects including the problems of climatic change, such as the emissions of the two most important greenhouse gases, the alteration of the radiative balance on Earth, and the necessary steps in order to evaluate the social and economic consequences of the climate change.

(ii) Formulation of strategies as a realistic response to the problems set by the climate change.

The group of experts started their duty by establishing three work teams charged with:

(a) assess available scientific information on climate change,

(b) assess the environmental and socio-economic impacts of climate change, and

(c) formulate response strategies.

The Group of Experts completed their first evaluation report in 1990, which consisted of:

- General review
- Resumes for those responsible of policies in the three work teams of IPCC.
- Reports from the three work teams of IPCC.

In their fifth session, in March 1991, the Panel adopted a set of guidelines which the countries may utilize in order to implement national inventories on the emissions of greenhouse gases, base on the Compendium of Methods, compiled by the Organization for Economic Development and Cooperation (OECD), the International Agency for Energy (AIE), with support from the U.S.A., the UK, and Norway.

Since then, the Work Group for Scientific Evaluations (Group I), working together with the OECD and the AIE, refined the methodology for the generation of reports on the national emission rates, reports which would count with international recognition and, also establish systems and procedures for data gathering, such as the compilation, revision, and generation of reports of national inventories.

The IPCC/OECD program provided technical support for the national projects and studies on the inventories of greenhouse gases, sponsored by the UNEP and other organizations.

Taken from: IPCC, 1992

Box 4

GENERAL INFORMATION ON COSTA RICA

Costa Rica is a Central American country, located between latitude of 8° 2' 26" to 11°° 0' 0" and a longitude of 82° 33' 48" to 85° 57' 57". It has a extension of 51000 Sq. Km, and it is located between the Atlantic and Pacific Oceans.

Costa Rica has a mountain range which crosses the country from Northeast to Southeast, presenting a diverse range of terrains from lowlands up to peaks 3850 meters high; it has average temperatures of 25 to 27 °C in the lowlands, and 10 to 12.5 °C in the mountain zones, with precipitation ranging from 1500 mm to 5000 mm per year.

The country has a population of around 3 100 000 inhabitants, of which 1 500 000 inhabitants is the economically active population, and this is found mainly in the major economic activities: Agriculture (24%), Services (24%), Commerce (20%), Industry (19%), Construction (16%) and Public Services (6%).

The capital city, San Jose, is located in the central sector of the country and it is the labor hub of the nation. The Central Plateau is the most densely populated sector and hosts approximately 1 500 000 people, and it is also the sector with most of the industrial, commercial and services activities.

Aproximately, 20% of the national territory is found under some kind of protection (forestry, wildlife or national park), and this makes of Costa Rica one of the countries with more protected territory.

Agricultural exports and tourism are the main sources of currency. Bananas, coffee, sugar cane, flowers and ornamental plants are the main exports of the country. In 1990, there were 11 000 hectares planted with coffee, 28 296 hectares with bananas, 68 152 hectares with non-traditional crops (sepsa, 1993), which represented, respectively, 6%, 24% and 15% of the total cultivated lands for that year. Grains for internal consumption (rice, beans, corn) occupied an area of 180 893 hectares (SEPSA, 1993), equivalent to 40% of the total cultivated area.

SECTION 1. ENERGY

The energetic sectors are of primordial importance for national economies. Nevertheless, production activities, transformations, managements and consumption of energy, are known to generate important amounts of greenhouse gases such as carbon dioxide and monoxide, methane and other hydrocarbons, nitrous oxide and nitrogen oxides, among others.

Costa Rica utilizes hidroelectric, thermal and geo-thermal energy. As sources the biomass and fossil fuels are utilized. The main fossil fuel is petrol, which is imported as crude oil or as derivated products. The biomass is used as fuel in important amounts, and this biomass comes mostly from coffee peelings, sugar cane waste, firewood and other agricultural residues.

For the energy sector the emissions of CO_2 and other gases such as: CO, N_2O, CH_4, NO_x y NMVOC (acronym for Non Methane Volatile Organic Compounds) were estimated.

EMISSIONS OF CARBON DIOXIDE

For the calculations of CO_2 emissions the "top-down" system was used, which estimated emissions from the total consumption and subdivides this total by type of fuel. The basic information was taken from the National Energetic Balance for 1990 (DSE, 1991), which accounted all data for imports, exports and changes in stocks for that year.

The imports of fossil fuel, both solid and liquid, was of 42073 terajoules (TJ), of which 4088 TJ were exported and there was an increment in stocks of 1065 TJ. Of the imported total, 1743 were consumed in international air transport and, in accordance with the methodology, this amount is added up to international deposits. For the estimation of aviation kerosene, which adds to international deposits, the consumption of this fuel in domestic flights and was found to be 3.6% of the final consumption.

The apparent consumption for 1990, was of 35177 TJ; it was called apparent because some fuel was not utilized for energetic purpose, which means it does not act as a carbon deposit, such being the case of asphalt and asphaltic mixes, which were used in road pavement; of naphtha, both light and heavy, which was used in the production of plastics and solvents, and 1% of kerosene, which was also used as solvent.

The emission factors for carbon and for combustion efficiency, necessary for estimating CO_2 emissions, were provided by the IPCC in their Reference Manual. Fuel effciency for liquid fuels was assumed to be 0.99 and for solid fuels that of 0.98. (See appendixes).

Table 1.1 shows the types of fuels utilized in the country, as well as their respective apparent consumption, the emission factor for carbon and the estimated CO_2 emissions.

TABLE 1.1
CO_2 EMISSIONS, BY TYPE OF FOSSIL FUEL

TYPE OF FUEL		APPARENT CONSUMPTION (TJ)	CARBON EMISSION FACTOR	EMISSIONS OF CO_2 (Gg)
LÍQUIDS				
	CRUDE OIL	17391	20,0	1262.58
	GASOLINE	6393	18,9	438.61
	JET KEROSENE	-941	19,5	-66.62
	OTHER KEROSENE	67	19,6	4.69
	GAS/DIESEL OIL	12898	20,2	945.74
	RESIDUAL FUEL OIL	1087	21,1	83.27
	LPG	1049	17,2	65.49
	NAPHTHA	532	20,0	-47.73
	ASPHALT	246	22,0	-47.59
	IFOS	-3555	20,0	-258.1
LÍQUID TOTALS		35167	-	2380.34
SOLIDS				
	MINERAL CARBON	3	26,2	0.29
	COKE	7	29,5	0.77
SOLID TOTALS		10	-	1.06
TOTAL		35177	-	2381.4

In 1990, the apparent consumption of the solid biomass was that of 31029 TJ. This biomass account for the utilization of firewood, coffee peelings, sugar cane waste and other agricultural residues. Firewood is mostly used for domestic, industrial and commercial energy and the most common sources is pruning of shade trees in some crops such as coffee, along with wood from agroforestry systems and garden hedges. This energetic source is considered to be sustainable as it allows the biomass to grow again. For that reason, the emissions of CO_2 from the biomass when used as fuel, do not account for the total of emissions.

Table 1.2, shows CO_2 emissions, by biomass combustion.

TABLE 1.2
CO_2 EMISSIONS ORIGINATED FROM THE BIOMASS

TYPE	APPARENT CONSUMPTION (TJ)	CO_2 EMISSIONS (Gg)
Solid biomass	31029	3367.8
Liquid biomass	487	N/A
Gaseous biomass	N/A	N/A
TOTAL	31516	3367.8

N/A: Does not apply.

CO_2 emissions for the Energy Sector, were estimated in 2381.4 Gg which represents a 48.4% of the total emissions for the gas in the sector.

EMISSIONS OF OTHER GASES

The calculations for the emissions of other greenhouse gases, different from CO_2, were divided in the following subsections: mobile sources, stationary sources, emissions from the burning of biomass and fugitive emissions.

The calculations for the emissions of stationary sources were done upon the basis of residual fuel oil and diesel oil consumptions in the industrial, commercial, residential, agricultural and transformation sectors. No calculation was done for the individual consumption, due to lack of information on group consumption.

As for mobile sources the consumption was itemized by type of fuel (gasoline or diesel oil), and also by type of motor vehicle.

In the biomass subsection for the emission of other gases produced by burning firewood, coffee peelings, sugar cane waste and other agricultural residues were accounted.

In the fugitive emissions subsection, the methane emissions caused by manipulation of hydrocarbons was estimated.

EMISSIONS BY MOBILE SOURCES

For the estimation of emissions coming from mobile sources we performed a research to find out the average annual mileage and the existence or non-existence of catalytic convertors in motor vehicles in Costa Rica, for the year 1990. The research was directed to both gasoline and diesel oil cars. The motor vehicles under the study were: automobiles (motor cars of particular use), jeeps (four-wheel traction cars), family vans, light and heavy trucks. Following this categories, in order to determine their annual average mileage and to determine the use of catalytic converters was carried to sampling.

In order to estimate the annual average running of buses, taxis and motorcycles, information on the amount of these types of vehicles found at the Public Registre for Property was obtained at the Energy Sector Direction the annual mileage was calculated (DSE, 1991).

The number of vehicles in Costa Rica was obtained from the report "Information Update on the motor vehicle sector, up to December, 1993" (Villegas, 1994).

CO, CH_4, NO_x, N_2O y NMVOC for emissions were calculated utilizing the emission factors provided by the IPCC methods, both for diesel oil vehicles and gasoline cars. The emission factors used for vehicles without an emission control device, as according to the results of the research on annual average mileage and usage of converters (Villegas, 1994), most motor vehicles in the country do not have a catalytic converter, or else if it once had that type of device, it is malfunctioning or has been eliminated.

The emission factors for gasoline vehicles, by type of gas emitted, appear on Table 1.6, in appendix 1.

In Costa Rica, the number of automobiles surpasses that of other types of motor vehicles. All heavy trucks in the country use diesel oil, carbon monoxide emissions for use of gasoline in mobile sources were as follows: 50%, thhat is 80.85 Gg was provided by automobiles; light trucks show

25% (40.66 Gg) and motorcycles follow with 13% (21.32 Gg),

As for methane emissions, the most important contribution were from automobiles, with 35%, followed by four-wheel traction (jeeps) cars and motorcycles with 29% each.

Likewise, automobiles contribute with 54% of the NO_x emissions, followed by the light trucks with 31%.

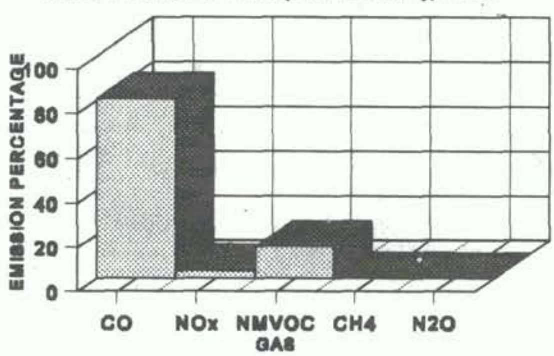
On what concerns N_2O emissions, automobiles and light trucks account, each one respectively, for 50%.

Finally, 43% of the NMVOC emissions was provided by automobiles, 27% by light trucks and 20% by motorcycles.

Emissions caused by gasoline in mobile sources, by type of gas, shown as percentages of the total of emissions, are presented in figure 1.1, it can be observed in the figure that CO contributes to 81% and NMVOC accounts for 15%.

FIGURE 1.1

TOTAL EMISSIONS
MOBILE SOURCES (GASOLINE), 1990



As for transportation vehicles using diesel oil, heavy trucks account for 80.4% of the CO emissions, followed by light trucks with a 9.9%.

Methane emissions and their proportions are very similar to carbon monoxide emissions.

NO_x emissions are mostly produced by heavy trucks and light trucks.

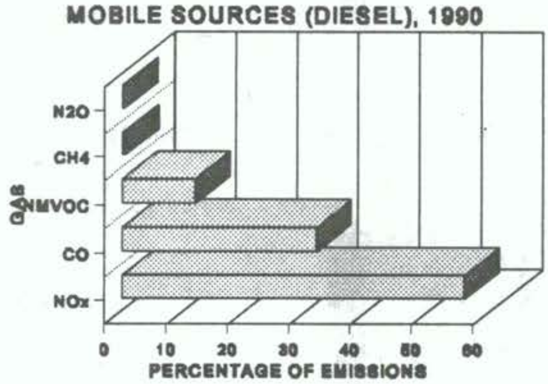
Two types of motor vehicles are found to be the sources of N_2O emissions, as they use diesel oil: heavy trucks, with a total of 0.03 Gg and light trucks with 0.011 Gg.

Of the 3.96 Gg of NMVOC thrown into the atmosphere by diesel fuel vehicles, 2.93 Gg correspond to heavy trucks, 0.17 Gg by buses and 0.53 Gg by light trucks. Those are the motor vehicles with a larger contribution of gases.

Of the total of emissions corresponding to mobile sources which use diesel fuel, three gases account for the largest shares on emissions: NO_x with 56%, CO with 32% and NMVOC with 12% (see figure 1.2).

FIGURE 1.2

TOTAL EMISSIONS
MOBILE SOURCES (DIESEL), 1990



The total of gases emissions, produced by combustion in mobile sources, is illustrated in table 1.3.

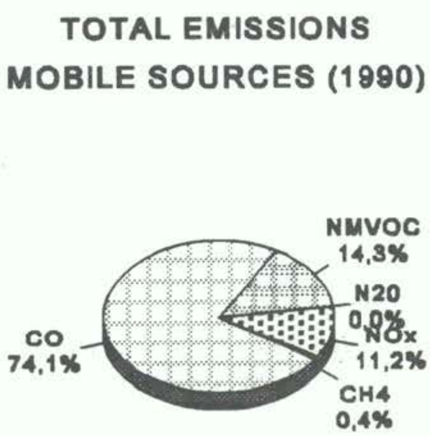
TABLE 1.3
EMISSIONS IN MOBILE SOURCES

FUEL	EMISSION Gg				
	CO	CH_4	N_2O	NOx	NMVOC
Gasoline	162,23	0,88	0,02	7,86	29,27
Diesel oil	10,40	0,12	0,05	18,32	3,96
Total	172,63	1,00	0,07	26,18	33,23

The total emissions by gasoline was 200.3 Gg (85.9%) and by diesel oil was 32.85 Gg (14.1%).

In general, from total emissions by mobile sources, 74.1% is carbon monoxide, NMVOC and NOx with 14.3% and 11.2%, respectively. (figure 1.3).

FIGURE 1.3



EMISSIONS FROM STATIONARY SOURCES

Emissions due to stationary sources for 1990, have been classified in various sectors, according to sources: industrial sector, residential, commercial, public, agricultural and the transformation sector.

The agricultural and industrial sector include the energy consumption of manufacturing industries and agricultural industries, as well as the agricultural consumption by itself.

The residential and commercial sectors include all consumption corresponding to the domestic and commercial activities.

The public sector comprehends the government consumptions and that from government institutions, including public services and utility companies.

The transformation sector includes energy consumption caused by the production of electricity with thermal plants and the transformation of primary sources into secondary sources, by oil refinement.

The consumption rates for diesel and residual fuel oil for each one the above mentioned sectors, were taken from the National Energetic Balance, for 1990 (DSE, 1991).

The emission factors, itemized by type of fuel, and for each energetic activity, were taken from data base of the Energetic Information System of Latin American Organization for Energy (OLADE, 1992). Those emission factors were used since specific data concerning fuels and equipment in Costa Rica were not available.

Also only the emissions of NO_x, NMVOC y CO, since there were no emission factors for the other gases.

The results obtained for those gases are presented in table 1.4. In the table emission sector, for each one of the estimated gases can be observed. It can also be observed that both the industrial and the transformation sector are the greatest contributors, with 1.6 Gg and 0.455 Gg, accordingly.

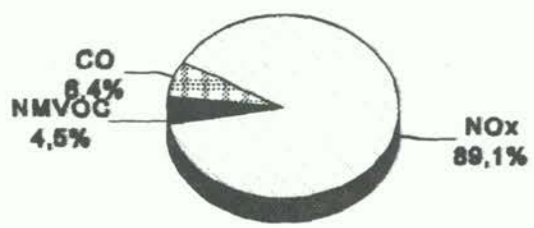
TABLE 1.4
EMISSIONS FROM STATIONARY SOURCES

SECTOR	TOTAL 1990 (EN Gg)		
	NO_x x E-6	NMVOC x E-6	CO x E-6
Residential	2281.2	124.7	179.5
Commercial	54051.8	2914.6	4181.6
Public	65642.8	3348.8	4744.5
Industrial	1467115.6	74157.7	104835.1
Agricultural	68446.2	3661.2	5243.5
Transformation	405661.4	20475	28934.9
TOTAL	2063199.1	104681.9	148119

Figure 1.4 shows the percentage distribution for the emissions from stationary sources, originated by the usage of diesel and residual fuel oil.

FIGURE 1.4

TOTAL EMISSIONS
STATIONARY SOURCES (1990)



BIOMASS EMISSIONS

It was taken into consideration two types of biomass: solid and liquid. The liquid biomass comprehends the production of ethanol, with a value, for 1990, of 487 Terajoules (TJ). Notwithstanding the value, this alcohol is produced for non-energetic values, it is used entirely for pharmaceutical usage and for the elaboration of alcoholic beverages.

The solid biomass, as it was mentioned before, includes firewood, coffee peelings, sugar cane waste and other agricultural residues. In order to estimate the emissions of this subsection, data on consumption was utilized, provided by the National Energetic Balance for 1990 (DSE, 1991) was used. Carbon production uses firewood as raw material, with a production of 25 Kg of carbon per each 100 Kg of firewood burned; that means an eficacy of 25 %. Therefore, the total biomass consumed in the carbon production was estimated applying a factor of 4 to the total carbon consumed in 1990. The carbon fractions for the biomass were taken from the IPCC methodology (IPCC, 1994); the combustion efficiency was estimated according from data provided by the National Energetic Information System (SIEN, 1992).

On what concerns the carbon rates in relation to other gases herein evaluated, the values recommended in IPCC methodology were applied..

Table 1.5 shows the values for the emissions of other gases, by burning of biomass and in accordance to the data in table 1.5, methane represents 8.0% and carbon monoxide 88.2% of the total emissions by biomass burning.

TABLE 1.5
EMISSIONS OF OTHER GASES, BY BURNING THE SOLID BIOMASS

GAS	TOTAL EMISSION (Gg)
Methane (CH_4)	4.31
Carbon monoxide (CO)	42.63
Nitrous oxide (N_2O)	0.05
Oxides of Nitrogen (NOx)	1.81
NMVOC	N/A

N/A: Do not aply.

FUGITIVE EMISSIONS

Fugitive emissions are those obtained from volatile hydrocarbons released by the manipulation of fuels.

Methane emissions from fugitive sources are relatively low in Costa Rica, as there are no natural oil nor natural gas wells in the country, and the only existing emissions are those from crude oil storage and refinement.

In order to calculate the said emissions, the emission factors provided by the IPCC methods were utilized. (see appendix 1).

The result was 1.55 E-2 Gg for methane, which corresponds to a 0.3% of the total emissions of that gas in the energy sector.

Table 1.6 shows the corresponding values for the emissions of other gases in the study for different energy subsectors, except for CO_2.

TABLE 1.6
TOTAL EMISSIONS OF OTHER GASES, BY SECTOR

SECTOR	CO	CH_4	N_2O	NO_x	NMVOC
Mobile source	172.63	1.00	0.07	26.18	33.23
Stationary sources	0.15	ND[a]	ND	2.06	0.1
Biomass	42.63	4.31	0.05	1.81	ND
Fugitives	ND	1.55 E -2	ND	ND	ND
TOTAL	215.4	5.32	0.12	30.05	33.33

N/D: No available data.

The emissions of other gases, for 1990, had a percentile contribution for the Energy Sector, corresponding to the totals for each one of the included gases, itemized as follows:

CH_4	3.3 %	N_2O	17.6 %
NO_x	89.7 %	NMVOC	100.0 %
CO	65.0 %		

SECTION 2. INDUSTRIAL PROCESSES

A great variety of industrial processes not related to energy production, originate emissions of greenhouse gases. The main sources of emission are those process in which some chemical or physical transformation or from one material to another occur.

In diverse processes, such as the production of coke, iron, steel, aluminum, iron alloys, fertilizers, limestone, dolomite, bricks, glass, paper, paper pulp, printing, etc., CO_2 emissions are produced. Some processes also produce other emissions related to fuel combustion in order to obtain energy, but those emissions are consider in the Energy Sector.

Of the industrial processes considered in the development of methods for evaluation of greenhouse gases, the cement production has been identified as one of the main sources of CO2 emissions, and for that reason, on what concerns industrial processes, the proposed IPCC methodology for evaluation of national inventories includes only guidelines for the estimations of emissions in that type of industrial processes.

CEMENT PRODUCTION

In Costa Rica there are only two industries dedicated to cement production: the "Industria Nacional de Cemento" (INCSA) and "Cementos del Pacifico" (CEMPASA). These two plants produce cement from local limestone.

Carbon dioxide is generated during the production of clinker, an intermediate subproduct of cement. During the calcination process, calcium carbonate is heated and thus lime and carbon dioxide are obtained by means of the following chemical reaction:

$$CaCO_3 \xrightarrow{\text{calor}} CaO + CO_2$$

For the evaluation of the national inventory CO_2 emissions on the data of cement production for 1990, provided by both industries were estimated. Table 2.1 shows this data:

TABLE 2.1
CEMENT PRODUCTION

Industry	Production Ton cement
INCSA	415000
CEMPASA	323000
TOTAL	738000

In order to obtain the CO_2 emissions the IPCC methodology for obtaining the emission calculation was based on was applied the asumption that all cement produced is Portland Cement, with an intermediate content of CaO, of 63.5%. An emission factor of 0.4985 t. for CO_2 by each ton of produced clinker or cement, which is the factor proposed in the methodology for that type of cement was used in the calculations.

Table 2.2 presents the amount of cement produced in 1990, the emission factor and the amounts of CO_2 emitted from the cement production process.

TABLE 2.2
CO_2 EMISSION IN CEMENT PRODUCTION

Cement production tonnes	Emission factor t CO_2/t clinker o cement produced	Emission of CO_2 Gg
738000	0.4985	367.9

The table shows that emissions in this process totalized 367,9 Gg. Such CO_2 emission represents 7.5% of the total emissions for this gas.

SECTION 3. AGRICULTURE

Greenhouse gas emissions due to agricultural activities are related to diverse production and management processes which eventually release methane, carbon monoxide and nitrous oxide.

For the purpose of a better evaluation, in this inventory the Agriculture Section was subdivided in five subsections:

- Emissions from domestic livestock
- Emissions from flooded rice fields
- Emissions from prescribed burning of savannas
- Emissions from field burning of agricultural residues
- Emissions from agricultural soils

DOMESTIC LIVESTOCK

The subsection domestic livestock includes the evaluation of methane emissions caused by enteric fermentation and manure management.

Methane is produced naturally through the digestion processes of animals due to bacteria inhabiting their digestive tracts and helping in the fermentation of food. The amount of methane that animals emit depends on their particular digestive system and on the amount and type of ingested food. (Rosales, 1994 and CNP-SEPSA, 1990).

The most important animals causing this type of emissions are dairy and non-dairy cattle , because of the large number of individuals and because of their particular digestive system, since they are rumiants and therefore they produce larger amounts of methane than other animals.

The estimation of emissions was performed taking into account the animal population in the country by 1990 and the available information on handling and feeding systems. Concerning the done extensively in the "apartos" (grouping) system. Cattle is fed with manufactured cow food given at milking time, which is performed twice a day. Cow food consumption is 0.26 tonnes per year by head of cattle (Quam, 1994). 45% of the dairy cattle population is found in farms located in higher zones with temperatures lower than 25 °C and the remaining 55% is found in lower lands.

As for the double-purpose cattle it is also a very extended activity and it is usually found in lower, warmer locations (over 25 °C).

The information on domestic animals population in the country was obtained from publications of the Secretary for Agricultural Plaining (SEPSA, 1991), Molina, 1994 and Sandoval, 1994).

In table 3.1 the population of each one of the species considered in this inventory, can be observed; mules and camels were not included, since there were no estimates for mule population in the country; nevertheless, it is known that the population is very small so it was considered that their emissions were not significant and there are not camels at all in the country.

Total emissions for enteric fermentation were calculated by applying to the population data emission factor by specie taken into account average weight per head and per year. Due to the lack of specific factors develop for animals under the conditions of husbandry in Costa Rica, the values proposed by Latin America in the Reference Manual of the IPCC methodology were adopted.

For the estimation of emissions from manure management, the total number of domestic animals were taking into account. For swine and poultry that are confined it that most of the manure is mananged in closed systems. Cattle and other animals are managed in pastures. Emission factors from the different species took this difference into account.

Tables 3.1 and 3.2 show data in populations, emission factors and methane emissions, by handling of manure and by enteric fermentation, estimated under the aforementioned suppositions.

TABLE 3.1
METHANE EMISSIONS DUE TO
MANURE MANAGEMENT IN DOMESTIC LIVESTOCK

Specie	Poblation Number of head	Emission factor (kg/head/year)	Methane emission Gg de metano
Non - dairy cattle	1886415	1	1.89
Dairy cattle	297614	1	0.29
Buffalo	2000	2	0.004
Sheep	7000	0.16	0.001
Goats	20000	0.17	0.003
Horses	93007	1.6	0.15
Swine	346200	2	0,69
Poultry	27852778	0.018	0.5
Total	30505014	-	3.54

TABLE 3.2
METHANE EMISSIONS BY ENTERIC FERMENTATION IN DOMESTIC LIVESTOCK

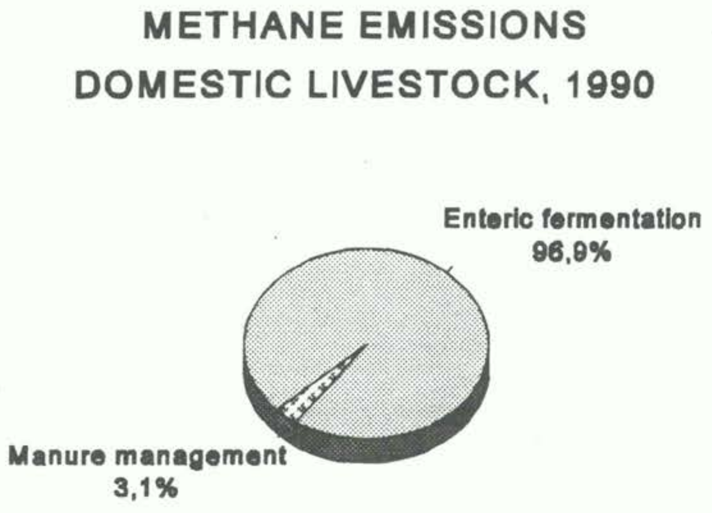
Specie	Poblation Number of head	Emission factor (kg/head /year)	Methane emission Gg of methane
Non- dairy cattle	1886415	57	92,43
Dairy cattle	297614	49	16,96
Buffalo	2000	55	0.11
Sheep	7000	5	0.04
Goats	20000	5	0.1
Horses	93007	18	1.67
Swine	346200	1	0.35
Poultry	27852778	-	N/D
TOTAL	30505014	-	111,66

N/D: Not determined.

From table 3.1 and 3.2 can be observed that emission for enteric fermentation totalized 111.66 Gg, and that emissions for manure management were 3.54 Gg. In total, the emissions from domestic livestock totalized 115.2 Gg.

The relationship between the emissions by enteric fermentation and by manure handling is presented in figure 3.1. In the figure can be observed that enteric fermentation is responsible for 96.9% of methane emissions produced by cattle and other farm animals.

FIGURE 3.1



METHANE EMISSIONS FROM RICE CULTIVATION

Flooded fields produce methane due to the reduction of carbon dioxide by hidrogen; this reaction depends on the amount of hydrogen producing agents and on the type of soil. This is the mechanism that causing emissions from flooded rice fields. Methane emissions, are produced by the anaerobic decomposition of organic matter that remain under water.

In Costa Rica, the flooded rice production area not very large. According to information provided by Oficina del Arroz (Hernández, 1994 perssonal communication) 12000 ha (hectares). In 1990, were cultivated with rice in 1990, using the flooding.

This plantations were located at altitudes usually below 200 meters over sea-level, and with temperatures on a average of 27 °C. According to the same source mentioned above, the average growing cycle is 125 days and in the average the field is kept flooded for 120 days.

The emission factor for an average temperature of 27 °C during the cultivation period, and with an average flooding range of 120 days, was estimated in accordance to the IPCC methodology (IPCC, 1994) and for the rice cultivation conditions in Costa Rica.

For 1990, the methane emissions in rice production was estimated to be 8.67 Gg.

TABLE 3.3
METHANE EMISSIONS FOR RICE PRODUCTION

Regime from water management	Area harvested ha	Emission factor (kg/ha-day)	Methane emission Gg
Continuously flooded	12238.5	5,90	8.67

EMISSIONS FROM SAVANNA BURNING

The vegetation of pastures and savannas is cntrolled by alternating rainy and dry seasons and naturally most of its growth occurs during the rainy season. Natural and man-provoked fires usually occur during the dry season and the result is a recycling of nutrients and the consequent vegetation growth. Savanna fires are a source of carbon dioxide emissions but notwithstanding net CO_2 emissions are considered to be zero since the burned biomass is replaced by the savanna's natural growth during the following year.

Pastures and savanna fires do release many other gases such as CO, CH_4, NOx y N_2O, among others. Contrary to the above stated fact concerning carbon dioxide, these are not considered to be "net" emissions.

The estimates for those gases emissions were performed in the same way than those from the burning of other biomass in the energy section.

In Costa Rica, there savanna areas are less extensive them those found in other countries, but it does have bushy lowlands which are seasonally affected by fires, especially in the Northwestern area of the country (near the Pacific Coast), where the dry season lasts six months.

There are no statistical data published on the actual number of hectares under fire each year, and for that reason in order to estimate the emissions the only information on fires used was that on statistics provided by the National Insurance Institute (INS, 1994) about fires attended. Such information was complemented with the evaluation of the burned areas, obtained by means of the Landsat TM images, for the dry season of 1992.

Also due to lack of information on the fraction of living biomass which is burned, the value provided in the IPCC methodology for Guinea, in Africa was used. Such a selection, was made taking into account the similarities in some climatic factors of the referred Costa Rican zone with that from Guinea. On what concerns the biomass density in the savanna, it was determined by means of consultation with experts (Marielos Alfaro, 1995).

Values for the carbon fraction in the living and dead biomass for the savanna and shruby systems in Costa Rica were not found, therefore, this fraction, as well as the emission factors for the different gases were taking from the IPCC, Reference Manual.

Table 3.4 shows the different values for the emission estimated in accordance to those assimptions. It can be observed from the table that carbon monoxide represents 95% of the total emissions and CH_4, N_2O, y NOx emissions were very small.

TABLE 3.4
GASES RELEASED BY SAVANNA BURNING

Gas	Emission Gg
CH_4	0.1
CO	2.62
N_2O	1.23E-3
NOx	0.04

EMISSIONS FROM FIELD BURNING OF AGRICULTURAL WASTES

Large amounts of residues and waste are produced by agricultural activities. Such waste is sometimes burned on the field, and some other times it is left on the field to decay, and sometimes it is utilized as biomass for energy production.

In accordance to the methodology, it was that on-site burning of agricultural residues was a non-producer of net CO_2 emissions, as it is supposed that emitted CO_2 is re-absorbed in the following crop. The emissions of other gases produced by burning waste were considered to be net emissions.

According to the Secretary of Agricultural Planning in Costa Rica, the crops which render more residues are: corn, rice, bananas, coffee, beans, sorghum, sugar cane and cotton (SEPSA, 1993 and DSE, 1986).

The estimations were done for all those crops, with the exception of bananas which residues are not burned and coffee which residues accounted for in the energy sector. In the case of sugar cane, the volume took into consideration did not include "bagaze" the dried sugar cane stalks, which also accounted for in the energy sector.

For the estimations of emissions of other gases, the emission factors provided in the IPCC methodology were used. Due to lack of data on the fraction of dry matter in the residues, which is the case of Costa Rica, the corresponding values for cotton and beans, provided by the National Inventory of Uganda (Ministry of Natural Resources, 1994) and as for sorghum and sugar cane used in the National Inventory of the United States (U.S. EPA, 1994) were used. Data for the fraction burned on the field and the for the relationship of product/residue, was determined in consultation with national experts (F. Mojica, personal communication).

Table 3.5 shows a list of crops which residues are burned on the field, as well as their respective volumes and gas emissions from each one.

TABLE 3.5
EMISSIONS FROM AGRICULTURAL WASTES

Crop	Quantity of residue Gg	Gas emitted Gg			
		CH_4	CO	N_2O	NOx
Maize	225.851	0.06	1.28	0.002	0.06
Rice	20	0.01	0.24	0.000'	0.01
Beans	16.621	0.01	0.19	0	0.01
Sorghum	38.751	0.02	0.49	0.001	0.02
Sugar Cane	739.763	0.45	9.44	0.011	0.4
Cotton	0.186	0.00*	0.00*	0.000'	0
Total	32162.7	0.55	11.64	0.014	0.5

*: Minus of 0.01
': Minus of 0.001

EMISSIONS FROM AGRICULTURAL SOILS

Agricultural or cultivation soils may emit or absorb gases such as N_2O, CO_2 and methane. N_2O emissions are produced by the application of synthetic and organic fertilizers, and biologic fixation of nitrogen in the soil. The emissions volumes depend on the humidity contents of the soil, on its temperature, on the concentration of nitrate or ammonia in the soil and on the carbon contents and pH.

Estimations of N_2O emissions were done by applying a simple approximation to the metodology proposed by the OCDE in 1991 which estimates emissions upon the basis of total consumption of fertilizers.

Information on the total consumption of non-organic fertilizers during 1990 was obtained from statistics on the national production and on imports carried on by the company Fertilizantes de Centro América (FERTICA), the most important producer and imported of fertilizers in the country and FAO (1991). The applied emission factor was that from the report of the National Inventory of the United States (U.S. EPA, 1994).

Table 3.6 presents the volume of fertilizers used in Costa Rica for 1990, and the emissions of nitrous oxide cause by its application on the crops.

With forementioned assumption the N_2O emissions from agricultural soils were 0.465 Gg.

Such estimation did not include organic fertilizers as, according to experts on the field, its usage in this country is scarce, and because of that it was not quantified (Mojica, F., 1995).

TABLE 3.6
EMISSIONS FROM AGRICULTURAL SOIL

Volume from fertilizer Tonnes	Emission factor	Nitrous oxide emission Gg
25310.4	0,0117	0.465

In 1990, agricultural activities were responsible for the emission of 139.81 Gg of greenhouse gases, an amount that represents 2.6% of the total emissions.

The most abundant gas was methane, which totalized 124.52 Gg. To that amount, cattle and farm animals contributed with 115.2 and rice cultivation contribute with 8,67 Gg.

FIGURE 3.2

EMISSIONS IN AGRICULTURE 1990

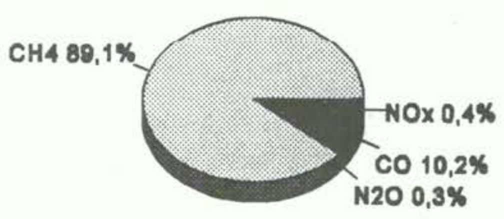


Figure 3.2 shows the total emissions for the agriculture sector, and it can be observed relative contribution to that 89.1% were methane emissions and 10.2 % of the emission were carbon monoxide.emisión de monóxido de carbono.

SECTION 4. LAND USE CHANGE AND FORESTRY

Through the photosynthesis carbon is stored in plants biomass. When this plant biomass is burned or decomposes, that carbon is released as CO_2. Changes in the different usages of the soil produce changes in the amount of carbon stored in the biomass, and consequently produce changes in the emissions of CO_2, when biomass is burned or decomposes. Other gases such as CH_4, CO, N_2O, and NOx are also emitted when the biomass is burned.

During the evaluation of inventories on the emissions of greenhouse gases, it must be taken into consideration all the changes of the biomass in the biosphere, that could change the amount of carbon stored, this shall include changes in forests, savannas with trees, pasture fields, and farming land, either for crops or for cattle raising; changes also include reforestation, and the secondary growth which is found in abandoned fields or pastures.

For the inventory of net emissions of greenhouse gases in Costa Rica, the emissions of carbon dioxide and monoxide, nitrogen oxides, nitrous oxide and methane produced by :

- Changes in forest and other woody biomass stocks.
- Forest and grassland conversion.
- Abandonment of managed lands, were estimated.

CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS

In this subsection CO_2 emissions from tree plantations, managed forests and other bodies of trees which are affected by human activity were considered. Also, the absorption of CO_2, by the annual increment of the biomass in plantations or forests under explotation were accounted.

The carbon fixed in the plantations was estimated over the data of planted area and on the annual growth rates of each of the species planted

Data on plantations area in the last decade were obtained from statistics at the General Forestry Direction (1994), and from SEPRENA (1990), covering a period from 1980 to 1990. The annual growth rates for the different species were taken from the IPCC Reference Manual, as it was found their values to be consistent with the country's data on the most common species. For the carbon fraction in dry matter, the value of 0.45, proposed in the IPCC methodology was adopted.

The biomass extracted from forest or tree plantations was treated according to its final destination, being it timber or firewood. In the 80's decade in Costa Rica, commercial timber was extracted mainly from the natural forests and not from tree plantations. On the other hand, according to the information on the energy balance, firewood is obtained from seasonal pruning of trees used as shade for coffee or from garden hedges. To avoid double counted, therefore, emissions from forest cutting were calculated in the forest conversion subsection and emissions from firewood were consider in the energy section, and these two sources of emission were not considered in the final calculations of this subsection.

CO_2 fixation was estimated on the basis of the data of reforested areas from 1980 to 1990, since these cultivated areas were supposed to be still growing in 1990.

Table 4.1. presents the data for the plantations areas in thousands of hectares (kha), the annual growth rates for each species, in tons of biomass, and the fixation of CO_2 in gigagrams. As it can be observed in the table, taking all these into consideration, the total absorption in plantations during such period was estimated to be 883,2 Gg.

TABLE 4.1
CO_2 ABSORPTION IN TREE PLANTATIONS

Plantation	Area of forest/biomass stocks kha	Annual growth rate ton/ha	CO_2 removal Gg
Eucalyptus spp.	3,8	14,5	90,7
Tectona grandis	3,3	8,0	44,0
Pinus caribea	1,3	10,0	22,1
Cupressus lusitanica	0,9	10,0	14,5
Gmelina arborea	21,6	14,5	516,0
Mixed hardwoods	17,5	6,8	195,9
Total	48,4	-	883,2

FOREST AND GRASSLAND CONVERSION

In this subsection, CO_2 emissions due to deforestation were estimated.

Changes in the land use, like changing a forest into pastures or crop fields, is usually followed by the cutting of all plants and slash and burn techniques or by burning wood as firewood. These actions, plus the decaying left-over wood and plant matter may cause that carbon, the main component of vegetal material, returns to the atmosphere as CO_2. The pastures or agricultural systems that develops after the clearing, store less carbon than the original forest.

Pastures or crop fields which are not cultivated for long periods regrowth . The ecosystems that develops with this secondary growth, normally store less carbon per hectare than the original forest system; therefore, the change from forest to field crops or pastures represents a net emission of CO_2.

The combustion of the felled biomass, both at the location or elsewhere, also produces nitrous oxides, nitrogen oxide, carbon monoxide and methane and they all have greenhouse effect.

In Costa Rica, the development of agriculture, from the historical point of view, was due to the enlargement of the cultivated lands, as more forest were cut and more forest land became farmland.

Around 1822, the population density was of 1 inhabitant per square kilometer. In the 19th century, sugar cane, tobacco and coffee (which was first exported in 1825) became the dominant crops and most agricultural land in the center zones of the country were dedicated to those products. At the turn of the century, a spontaneous colonization toward the coastal zones, expanded the agricultural frontier, from the center hub towards the Pacific coast; colonies turned into cattle ranches and they occupied extensive areas always with very scarce population (Tossi, 1974).

The said process turned more critical during the last four decades, due mainly to official expansion policies, to very liberal land-owning regulations, and to a high population growth rate, caused by the traditional idea of a very large family unit. In the 1950's decade, another social process started, which was known as the Cattle Sub-culture, which fostered the conversion of forest into cattle pastures even farther. This process was based on policies which sponsored the exports of meat and offered credit -mostly backed up by external sources- and subsidized cattle farming. Finally, a large sector of the country became cattle ranches and large pastures, causing great damage to traditional agricultural ways and, of course, to the natural forests (Solorzano, 1991).

Such a pattern was then reverted in the 1980's, when a process of awareness for reforestation was started all over the country. It was fostered by the Government and reinforced by the private enterprise. This change can be noted in the data of reforested areas. Since, between 1970 and 1979, approximately 20.6 Hectares per year were reforested and in the 1980-1989 period the average rate of reforested area of 2500 hectares per year, between 1990 and 1993 the rate grew to 14 367 ha/year (MIRENEM, 1994) for a total of 111 479.4 Ha reforested in 24 years.

In 1989, the forest cover represented 28% of the national territory, which means 1 556 275 ha, of which 893 325 ha were found under some protection system, and 155 338 ha corresponded to secondary forests (MIRENEM, 1994).

CO_2 RELEASE

As it was mentioned before, due to the fact that CO_2 emissions are caused either by burning or by decomposition of plant matter, for the calculations of this inventory, both, the immediate emissions, those caused by slash and burn of the natural forest, and the delayed emisions, those caused by the decay, were estimated.

According to the assumptions of the methodology, immediate emissions are referred to as yearly in the inventory, while those caused by decay, under tropical conditions, may occur after 10 years (for above ground biomass) and 25 years for the roots and underground matter.

Immediate emissions were estimated for 1990. Datum of deforested area in that year was used as starting point for the calculation. Emissions from the decaying of plant matter left over on the site after cutting was estimated for the 10 years period prior to the inventory year, using the average anual deforestation rate between 1980 to 1989 as basic data. Regarding the emisions from underground biomass, information on land use, as shown in a 1965 map (AID, 1965) was used as reference to estimate changes in the 25 years period before 1990; nevertheless, due to a lack of well-developed methods for the calculation of emissions by root decomposition in tropical soils, the calculus for the emissions of decaying plant matter in the soil were not performed.

Information on the deforested area for 1990 was obtained from the Direction of Forestry in the Ministry of Natural Resources, Energy and Mines (MIRENEM, 1994). Only one type of forest: the tropical rain forest was consider since, after consulting national the experts, it was determined that deforestation in the last years of the 80's decade and beginning of the 90's occurred only in that type of forest.

The biomass by hectare in this ecosystem was assumed to be 155.1 Ton/Ha, a value that was determined for forests in the Tropical Zone of the Americas (Brown and Lugo, 1984).

According to MIRENEM (1994), the average annual deforested area between 1990 and 1993 was of 18 000 ha, which, according to the preceding assumption, representes 2791.8 kTn of biomass. This value was considered a representative datum for the year 1990, on which to start the calculations for the emissions.

In applying the methodology, the emissions were calculated in relation to the cut biomass, therefore, the rest of the biomass in the system, that means the one which is left intact and the one which grows back in the same site in the coming years was deducted.

As it was mentioned above, in Costa Rica, deforestation for the last 25 years was caused fundamentally by the expansion of cattle activities, anyhow, the traditional conversion of natural forests into pastures did not mean the absolute destruction of all trees, since it was a custom to leave in the "potreros" (the traditional pasture or grazing area) around 15 to 20 trees per hectare, in order to provide some shade for the animals (Eng. Marielos Alfaro, personal communication). In this type of pasture spotted with trees or "potrero", the persistent amount of biomass is much larger than that of a flat treeless pasture.

Assuming an average biomass value of 1 Ton/tree, it was estimated that after the clearing, the site might hold an amount of biomass around 20 Ton/ha. This amount expanded to 18000 ha represents a biomass of 360 kTn. This amount was deducted from the 2791.8 kTn and then the total of the felled biomass was supposed to be 2431.8 ktn.

To estimate the emissions the portion of that biomass was used as timber and was not burned at the felling location was also deducted. According to permits issued by the General Forestry Direction, in 1990 the extraction allowances amounted 643304 cubit meters of timber (MIRENEM, 1994). A similar amount, nonetheless, could haven extracted with no authorization at all (E. Cyrus, M. Alfaro: personal communication). For that reason and based on the opinion of other experts in the timber business, an average extraction of 60 m^3/ha was assumed.

Taking 0.5 Tn /m^3 as the density of the extracted wood, this extraction turns to be 30 Tn/ha, and applied to 18000 ha this represented a total of biomass extracted as timber of 540 kTn.

Deducting this amount, a value of 1891.8 kTn was obtained as the total biomass that produced emissions.

Emissions from the burning were estimated for the burning of biomass on and off site. The value of 0.45 for the carbon fraction in the biomass and 0.9 as the combustion efficiency proposed in the IPCC methodology were used.

The amount of biomass which remains as trunks and branches for decay represents 4% of the total biomass (M. Alfaro, personal communication), with respect to the total biomass (2431.8 kTn), it means that 2334.52 kTn is burned on site or extracted from it. Deducting the timber 540 kTn of timber extraction it was obtained that the amount of biomass burned on site could be estimated as 1794.7 kTon.

In the case of Costa Rica, because firewood extraction was not consider as one of the driving forces for the cutting, estimations of emissions from biomass burned off site included only that of the industrialization of timber. In Costa Rica, industry utilizes only 55% of the total extracted volume, the remaining 45% is left in the process as residues (Censo de la Industria del aserrio, 1984). Over an extraction of 540 kTn this represents 243.0 kTn of sawdust and other residues which are burned or use as organic fertilizer. Data on the amounts of sawdust which is re-utilized, were not available, but agricultural experts agree on that this is not significant since they assume that most of the residue is burned.

The total amount of biomass burned was then estimated in 2037.9 kTn (1794.7 in the felling site and 243.0 kTn elsewhere). In the case of forest conversion emissions of CO_2, were estimated for this whole amount since no fixation in the following year is supposed to occur, and regrowth is considered in the abandoned land section.

Given all the previuos assumptions, total emissions of CO_2 due to forest burning were estimated as 3026.1 Gg of CO_2.

The biomass which is left to decay was considered to be 4% of the total felled biomass. The emissions by decaying of the biomass were calculated upon 31830 Ha, a datum of the average deforested area between 1974 and 1989 (DGF). Therefore, the total biomass which decomposed in the felling site was estimated to be 172.0 kTn, and the emission for this source as 283.8 Gg of CO_2.

The details for the emissions by burning and decaying are shown in Table 4.2. The Table also shows the total emissions of CO_2 produced by the conversion of forests. According to the assumptions previously described, in the period of time to which this inventory is referred, the emissions from this source, totalized 3310.0 Gg. The detailed calculations appear in Table 5.2 of Annex 1.

TABLE 4.2
EMISIONS FOR FOREST AND GRASSLAND CONVERSION

Process	Area kha	CO2 Emisions Gg
Inmediate emisions by burning	18.00	3026.1
Emision for Decay	31.83	283.8
Total	49.83	3310.0

EMISSIONS OF OTHER GASES BY FOREST CLEARING

The emissions of other gases different from CO_2, were calculated over the amount of biomass felled and burned on site (1794.7 kTn). The biomass which is burned outside of the felling site is not taken into account, in order to avoid a double calculation, since it accounted for the emissions of biomass used as fuel (firewood). The emissions ratios of each gas to estimate the amount of each gas produced in the burning were adopted from the IPCC methodology.

The results obtained are shown in Table 4.3

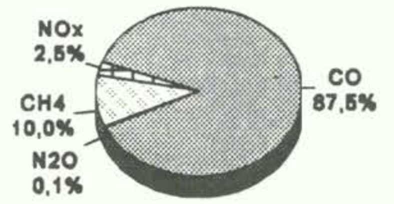
TABLE 4.3
EMISSIONS OF OTHER GASES

Gas	Emission Gg
CH_4	11.63
CO	101.75
N_2O	0.08
NOx	2.89
Total	116.35

The porcentual contribution from each one those gases to the total emissions by changes in land use, may be observed in Figure 4.1. The graph shows that the gas emitted in the largest amount, representing 87.5%. of the emisiones of the other gases is carbon monoxide.

FIGURE 4.1

EMISSIONS OF OTHER GASES IN FOREST CONVERSION, 1990



ABANDONMENT OF MANAGED LANDS

When lands or crop fields or "potreros" (pastures) are abandoned and allowed to regrowth in natural ecosystem, there is an accumulation of carbon in the aboveground biomass and in some cases, also in the underground biomass.

For this inventory, in order to estimate the fixation of carbon in the secondary forest developed over crop fields or in cattle pastures which were abandoned, the amount of land affected by this change, was determined comparing the changes in land use between 1979 and 1990-91.

In order to determine the extension and type of change in the last years, maps of land use, developed on the interpretation of Landsat MSS sattelite images from 1979 and Landsat TM, with band combination of 3, 4 and 5 from 1990 to 1992 were used. The analysis could not be taken back 25 years because of lack of data and information on comparable scales to those of 1979 and 1990. For the 60's decade, the only map available on land use was a map of 1965 at the 1:750000 scale. According to that in 1965, 63% of the country, that is 3 213 000 Ha was covered by some type of forest, 1.43% by improved pastures, 4% by abandoned pastures, 12.5% by crop fields, and the rest of the territory by water bodies or urban areas. However, this information was used only as reference, since the emissions by underground biomass decay were not accounted.

For the 1979 map the images utilized were at the scale of 1:200000, while for the 1990 map the scale was 1:100000, in both cases the minimal mapping unit was 25 Ha (0.25 km^2). Whenever possible and/or necessary aerial pan-chromatic photographs in scale 1:600000, covering most of the national territory were used to compare or verify the interpreted units.

The information obtained from the image interpretation 90-92 was verified with field trips, more specifically for revising areas which were doubtful in their initial interpretations.

In the interpretation of the images the following types of cover, were identified:

- Primary forest.
- Secondary forest.
- Pastures.
- Wetlands.
- Crop fields, cultivated areas (temporary and permanent).
- Burned areas (only in the 1990-1992 map).
- Other types of cover (combinations of various covers).
- Naked soil, infrastructures, and water bodies.

From the maps, the number of hectares in each of categories was evaluated and the changes in use, determined by comparison of the covers between the two periods. The following changes were identified:

- From natural forest to pasture.
- From secondary forest to temporary crop field.
- From secondary forest to pasture.
- From crop field to pasture.
- From natural forest to permanent crop field.
- From natural forest to temporary crop field.
- From pasture to secondary forest.
- From pasture to crop field.
- From crop field to secondary forest.
- From secondary forest to permanent crop field.

The maps for the area of peninsula de Nicoya, in the western part of the country is included as an example.

The evaluation was performed using a geographical information system (ARCINFO), files with the total of the information, were created in order to use them later as the basis of the future updates of the inventory.

Due to lack of time for the presentation of this report only the estimations of changes of land use, for two zones in the country: The Atlantic Basin and the Nicoya Peninsula, in the Dry

Pacific Coast were included in the quantification of the emissions. Those two areas were considered to be representative of the different conditions related to trends in the changes of land use for the last decade. The complete evaluation will be published as an Appendix to this report, once the evaluation for the rest of the national territory is concluded.

The areas corresponding to each one of the changes are presented in Table 4.4.

TABLE 4.4
CHANGES IN USE BETWEEN 1979 AND 1990-91

Type of change	Area kha
Pasture to secondary forest	70,28
Secondary forest to pasture	122,15
Secundary forest to annual crop	12,64
Primary to Secundary forest	28,52
Crops to pasture	24,1
Pasture to crops	65,48
Crops to secondary forest	10,42
Primary forest to pasture	74,28
Primary forest to crops	23,9

In order to estimate the CO_2 absorptions only the changes from pasture or crop field to secondary forest, changes in which there is significant change in the biomass stored in the system were consider. Considering the maps as representing the situation in 1990, that amounted 80.7 kha.

To estimate the carbon fixation for this natural regeneration, an annual growth rate of 8.0 Tn/ha was adopted for the moist forest of the Atlantic region and 4.0 Tn/Ha for the dry forest of the peninsula de Nicoya was used. These growth rates are derived by assuming that tropical forest regrowth to 70% of its undisturbed biomass on the first 20 years.

To the total biomass generated a carbon fraction of the surface biomass of 0.45 (as proposed by IPCC) was applied to estimate the CO2 uptake. In order to avoid the double accounting of tree plantations and reforested areas, these were included in the category of "permanent crops".

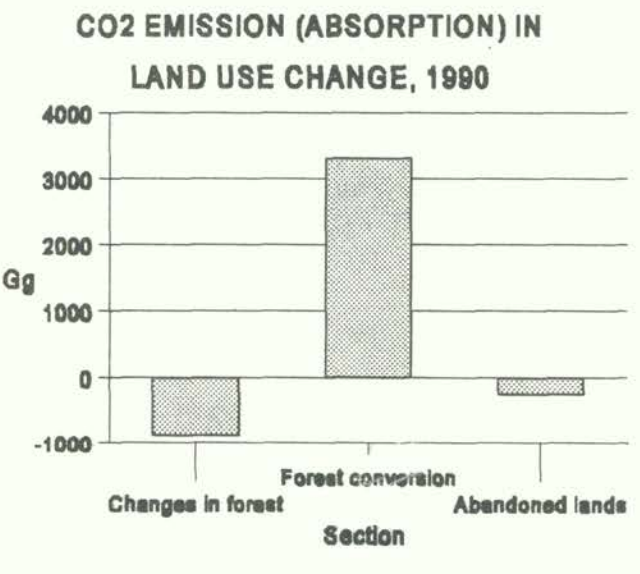
Table 4.5. presents the estimated values of CO_2 absorption by plant growth in abandoned areas.

TABLE 4.5
CO_2 ABSORPTION IN ABANDONED LANDS

Abandoned area kha	CO_2 absorption Gg
80,70	257,70

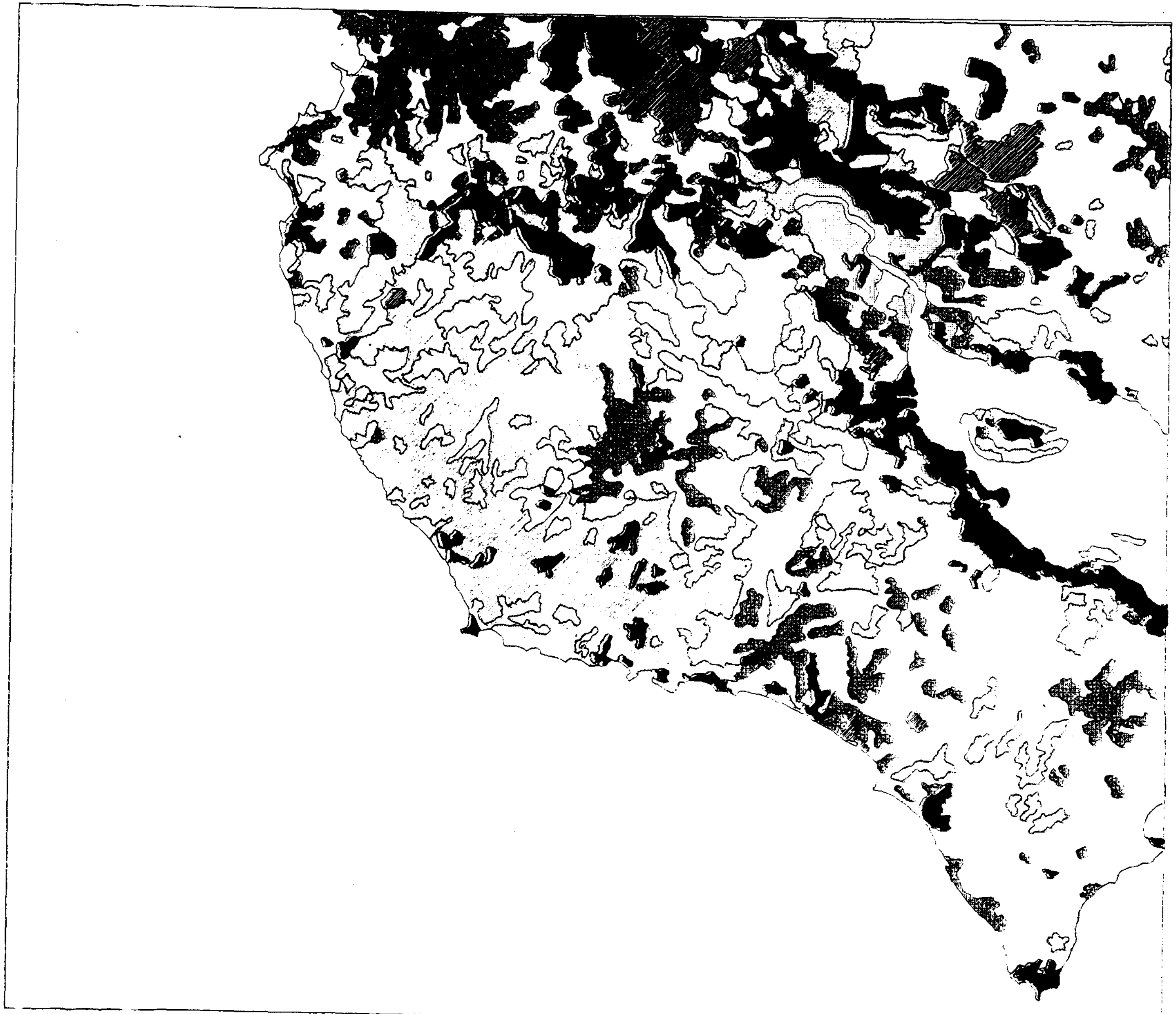
The emissions for the different activities included in the Section Land Use Change and Forestry are presented in figure 4.2. There emissions from forest clearing and uptake by plantations and regeneration on abandoned land can be compared.

FIGURE 4.2



The result of the global evaluation of the three sub-sections was a total net emission of CO_2 of 2169.1 Gg, which represents a 44.1% of the total emissions of CO_2 in Costa Rica, for 1990.

USO DE LA TIERRA
NICOYA 1979



Uso de la tierra
- Bosque natural
- Pasto
- Humedal
- Infraest. o cuerpo agua
- Bosque nat. interv.
- Bosque secundario
- Mangle
- Cultivo temporal
- Cultivo permanente

metros
0 10000 20000

Fuente: interpretacion de imagen LANDSAT MSS de 1979, esc. 1:200,000

Mayo 1995

CONVENIO DGF - IMN - IGN - MAG

USO DE LA TIERRA
NICOYA 1992

Uso de la tierra
- Bosque natural
- Pasto
- Quema
- Humedal
- Infraest. o cuerpo agua
- Bosque interv.
- Bosque secundario
- Mangle
- Cultivo temporal
- Cultivo permanente

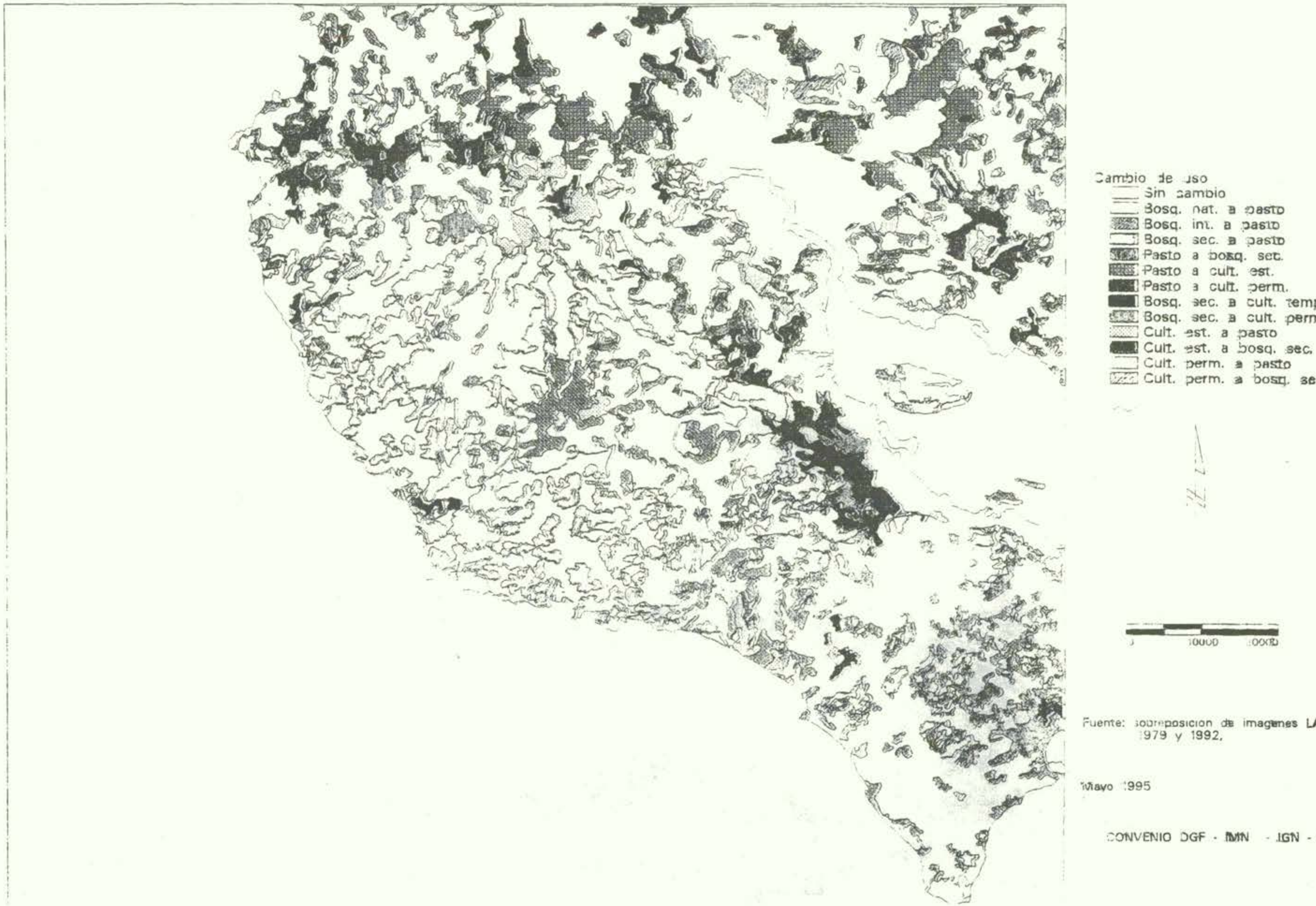
0 10000 20000

Fuente: interpretacion de imagen LANDSAT TM
bandas 3, 4, y 5 de 1992,
esc. 1:100,000.

Mayo 1995

CONVENIO DGF - IMN - IGN - MAG

CAMBIO DE USO DE LA TIERRA
NICOYA 1979 - 1992



Fuente: sobreposicion de imagenes LANDSAT 1979 y 1992.

Mayo 1995

CONVENIO DGF - IMN - IGN - MAG

USO DE LA TIERRA NICOYA 1979 - 1992

UNIDADES	PEIORDO 1979 AREA (ha)	%	PERIODO 1992 AREA (ha)	%
BOSQUE NATURAL	21,417.00	3.40	7,006.50	1.11
BOSQUE NATURAL INTERVENIDO	63,715.20	10.12	17,113.20	2.71
BOSQUE SECUNDARIO	172,325.50	27.37	158,055.60	25.03
MANGLAR	12,187.80	1.94	12,705.70	2.01
HUMEDAL	10,546.70	1.68	8,602.70	1.36
PASTO	281,390.30	44.70	296,163.10	46.89
CULTIVOS TEMPORALES	18,296.50	2.91	53,670.80	8.50
CULTIVOS PERMANENTES	49,279.00	7.83	65,140.00	10.31
QUEMAS		-	12,142.40	1.92
INFRAESTRUCTURA, CUERPOS DE AGUA	350.30	0.06	965.20	0.15
TOTALES	629,508.30	100.00	631,565.20	100.00

SECTION 5. WASTE

Humankind generates a large amount of waste through production and almost any other activity. When such waste contains organic matter, its decomposition generates greenhouse gases, especially methane.

Waste disposal, either at an open garbage dump or in landfills may generate methane, although in different amounts. Likely, residual waters containing organic material may also generate significant amounts of methane.

For this inventory the evaluation of emissions coming from waste was subdivided in two sub-sections:

- Emissions caused by waste in landfills.
- Emissions caused by wastewaters.

LANDFILLS

Organic material decomposes with help of aerobic bacteria producing other compounds, which in turn are attacked by anaerobic bacteria not methanogenic and finally by methanogenic bacteria which do produce biogas. This biogas is composed by 50% of CO_2 and by of 50% of methane. Carbon dioxide dissolves in soil water while methane is released into the atmosphere.

Methane production in landfills depend on a few factors such as aerobic decomposition, microbian biomass, lixiviation and methane oxidation, among other.

The simple method reccomended by IPCC supposses that methane is released the same year when the waste is deposited in the landfill. This does not really happen but it provides a good approximations to the real emission amounts.

In open garbage dumps, emissions are not a very significant soruce of methane since methane formation happens by the effect of methanogenic bacteria which work in absence of oxigen.

For the calculations of methane emissions, data on the volume of solid waste of domestic origin going to the landfills in urban and rural areas, were taken from the National Waste Management Plan (Government of Costa Rica, GTZ, 1991). Decomposition of organic carbon in the garbage dumps is not total and part of that matter remains in the landfill for a longer term. In the country there is no available information on the fraction of organic carbon which decays, and because of that the value of 0.15 as the fraction that decay recomended in the methodology and for the actual decaying, the factor 0.77 was used. As for the fraction of methane in the garbage dump gas the value of 0.5, suggested for developing countries was used.

In Costa Rica, the most highly concentrated urban area is the Central region. This Great Metropolitan Area hosts 1 657 771 inhabitants, which corresponds to 56% of the total population. According to data published by the National Waste Management Plan (Government of Costa Rica, GTZ, 1991), this area produces 915.5 tons of waste every day, which accounts for 334157.5 tons per year. This waste is composed by a 62.1% of bio-degradable matter. Thus, emissions for 1990 were estimated over a total of 207511.8 tons of bio-degradable matter.

The methane output is not recovered at all and therefore it is released into the atmosphere entirely.

Methane emissions produced by the said volume of waste, were estimated to be 15.98 Gg.

For the rest of the country, the waste is deposited in open garbage dumps, since that waste amounts to 175236.5 tones per year, of which 108821.86 tons are bio-degradable. Emissions from thus part of the wastes were not calculated due to the incertitude of data and the methodology to be applied.

Are presented in table 5.1. values for bio-degradable domestic waste, as well as the methane emissions from that waste, in 1990.

TABLE 5.1
METHANE EMISSIONS FROM LANDFILLS

Area	Biodegradable wastes Gg	Methane emission Gg
Central counties, part of GAM	99.89	7.69
Rest of GAM	107,62	8.29
Rest of the country	108,82	N/A
Total	316,33	15,98

GAM: Great Metropolitan Area

As it is seen in the table, emissions from landfills totalized 15.98 Gg.

WASTEWATER

Residual waters may emit methane according to the amount of organic material contained therein; this may be evaluated by the amount of oxigen which is consumed in the decaying process of such organic matter. This factor is identified by the bio-chemical demand of oxigen (DBO) of residual waters.

For the estimation of emissions from residual waters this section was subdivided into:

- Emissions from municipal wastewaters.
- Emissions from industrial wastewaters.

MUNICIPAL WASTEWATERS

According to the reccomended methodology, the emissions were estimated over the volume of residual waters. The generation rates of DBO was suppossed to be 0.0146 Gg DBO_5 /1000 people/year (IPCC, 1994).

The volume of wastewaters was calculated according to the population in urban areas where a larger percentage of residual waters was supposed to be treated anaerobically. Emissions were estimated for a population of 1 657 771 inhabitants of the Great Metropolitan Area (GAM), in 1990 (Government of Costa Rica, GTZ, 1991). Since there was no complete information available on what concerns the volume of water, the value of 0.10 as the fraction of residual waters anaerobically treated, proposed for Latin America by the IPCC was adopted.

Emissions from municipal wastewaters were the population and the results are presented in table 5.2.

TABLE 5.2
METHANE EMISSIONS BY MUNICIPAL WASTEWATER

Zone	Population (Nbr. inhabitants)	Methane emissions Gg
Great Metropolitan area	1 657 771	0.53

INDUSTRIAL WASTEWATERS

In Costa Rica residual waters are generated by various industries, mainly food industries.

For the calculation of methane emissions of the industrial output information on the volume of residual waters for the main industries in the country, included in the Plan for Sanitation and Sanitary Tubing of the Great Metropolitan Areas (SNAA, 1990) was used and for the calculations the methodology from IPCC was applied. The values of the bio-chemical oxigen demand (BOD) in residual waters for those types of industries were taken from the those proposed in the Reference Manual of the IPCC. For municipal waters, it was suppossed that only a 10% of the total of residual waters were treated anaerobically.

The different types of industries, the corresponding volumes of residual waters and the BOD values, are presented in Table 5.3

TABLE 5.3
EMISSIONS FROM INDUSTRIAL WASTEWATER

Industry	Volume of residual water, in Ml	BOD concentrations in kg/l	Methane emissions Gg
Fruit and grain processing	341,768	0,003	0,02
Beer production	821,232	0,085	1,54
Meat packing	67,131	0,02	0,03
Agricultural industry	23683,857	0,019	1,04
Oil and grease	3102,018	0,002	1,30
Paper mills	71,504	0,004	0,01
Slaughtering	1224,261	0,004	0,05
Total	29311,77	-	3,99

The contribution percentages for each one of those industrial emissions and their residual waters, are presented in figure 5.1, by type of industry. It can be easily observe that the beer processing plants are the largest sources of methane with 38.6% of all methane emissions on industrial residual waters, followed by oil and grease processing industries, with a 32.6%.

Figure 5.1

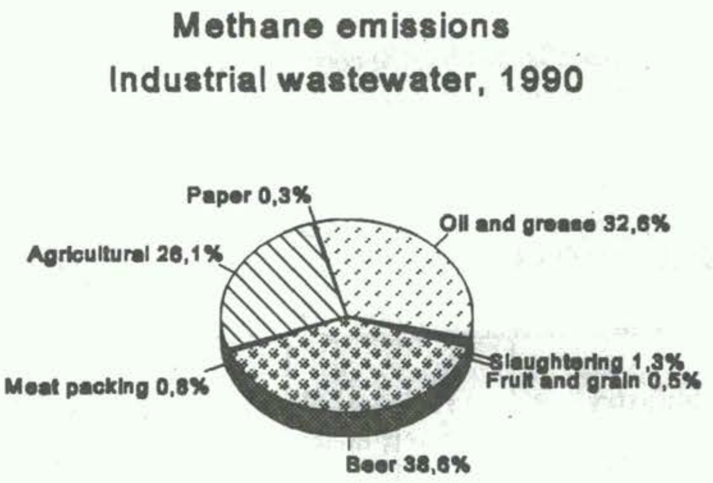
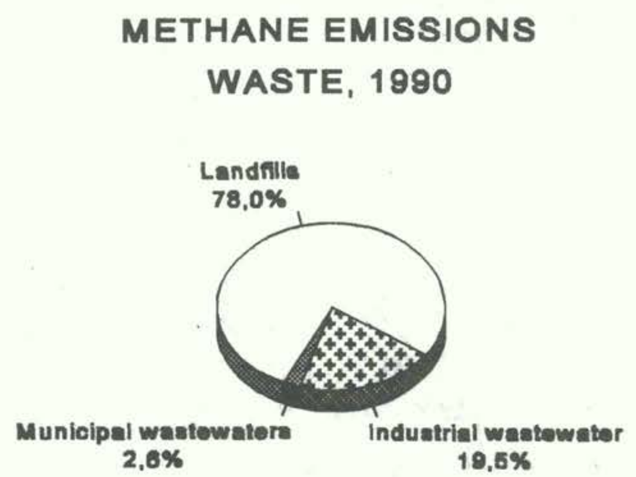


Figure 5.1 represents the percentage distribution of methane emissions from the Waste Section. It can be observed that emissions from landfills amount for a 78% while emissions from wastewaters get a 22%.

Figure 5.2



The total for the Waste Management Sector, was estimated to be that 20.5 Gg for methane, and this corresponds to a 12.6% of the total emissions for that gas. It can be observed in Chart 5.1., emissions from landfills correspond to a 78% of the total emissions of that gas for the Waste Section.

SECTION 6. TOTAL EMISSIONS AND WARMING POTENTIALS.

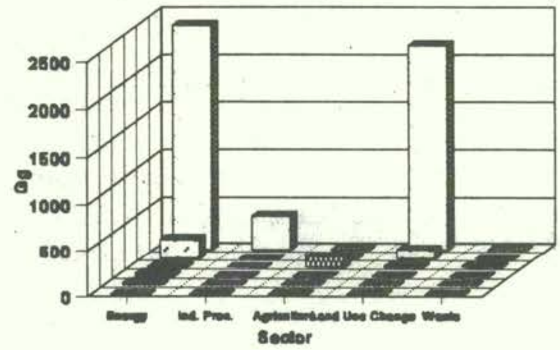
The total gas emissions with greenhouse effect in Costa Rica, estimated for 1990 was that of 5479.3 Gg (5 479 300 tons). The contributions for that total are in case of the Energy Sector 2665.6 Gg and the Land Use Change Sector with 2285.4 Gg. In both cases the gas with the largest emission was CO_2, a 90% of the total emissions. The totals for gas emissions by sector are represented in both Table 6.1 and figure 6.1.

TABLE 6.1.
TOTAL EMISSIONS FOR GREENHOUSE GASES, 1990.

SECTION	TOTAL EMISSIONS Gg						
	CO_2	CH_4	CO	N_2O	NOx	NMVOC	TOTAL
Energy	2381.4	5.32	215.4	0.12	30.05	33.33	2665.6
Industrial Processess	367.9	-	-	-	-	-	367.9
Agriculture	-	124.52	14.26	0.48	0.55	-	139.81
Land Use Change	2169.1	11.63	101.75	0.08	2.89	-	2285.4
Waste	-	20.5	-	-	-	-	20.5
Total	4918.4	161.97	331.41	0.68	33.49	33.33	**5479.3**

FIGURE 6.1

TOTAL EMISSIONS
COSTA RICA, 1990



Box 6.1

RADIATIVE FORCING

The Earth's climate depends on the radiative equilibrium of the atmosphere. A few factors such as energy variations on radiation from the Sun or the concentrations of greenhouse gases, may alter such balance causing a "radiative forcing" on the climate. The increase of such human-originated gas concentrations with a greenhouse effect is presently causing a radiative forcing.

The increase of the radiative forcing does force the Earth/Atmosphere system into reaching new balancing temperatures in accordance with gas concentrations. In order to facilitate the calculations and in also in order to evaluate the possible political options, experts have developed the concept of GWP (Global Warming Potential). The GWP is defined as the warming obtained through a certain period of time which produces an instantaneous release of a mass unit (1 Kg) of a determined greenhouse gas.

In order to estimated its effect on climate the GWP also accounts for the concentration, average permanence of each gas in the atmosphere and all this is expressed in terms of the effects caused by the release of an equivalent amount of CO_2. Thus, it is estimated that in the term of 20 years, methane proves to be 63 times more effective than CO_2, and nitrous oxide 270 times more effective, while over a period of 100 years methane, which permanence rate in the atmosphere is shorter, is 21 times more effective and oxide nitrous proves to be 290 times more effective.

Briefed from the IPCC, 1994.

In order to provide an instrument that contributes to the analysis of mitigation options, the global warming potentials were estimated, based upon the total emissions for 1990, over time horizons of 20 and 100 years. The results are presented in Tables 6.2. and 6.3.

As it can be observed from the Tables, in the middle length term (20 years), on what concerns Costa Rica, the main contribution to global warming would be that from methane, produce mostly by the Agriculture Sector, and which relative total, in reference to the equivalent potential of CO_2, will amount to a relative contribution of 66.3%. The second most important contributor is Carbon Dioxide, with a relative contribution of 32.5%, provided, in equal shares, by the Energy and Land Use Change sectors. For a time horizon of 100 years, the main radiative forcing comes from CO_2, with a relative distribution of 58.2%. With that time horizon, methane only accounts for a relative distribution of 39.5%.

TABLE 6.2
RELATIVE EMISSIONS OF GRENHOUSE GASES CONCERNING THEIR GLOBAL WARMING POTENTIALS, FOR A TIME HORIZON OF 20 YEARS

GAS	EMISSION Gg	GWP Horizon 20 years	RELATIVE TOTAL	RELATIVE CONTRIBUTIONS %
Carbon dioxide (CO_2)	4918.4	1	4918.4	**32.1**
Energy	2381.4		2381.4	15.6
Industrial Processes	367.9		367.9	2.4
Land Use Change	2169.1		2169.1	14.2
Methane	161.97	63	10204.1	**66.7**
(CH_4)	5.32		335.2	2.2
Energy	124.52		7844.8	51.2
Agriculture	11.63		732.7	4.8
Land Use Change	20.5		1291.5	8.4
Waste				
Nitrous oxide (N_2O)	0.68	270	183.6	**1.2**
Energy	0.12		32.4	0.2
Agriculture	0.48		129.6	0.9
Land Use Change	0.08		21.6	0.1

TABLE 6.3
RELATIVE EMISSION OF GREENHOUSE GASES CONCERNING THEIR GLOBAL WARMING POTENTIALS FOR A TIME HORIZON OF 100 YEARS

GAS	EMISSION Gg	GWP Horizon 100 years	RELATIVE TOTAL	RELATIVE CONTRIBUTION %
Carbon dioxide (CO_2)	4918.4	1	4918.4	**57.7**
Energy	2381.4		2381.4	28.0
Industrial processes	367.9		367.9	4.3
Land Use Change	2169.1		2169.1	25.5
Methane	161.97	21	3401.4	**39.9**
(CH_4)	5.32		111.7	1.3
Energy	124.52		2614.9	30.7
Agriculture	11.63		244.2	2.9
Land Use	20.5		430.5	5.1
Change				
Waste				
Nitrous oxide (N_2O)	0.68	290	197.2	**2.3**
Energy	0.12		34.8	0.4
Agriculture	0.48		139.2	1.6
Land Use Change	0.08		23.2	0.3

REFERENCES

- Alvarado, F., Leiva, C. 1991. Balance Nacional de Energía de Costa Rica 1990. Dirección Sectorial de Energía. San José.

- Alvarado, F. et al. 1993. Encuesta sobre el consumo energético del Sector Industrial costarricense. Dirección Sectorial de Energía. San José.

- Andrasko, K. 1990. "El recalentamiento del globo terráqueo y los bosques: estado actual de los conocimientos" Unasylva 163:41.

- Brown S., Lugo A. 1984. "Biomass of Tropical Forests: A New Estimate Based on Forest Volumes" Science 223:1290-1293.

- Calvo, J., Hernández A. y Solera L. 1994. Balance Energético Nacional 1993. República de Costa Rica. Dirección Sectorial de Energía.

- CENERGIA. 1994. Segundo Curso Latinoamericano de eficiencia energética y Medio Ambiente. Lima.

- Chacón-Vega, L. 1991. Introducción a la problemática ambiental Costarricense. EUNED, San José, Costa Rica.

- CNP, SEPSA. 1990. Encuesta Ganadera Nacional. SEPSA, San José, Costa Rica.

- Dirección General de Estadística y Censo. 1984. Censo Agrícola 1984. Ministerio de Economía, Industria y Comercio. San José, Costa Rica.

- Dirección Sectorial de Energía. 1986. Producción de Energía nuevas y renovables en áreas prioritarias de desarrollo: región Huetar Norte, primera parte. Proyecto plurinacional de cooperación técnica, OEA & República de Francia.

- Dirección Sectorial de Energía. 1987. I Seminario Nacional de Biomasa. Ministerio de Industria, Energía y Minas, San José, Costa Rica.

- Dirección Sectorial de Energía. 1986. Potencial de producción de biomasa a partir de desechos Agropecuarios - Costa Rica. Ministerio de Industria, Energía y Minas. San José, Costa Rica.

- FAO. 1991. Fertilizantes. Anuario, vol. 1. FAO, Roma, Italia.

- FAO. 1992. Avances en la producción de leche y carne en el Trópico Americano. ONU - FAO, Santiago,Chile.

- FERTICA. 1993. Areas de cultivo y consumo de fertilizantes. Gerencia Técnica Agronómica, Fertica, San José, Costa Rica.

- Gobierno de Costa Rica-GTZ. 1991. Plan Nacional de Manejo de Desechos de Costa Rica, Informe Final. San José, Costa Rica.

- Graedel, T, Crutzen, P. " Una Atmósfera Cambiante" Investigación y Ciencia 158:22-30.

- Hernández, C. 1994. Información sobre el cultivo de arroz anegado. Oficina del arroz. Comunicación Personal.

- Houghton, R., Woodwell, G., 1989. "Cambio Climático Global" Investigación y Ciencia. 153:

- IDA & FAO. 1990. VI° Mesa Redonda latinoamericana sobre Palma Aceitera. Red Latinoamericana de Palma Aceitera. San José, Costa Rica.

- IICA. 1989. Compendio de Agronomía Tropical. IICA. San José, Costa Rica.

- Industria Nacional de Cemento. Información sobre producción de clínker y cemento año 1990. Comunicación personal.

- IPCC/OECD, 1994. IPCC Draft Guidelines for National Greenhouse Gas Inventories: Vol. I, Reporting Instructions; Vol. 2, Workbook; Vol. 3, Reference Manual. Intergovernmental Panel on Climate Change, Organization for Economic Co-operation and Development.

- IPCC, 1992. Cambio Climático. Vol. 1 Evaluación científica del IPCC, Vol.2 Estrategias de Respuesta del IPCC. Traducido al español por el Instituto Nacional de Meteorología basandose en la edición en inglés editada por Island Press, California.

- IPCC,1994. Radiative forcing of Climate Change. The 1994 Report of the Scientific Assessment Working Group of IPCC. Summary for Policymakers.

- Kiehl, E. 1985. Fertilizantes Orgánicos. Informacóes Agronomicas. Brazil.

- Ministerio de Agricultura y Ganadería. 1993. Diagnóstico del Sector Agropecuario. Secretaría Ejecutiva de Planificación Sectorial Agropecuaria. Tomo I, San José.

- Ministerio de Recursos Naturales. 1994. Información sobre quemas en el país..

- Ministerio de Recursos Naturales, Energía y Minas. 1994. OPUS MAGNA, 1990 - 1994. MIRENEM, San José, Costa Rica.

- Ministerio de Recursos Naturales, Energía y Minas. DGF 1984. Censo de la Industria del Aserrío. San José.

- Ministerio de Recursos Naturales, Energía y Minas. DGF 1994. Censo de la Industria del Aserrío. San José. (Por publicar).

- Ministry of Natural Resources. 1994. The National Inventory of anthropogenic sources and sinks of Greenhouse Gases in the Republic of Uganda.

- Mojica, F. 1994. Mesa Redonda: Agricultura Orgánica. En: XL Congreso del PCCMCA. San José, Costa Rica.

- Molina, R. 1994. Población de Búfalos en Costa Rica. ITCR. Comunicación personal.

- National Academy of Sciences. 1977. Methane Generation from Human, Animal and Agricultural Wastes. Washington D.C.

- O.L.A.D.E. 1984. Metodología O.L.A.D.E. para la elaboración de Balances Energéticos. No. 8.

- O'Callaghan, P. 1992. Energy management. McGraw Hill, London,

- Pomareda, C. 1992. La Agricultura en el Desarrollo Económico de centroamérica en los 90. IICA, San José.

- Quam, A. Volumen de Concentrado consumido por ganado lechero. MAG, comunicación personal.

- Rosales, R. Ganado lechero en Costa Rica. UCR, comunicación personal.

- Sandoval, B. Población de ovejas en Costa Rica. MAG, Programa de Rumiantes menores, comunicación personal.

- SEPSA. 1991. Comportamiento de las actividades productivas y los servicios de apoyo al sector agropecuario. Secretaría Ejecutiva del Sector Agropecuario. San José.

- SEPSA. 1993. Análisis coyuntural de la ganadería de carne. Dirección de Estudios Básicos. San José.

- SEPSA. 1993. Diagnóstico del Sector Agropecuario. Tomo I, Secretaría Ejecutiva de Planificación del Sector Agropecuario. San José.

- SIEN, Sistema Información Energético Nacional, Dirección Sectorial de Energía. Módulo de eficiencias de combustión.

- SNAA. 1990. Plan Maestro de Saneamiento y Alcantarillado Sanitario de la Gran Area Metropolitana: Informe Final. PLAMAGAM. Tomo II. MIDEPLAN - BID.

- Solera, L. et al. 1994. Balance Energético Nacional 1993: República de Costa Rica. Dirección Sectorial de Energía. San José.

- Solorzáno, R. 1992. La depreciación de los recursos naturales de Costa Rica y su Relación con el sistema de Cuentas Nacionales. Centro Científico Tropical, San José.

- Sorensen, K., 1994. "Los cambios climáticos y la biodiversidad" Actualidad Forestal Tropical, 2:2.

- Stern, A. 1976. Air Pollution: Measuring, Monitoring and Surveillance or Air Pollution. Third Edition, vol. III, Academic Press Inc., Florida.

- —— 1982. Rapid assessment of sources of air, water and land pollution. World Health Organization, Geneva.

- Villegas, G. 1994. Actualización del Parque Automotor. Ministerio de Recursos Naturales, Energía y Minas. San José.

- Villegas G. y Valverde, J. 1994. Estudio sobre el recorrido medio anual y la tenencia de catalizadores en los vehículos de Costa Rica.

- U. S. EPA. 1994. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 1993. U.S.Environmental Protection Agency. Washington, U.S.A.

ANNEX 1

		Modulo	Energia					
		Submodulo	CO2 de fuentes de energia (enfoque de combustibles detallados)					
		Hoja de trabajo	1.1					
		Hoja	1 de 5					
			A produccion	B Importación	C Exportación	D Depósitos intern.	D Cambios de stock	E Consumo aparente
Tipo de combustible			TJ	TJ	TJ	TJ	TJ	TJ
Fosiles liquidos	Combustibles primarios	Petroleo crudo	-	17592	-		201	17391
		Liquidos de gas natural	-	-	-		-	-
	Combustibles secundarios	Gasolina		6504	10	-	101	6393
		Queroseno de aviación		1285	379	1743	104	-941
		Queroseno		0	0	0	-67	67
		Diesel		13153	162	0	93	12898
		Fueloil residual		2258	0	0	1171	1087
		LPG		1098	0		49	1049
		Etano		-	-		-	-
		Nafta		0	2		-534	532
		Asfalto		173	0		-73	246
		Lubricantes		-	-	-	-	-
		Coque de petroleo		-	-		-	-
		Materias primas de refineria		-	-		-	-
		Otros aceites		0	3535		20	-3555
Total de liquidos fosiles			-	42063	4088	1743	1065	35167
Fosiles sólidos	Combustibles primarios	Antracita	-	-	-	-	-	-
		Carbon de coq	-	-	-	-	-	-
		Otro	-	-	-	-	-	-
		Carbon mineral	-	3	0	0	0	3
		Lignito	-	-	-	-	-	-
		Turba	-	-	-	-	-	-
	Combustibles secundarios	BI y briquetas prensadas		-	-	-	-	-
		Coque		7	0	0	0	7
Total de fosiles solidos			-	10	0	0	0	10
Fosiles gaseosos		Gas natural (sec	-	-	-	-	-	-
Biomasa		Biomasa solida	31029	0	0		0	31029
		Biomasa liquida	855	447	669		146	487
		Biomasa gaseosa	-	-	-		-	-
Total			31884	447	669		146	31516

		Modulo	Energia				
		Submodulo	CO2 de fuentes de energia (enfoque de combustibles detallados)				
		Hoja de trabajo	1.1				
		Hoja	2 de 5				
			G Factor de conversión (TJ/unit)	H Consumo aparente TJ	I Factor de emisión de carbón (t C/TJ)	J Contenido de carbón (t C)	K Contenido de carbón (Gg C)
Tipo de combustible						x E3	TJ
Fosiles liquidos	Combustibles primarios	Petroleo crudo	1	17391	200	347.82	347.82
		Liquidos de gas natural	-	-	-	-	-
	Combustibles secundarios	Gasolina	1	6393	189	120.83	120.83
		Queroseno de aviación	1	-941	195	-18.35	-18.35
		Queroseno	1	67	196	1.31	1.31
		Diesel	1	12898	202	260.54	260.54
		Fueloil residual	1	1087	211	22.94	22.94
		LPG	1	1049	172	18.04	18.04
		Etano	-	-	-	-	-
		Nafta	1	532	200	10.64	10.64
		Asfalto	1	246	220	5.41	5.41
		Lubricantes	-	-	-	-	-
		Coque de petroleo	-	-	-	-	-
		Materias primas de refineria	-	-	-	-	-
		Otros aceites	1	-3555	200	-71.10	-71.10
Total de liquidos fosiles			-	35167	-	698.08	698.08
Fosiles sólidos	Combustibles primarios	Antracita	-	-	-	-	-
		Carbon de coq	-	-	-	-	-
		Otro	-	-	-	-	-
		Carbon mineral	1	3	262	0.08	0.08
		Lignito	-	-	-	-	-
		Turba	-	-	-	-	-
	Combustibles secundarios	Bl y briquetas prensadas	-	-	-	-	-
		Coque	1	7	295	0.21	0.21
Total de fosiles solidos			-	10	-	0.29	0.29
Fosiles gaseosos		Gas natural (sec	-	-	-	-	-
Biomasa		Biomasa solida	1	31029	299	927.77	927.77
		Biomasa liquida	1	487	200	9.74	9.74
		Biomasa gaseosa	-	-	-	-	-
Total				31516	-	937.51	937.51

		Modulo	Energia				
		Submodulo	CO2 de fuentes de energia (enfoque de combustibles detallados)				
		Hoja de trabajo	1.1				
		Hoja	3 de 5				
			L Carbono almacenado (Gg C)	M Emisión neta de carbón (Gg)	N Fracción de carbón oxidada	O Emisión de carbón actual (Gg C)	P Emisión de CO2 actual (Gg CO2)
Tipo de combustible							
Fosiles liquidos	Combustibles primarios	Petroleo crudo	-	347.82	0.99	344.34	1262.58
		Liquidos de gas natural	-	-	-	-	-
	Combustibles secundarios	Gasolina	-	120.83	0.99	119.62	438.61
		Queroseno de aviación	-	-18.35	0.99	-18.17	-66.62
		Queroseno	0.016	1.30	0.99	1.28	4.69
		Diesel	-	260.54	0.99	257.93	945.74
		Fueloil residual	-	22.94	0.99	22.71	83.27
		LPG	-	18.04	0.99	17.86	65.49
		Etano	-	-	-	-	-
		Nafta	23.79	-13.15	0.99	-13.02	-47.73
		Asfalto	18.52	-13.11	0.99	-12.98	-47.59
		Lubricantes	-	-	-	-	-
		Coque de petroleo	-	-	-	-	-
		Materias primas de refineria	-	-	-	-	-
		Otros aceites	-	-71.10	0.99	-70.39	-258.10
Total de liquidos fosiles			42.33	655.76	-	649.18	2380.34
Fosiles sólidos	Combustibles primarios	Antracita	-	-	-	-	-
		Carbon de coq	-	-	-	-	-
		Otro	-	-	-	-	-
		Carbon mineral	-	0.08	0.98	0.08	0.29
		Lignito	-	-	-	-	-
		Turba	-	-	-	-	-
	Combustibles secundarios	Bl y briquetas prensadas	-	-	-	-	-
		Coque	-	0.21	0.98	0.21	0.77
Total de fosiles solidos			-	0.29	-	0.29	1.06
Fosiles gaseosos		Gas natural (sec	-	-	-	-	-
Biomasa		Biomasa solida	-	927.77	0.99	918.49	3367.8
		Biomasa liquida	9.74	0	0.99	0	0
		Biomasa gaseosa	-	-	-	-	-
Total			9.74	927.77	-	918.49	3367.8

	Modulo	Energia					
	Submodulo	CO2 de fuentes de energia (Referencia)					
	Hoja de trabajo	1.1					
	Hoja	4 de 5 Emisiones de depósitos internacionales (aéreo y marítimo)					
		A Cantidades estimadas	B Factor de conversión (TJ/unidad)	C Cantidades Estimadas (TJ)	D Factor de emisión de carbón (t C/TJ)	E Contenido de carbón (t C)	F Contenido de carbón (Gg C)
Tipo de combustible							
Fosiles sólidos	Otro carbón	-	-	-	-	-	-
	Carbón sub-bituminoso	-	-	-	-	-	-
Fósiles líquidos	Gasolina	-	-	-	-	-	-
	Queroseno de aviación	1743	1	1743	19.5	33988.5	33.99
	Diesel	-	-	-	-	-	-
	Fuel oil residual	-	-	-	-	-	-
	Lubricantes	-	-	-	-	-	-
			Total	1743			

Modulo		Energia					
Submodulo		CO2 de fuentes de energia (Referencia)					
Hoja de trabajo		1.1					
Hoja		5 de 5 Emisiones de depósitos internacionales (aéreo y marítimo)					
		G Fracción de carbono almacenado	H Carbono almacenado (Gg C)	I Emisiones netas de carbón (Gg C)	J Fracción de carbón oxidada	K Emisión de carbón actual (Gg C)	L Emisiones de CO2 actuales (Gg CO2)
Tipo de combustible							
Fosiles sólidos	Otro carbón	-	-	-	-	-	-
	Carbón sub-bituminoso	-	-	-	-	-	-
Fósiles líquidos	Gasolina	-	-	-	-	-	-
	Queroseno de aviación	0	0	33.99	0.99	33.65	123.38
	Diesel	-	-	-	-	-	-
	Fuel oil residual	-	-	-	-	-	-
	Lubricantes	-	-	-	-	-	-
						Total	123.38

Módulo	Energia							
Submódulo	CO2 de fuentes de energia (Referencia)							
Hoja de trabajo	Hoja auxiliar 1.1 Estimación de carbono almacenado en productos							
Hoja	1 de 1							
	A Cantidad de combustible TJ	B Factor de conversión (TJ/unidad)	C Cantidad de combustible (TJ)	D Factor de emisión de carbón (t C/ TJ)	E Contenido de carbón (t C)	F Contenido de carbón (Gg C)	G Fracción de carbono almacenado	H Carbono almacenado (Gg C)
Tipo de combustible								
Nafta	1487	1	1487	20.0	29740	29.74	0.8	23.79
Lubricantes	-	-	-	-	-	-	-	-
Asfalto	842	1	842	22.0	18524	18.52	1.0	18.52
Aceites y alquitranes	-	-	-	-	-	-	-	-
Gas natural	-	-	-	-	-	-	-	-
Diesel	-	-	-	-	-	-	-	-
LPG	-	-	-	-	-	-	-	-
Otros combustibles	1	1	1	19.6	19.6	19.6E-3	0.8	0.016
Biomasa líquida	487	1	487	20.0	9740	9.74	1.0	9.74

Módulo	Energia
Submódulo	Biomasa tradicional quemada como combustible
Hoja de trabajo	1.3
Hoja	1 de 3

	A	B	C	D	E	F	G	H
	Biomasa consumida (kt dm)	Fracción de carbón de la biomasa	Contenido de carbón (kt dm)	Fracción oxidada	Total de carbón liberado (kt C)	Tasa C-CH4	Carbono emitido como CH4 (kt C)	Emisiones de metano de la biomasa (Gg CH4)
Madera (uso directo)	1495.6	0.48	717.9	0.19	136.4	0.012	1.64	2.18
Residuos Agrícolas	773.9	0.44	340.5	0.44	149.83	0.005	0.75	1
Consumo de carbón	12.68	0.87	11.03	0.45	4.96	0.0014	0.00695	0.00927
Producción de carbón					13.31	0.063	0.84	1.12
Otros (Especificar)								
				TOTAL				4.31
Producción de carbón								
Entrada (madera)	50.72	0.48	24.34		24.34			
Entrada (otro)	-	-	-		-			
Salida (carbón)	12.68	0.87	11.03		11.03			
Carbono liberado					13.31			

Módulo	Energia
Submódulo	Biomasa tradicional quemada como combustible
Hoja de trabajo	1.3
Hoja	2 de 3

	I	J	K	L	M	N	O	P
	Tasa de emisión C-CO	C emitido como CO (kt C)	CO emitido (Gg CO)	Razón carbono/ nitrógeno	Nitrógeno total liberado (kt N)	Tasa de emisión N/N2O	Nitrógeno emitido como N2O (kt N)	N2O emitido (Gg N2O)
Madera (uso directo)	0.06	8.18	19.09	0.015	2.05	0.007	0.014	0.022
Residuos Agrícolas	0.06	8.99	20.98	0.015	2.25	0.007	0.016	0.025
Consumo de carbón	0.06	0.3	0.7	0.015	0.07	0.007	0.00052	0.00082
Producción de carbón	0.06	0.8	1.86	0.015	0.2	0.007	0.0014	0.0022
Otros (Especificar)								
		TOTAL	42.63					0.05

Módulo	Energia		
Submódulo	Biomasa tradicional quemada como combustible		
Hoja de trabajo	1.3		
Hoja	3 de 3		
	Q Tasa de emisión N/NOx	R N emitido como NOx (kt N)	S NOx emitido (Gg NOx)
Madera (uso directo)	0.121	0.25	0.81
Residuos Agrícolas	0.121	0.271	0.89
Consumo de carbón	0.121	0.00895	0.029
Producción de carbón	0.121	0.024	0.08
Otros (Especificar)			
		TOTAL	1.81

Módulo	Energia			
Submódulo	Emisiones de metano de actividades de gas y petróleo			
Hoja de trabajo	1.5			
Hoja	1 de 1			
Categoría	A Actividad	B Factor de emisión	C Emisiones de CH4 (kg CH4)	D Emisiones de CH4 (Gg CH4)
PETROLEO				
Exploración	-	-	-	-
Producción	-	-	-	-
Transporte	-	-	-	-
Refinación	17.59 PJ	745 kg CH4/PJ	13106	0.013
Almacenamiento	17.59 PJ	140 kg CH4/PJ	2462.9	2.5E-3
			Total CH4	0.0155
GAS	-	-	-	-
Producción/Procesamiento	-	-	-	-
Trasmisión y distribución	-	-	-	-
Otro	-	-	-	-
				-
Ventilación y flameado de producción de Petróleo y gas	-	-	-	-
			Total CH4 de petróleo y gas	0.0155

Estimacion de emisiones Fuentes Moviles
Vehiculos Pasajeros y Carga Liviana
de Gasolina

Tipo vehiculo	No. de vehiculos	Recorrido promedio anual km/veh. año	Recorrido anual total km/año	Factores de emisión g/km					Emision por contaminante Gg			
				CO	CH4	NOx	N2O	NMVOC	CO	CH4	NOx	N2O
automovil	97882	20334	1990332588	40,62	0,17	2,14	0,01	6,33	80,85	0,35	4,26	0,01
jeep	13662	20530	280480860	40,62	0,17	2,14	0,01	6,33	11,39	0,05	0,60	0,00
microbus familiar	9008	18442	166125536	40,62	0,17	2,14	0,01	6,33	6,75	0,03	0,36	0,00
Taxis	104	100000	10400000	40,62	0,17	2,14	0,01	6,33	0,42	0,00	0,02	0,00
carga liviana |(pick up, panel)	43034	21211	912794174	44,55	0,17	2,63	0,01	8,54	40,66	0,16	2,40	0,01
Autobuses	338	55000	18590000	44,55	0,17	2,63	0,01	8,54	0,83	0,00	0,05	0,00
Motocicletas	44794	20000	895880000	23,80	0,33	0,19	0,00	6,50	21,32	0,29	0,17	0,00
Total									162,23	0,88	7,86	0,02

Estimacion de emisiones Fuentes Moviles
Vehiculos Pasajeros, Carga liviana
y carga pesada de diesel

Tipo vehiculo	No. de vehiculos	Recorrido promedio anual km/veh. año	Recorrido anual total km/año	Factores de emision g/km					Emision por contaminante Gg			
				CO	CH4	NOx	N2O	NMVOC	CO	CH4	NOx	N2O
automovil	6275	22954	144036350	1,06	0,01	1,02	0,01	0,52	0,15	0,00	0,15	0,00
jeep	16346	16724	273370504	1,06	0,01	1,02	0,01	0,52	0,29	0,00	0,28	0,00
microbus familiar	1416	20096	28455936	1,06	0,01	1,02	0,01	0,52	0,03	0,00	0,03	0,00
Taxis	1886	100000	188600000	1,06	0,01	1,02	0,01	0,52	0,20	0,00	0,19	0,00
carga liviana (pick up, panel)	29878	21393	639180054	1,61	0,02	1,45	0,02	0,83	1,03	0,01	0,93	0,01
Autobuses	3778	55000	207790000	1,61	0,02	1,45	0,02	0,83	0,33	0,00	0,30	0,00
carga pesada (camion)	12473	78502	979155446	8,54	0,10	16,79	0,03	2,99	8,36	0,10	16,44	0,03
TOTAL									10,40	0,12	18,32	0,05

Módulo	Procesos Industriales		
Submódulo	CO2 de la producción de cemento		
Hoja de trabajo	2.1		
Hoja	1 de 1		
A Cantidad de clínker o cemento producido (t)	B Factor de emisión (t CO2/t clínker o cemento producido)	C CO2 emitido (t)	D CO2 emitido (Gg)
738000	0.4985	367893	367.9

Modulo	Agricultura
Submodulo	Emisiones de metano de ferment. entérica y manejo de estiércol en animales domésticos
Hoja de trabajo	4.1
Hoja	1 de 1

Tipo de animal	A Número de animales (1000s)	B Factor de emisión para fermentación entérica (kg/cabeza/año)	C Emisiones de fermentación entérica (t/año)	D Factor de emisión para manejo de estiércol (kg/cabeza/año)	E Emisiones por manejo de estiércol (t/año)	F Emisiones anuales totales de la ganadería (Gg)
Ganado de leche	297.614	57	16964	1	297.614	17.26
Ganado de carne	1886.415	49	92434.3	1	1886.415	94.32
Búfalos	2	55	110	2	4	0.11
Ovejas	7	5	35	0.16	1.12	0.04
Cabras	20	5	100	0.17	3.4	0.10
Camellos	-	-	-	-	-	-
Caballos	93.007	18	1674.1	1.6	148.8	1.82
Mulas y asnos	-	-	-	-	-	-
Cerdos	346.2	1	346.2	2	692.4	1.04
Aves	27852.778	-	-	0.018	501.4	0.50
		Totales	111663.7		3535.1	115.19

Módulo	Agricultura
Submódulo	Emisiones de metano de la producción de arroz
Hoja de trabajo	4.2
Hoja	1 de 1

Regimen de manejo del agua	A Area cosechada (Mha)	B Longitud de la estación (días)	C Megahectárea/ día (Mha-día)	D Factor de emisión (kg-ha-día)	E Emisiones de CH4 por manejo de agua (Gg)
Continuamente inundado	0.0122	120	1.47	5.90	8.67
Intermitentemente inundado	-	-	-	-	-
Totales	0.0122				8.67

Modulo	Agricultura
Submodulo	Quema de sabanas
Hoja de trabajo	4.3
Hoja	1 de 3

A Area quemada por categoria (especificar) (kha)	B Densidad de biomasa de sabana (t dm/ha)	C Biomasa total expuesta a la quema (Gg dm)	D Fracción actualmente quemada	E Cantidad actual quemada (Gg dm)	F Fracción de biomasa viva quemada	G Cantidad de biomasa viva quemada (Gg dm)	H Cantidad de biomasa muerta quemada (Gg dm)
pasto 8,801	5	44.01	0.8	35.2	0.55	19.36	
							15.84
charral 3,565	5	17.82	0.8	14.26	0.55	7.84	
							6.42

Módulo	Agricultura		
Submódulo	Quema de sabanas		
Hoja de trabajo	4.3		
Hoja	2 de 3		
I Fracción oxidada de biomasa viva y muerta	J Biomasa total oxidada (Gg dm)	K Fracción de carbón de biomasa viva y muerta	H Carbón total liberado (Gg C)
Viva 0.8	15.49	0.45	6.97
Muerta 1.0	15.84	0.4	6.34
Viva 0.8	6.27	0.45	2.82
Muerta 1.0	6.42	0.4	2.57
		Total	18.7

		Modulo	Agricultura			
		Submodulo	Quema de sabanas			
		Hoja de trabajo	4.3			
		Hoja	3 de 3			
L	M	N	O	P	Q	R
Carbón liberado total (Gg C)	Razón nitrógeno/ carbón	Contenido de nitrógeno total (Gg N)	Tasas de emisión	Emisiones (Gg C o Gg N)	Tasa de conversión	Emisiones de la quema de sabana (Gg)
			0.004	0.075	16/12	0.10 CH4
			0.06	1.122	28/12	2.62 CO
18.7	0.006	0.1122				
			0.007	7.85E-04	44/28	1.23E-3 N2O
			0.121	0.014	46/14	0.05 NOx

			Modulo	Agricultura				
			Submodulo	Quema de residuos agrícolas				
			Hoja de trabajo	4.4				
			Hoja	1 de 3				
Cultivos (Especificar)	A Producción anual (Gg cultivo)	B Razón residuo a cultivo	C Cantidad de residuo (Gg biomasa)	D Fracción de masa seca	E Cantidad de masa seca (Gg dm)	F Fracción quemada en	G Fracción oxidada	H Biomasa total quemada (Gg dm)
Maíz	-	-	225.851	0.4	90.34	0.25	0.9	20.33
Arroz	-	-	20	0.83	16.6	0.25	0.9	3.74
Frijol	-	-	16.621	0.8	13.30	0.25	0.9	2.99
Sorgo	-	-	38.751	0.9	32.16	0.25	0.9	7.85
Caña de azúcar	-	-	739.763	0.9	369.88	0.25	0.9	149.8
Algodón	-	-	0.186	0.8	0.15	0.25	0.9	0.03
							Total	184.74

Modulo	Agricultura			
Submodulo	Quema de residuos agrícolas			
Hoja de trabajo	4.4			
Hoja	2 de 3			
Cultivos (Especificar)	I Fracción de carbón del residuo	J Carbón total liberado (Gg C)	K Razón nitrógeno/ carbón	L Nitrógeno total liberado (Gg N)
Maíz	0.45	9.15	0.015	0.14
Arroz	0.45	1.68	0.015	0.025
Frijol	0.45	1.35	0.015	0.02
Sorgo	0.45	3.53	0.015	0.053
Caña de azúcar	0.45	67.41	0.015	1.01
Algodón	0.45	0.02	0.015	2.26E-04
		83.14		1.25

Modulo	Agricultura
Submodulo	Quema de residuos agrícolas
Hoja de trabajo	4.4
Hoja	3 de 3

	M Tasa de emisión	N Emisiones (Gg C o Gg N)	O Tasa de conversión	P Emisiones por quema de residuos agrícolas (Gg)
CH4	0.005	0.42	16/12	0.56
CO	0.06	4.99	28/12	11.64
N2O	0.007	0.01	44/28	0.01
NOx	0.121	0.15	46/14	0.49

		Modulo	Cambio de uso de la tierra y el bosque				
		Submodulo	Cambios en el bosque y otras existencias de madera				
		Hoja de trabajo	5.1				
		Hoja	1 de 3				
			A Area de bosque/biomasa existente (kha)	B Tasa de crecimiento anual (t dm/ha)	C Incremento anual de biomasa (kt dm)	D Fracción de carbón de materia seca	E Incremento en el carbón total (kt C)
Tropical	Plantaciones	Acacia spp.	-	-	-	-	-
		Eucalipto	3.79	14.5	54.96	0.45	24.73
		Teca	3.33	8	26.64	0.45	11.99
		Ciprés	0.88	10	8.80	0.45	3.96
		Pino	1.34	10	13.40	0.45	6.03
		Maderas duras	17.46	6.8	118.73	0.45	53.43
		Maderas duras de crecimiento rápido	-	-	-	-	-
		Maderas suaves	21.57	14.5	312.77	0.45	140.74
	Otro bosque	Húmedo	-	-	-	-	-
		Estacional	-	-	-	-	-
		Seco	-	-	-	-	-
	Otro (especificar)		-	-	-	-	-
Templado	Plantaciones	Douglas fir	-	-	-	-	-
		Loblolly pine	-	-	-	-	-
	Comercial	Siempreverde	-	-	-	-	-
		Deciduo	-	-	-	-	-
	Otro		-	-	-	-	-
Boreal			-	-	-	-	-
Arboles fuera de bosque (tipo)			A Número de árboles (1000s de árboles)	B Tasa de crecimiento anual (kt dm/1000)			
							240.88

Módulo	Cambio de uso de la tierra y el bosque							
Submódulo	Cambios en el bosque y otras existencias de madera							
Hoja de trabajo	5.1							
Hoja	2 de 3							
	F	G	H	I	J	K	L	M
Categoría de cosecha (especificar)	Cosecha comercial (si es aplicable) (1000 m3 de madera)	Tasa de conversión/ expansión de biomasa (t dm/m3)	Biomasa total removida la cosecha comercial (kt dm)	Leña tradicional total consumida (kt dm)	Otro uso total de madera (kt dm)	Consumo de biomasa total (kt dm)	Madera removida del bosque talado (kt dm)	Consumo de biomasa total de existencias (kt dm)
	-	-	-	-	-	-		
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-

Módulo	Cambio de uso de la tierra y el bosque
Submódulo	Conversión de bosque y pastizales
Hoja de trabajo	5.1
Hoja	3 de 3

N Fracción de carbón	O Liberación anual de carbón (kt C)	P Absorción o liberación neta de carbón (kt C)	Q Conversión a CO2 Emisión o absorción (Gg CO2)
0.45	0	240.88	883.23

		Modulo	Cambio de uso de la tierra y el bosque				
		Submodulo	Conversión de bosque y pastizales				
		Hoja de trabajo	5.2				
		Hoja	1 de 6				
Tipos de bosque			A Area convertida anual (kha)	B Biomasa antes de la conversión (t dm/ha)	C Biomasa después de la conversión (t dm/ha)	D Cambio neto en la densidad de biomasa (t dm/ha)	E Pérdida anual de biomasa (kt dm)
Tropical	Bosque húmedo	Primario	18	155.1	20	135.1	2431.8
		Secundario	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-
		Degradado	-	-	-	-	-
			-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
Boreal	Primario		-	-	-	-	-
	Secundario		-	-	-	-	-
Pastizales			-	-	-	-	-
Otro			-	-		-	-

		Modulo	Cambio de uso de la tierra y el bosque						
		Submodulo	Conversión de bosque y pastizales						
		Hoja de trabajo	5.2						
		Hoja	2 de 6						
Tipos de bosque			F Fracción de biomasa quemada en el sitio	G Cantidad de biomasa quemada en el sitio (kt dm)	H Fracción de biomasa oxidada	I Cantidad de biomasa oxidada (kt dm)	J Fracción de carbón de la biomasa superficial	K Cantidad de carbón liberado (de biomasa quemada) (kt C)
Tropical	Bosque húmedo	Primario	0.74	1794.7	0.9	1615.2	0.45	726.8
		Secundario	-	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-	-
		Degradado	-	-	-	-	-	-
			-	-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-
Boreal	Primario		-	-	-	-	-	-
	Secundario		-	-	-	-	-	-
Pastizales			-	-	-	-	-	-
Otro								

		Modulo	Cambio de uso de la tierra y el bosque							
		Submodulo	Conversión de bosque y pastizales							
		Hoja de trabajo	5.2							
		Hoja	3 de 6							
Tipos de bosque			L Fracción de biomasa quemada fuera del sitio	M Cantidad de biomasa quemada fuera del sitio (kt dm)	N Fracción de biomasa oxidada	O Cantidad de biomasa oxidada (kt dm)	P Fracción de carbón de la biomasa superficial	Q Cantidad de carbón liberado (kt C)	R Carbón total liberado (dentro y fuera) (kt C)	S CO2 total liberado (dentro y fuera del sitio) (kt CO2)
Tropical	Bosque húmedo	Primario	0.1	243.2	0.9	218.9	0.45	98.5		
		Secundario	-	-	-	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-	-	-	-
		Degradado	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-
Boreal	Primario		-	-	-	-	-	-	-	-
	Secundario		-	-	-	-	-	-	-	-
Pastizales			-	-	-	-	-	-	-	-
Otro										
			Subtotal	243.2			Subtotal	98.5	825.3	3026.10

Modulo	Cambio de uso de la tierra y el bosque
Submodulo	Conversión de bosque y pastizales
Hoja de trabajo	5.2
Hoja	4 de 6

Tipos de bosque			A Area promedio convertida (10 años) kha	B Biomasa antes de la conversión (t dm/ha)	C Biomasa después de la conversión (t dm/ha)	D Cambio neto en la densidad de biomasa (t dm/ha)	E Pérdida anual promedio de biomasa (kt dm)	F Fracción dejada para decaer	G Cantidad de biomasa dejada para decaer (kt dm)	H Fracción de carbón en la biomasa superficial	I C liberado de la biomasa dejada para decaer (kt C)
Tropical	Bosque húmeda	Primario	31.83	155.1	20	135.1	4300.2	0.04	172	0.45	77.4
		Secundario	-	-	-	-	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-	-	-	-	-
		Degradado	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-	-	-	-	-
		Secundario	-	-	-	-	-	-	-	-	-
Boreal	Primario		-	-	-	-	-	-	-	-	-
	Secundario		-	-	-	-	-	-	-	-	-
Pastizales			-	-	-	-	-	-	-	-	-
Otro			-	-	-	-	-	-	-	-	-
										Subtotal	77.40

		Modulo	Cambio de uso de la tierra y el bosque				
		Submodulo	Conversión de bosque y pastizales				
		Hoja de trabajo	5.2				
		Hoja	5 de 6				
Tipos de bosque			A Promedio anual bosque/pastizal convertido (25 años) kha	B Contenido de carbón del suelo antes de la conversión (t/ha)	C Pérdida potencial de carbón del suelo total anual (kt C)	D Fracción de carbón liberado sobre 25 años	E Carbón liberado del suelo (kt C)
Tropical	Bosque húmedo	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-
		Degradado	-	-	-	-	-
			-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
Boreal	Primario		-	-	-	-	-
	Secundario		-	-	-	-	-
Pastizales			-	-	-	-	-
Otro						-	-

		Modulo	Cambio de uso de la tierra y el bosque	
		Submodulo	Conversión de bosque y pastizales	
		Hoja de trabajo	5.2	
		Hoja	6 de 6	
A Liberación inmediata por quema (kt C)	B Emisiones por decaimiento (kt C)	C Emisiones del suelo a largo tiempo (25 años) (kt C)	D Liberación de carbón anual total (kt C)	E Liberación de CO2 anual total (Gg CO2)
825.3	77.4	-	902.7	3310

Modulo	Cambio de uso de la tierra y el bosque
Submodulo	Conversión de bosque y pastizales
Hoja de trabajo	5.2
Hoja	5 de 6

Tipos de bosque			A Promedio anual bosque/pastizal convertido (25 años) kha	B Contenido de carbón del suelo antes de la conversión (t/ha)	C Pérdida potencial de carbón del suelo total anual (kt C)	D Fracción de carbón liberado sobre 25 años	E Carbón liberado del suelo (kt C)
Tropical	Bosque húmedo	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Bosque	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Bosque seco o sabanas made-rables	Primario	-	-	-	-	-
		Degradado	-	-	-	-	-
			-	-	-	-	-
Templado	Siempreverde	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
	Deciduo	Primario	-	-	-	-	-
		Secundario	-	-	-	-	-
Boreal	Primario		-	-	-	-	-
	Secundario		-	-	-	-	-
Pastizales			-	-	-	-	-
Otro						-	-

Modulo	Cambio de uso de la tierra y el bosque
Submodulo	Conversión de bosque y pastizales
Hoja de trabajo	5.2
Hoja	6 de 6

A Liberación inmediata por quema (kt C)	B Emisiones por decaimiento (kt C)	C Emisiones del suelo a largo tiempo (25 años) (kt C)	D Liberación de carbón anual total (kt C)	E Liberación de CO2 anual total (Gg CO2)
825.3	77.4	-	902.7	3310

Modulo			Cambio de uso de la tierra y el bosque				
Submodulo			Quema en el sitio del bosque				
Hoja de trabajo			5.3				
Hoja			1 de 1				
A Cantidad de carbón liberado (kt C)	B Razón nitrógeno/ carbón	C Nitrógeno total liberado (kt N)		D Tasas de emisión de gases traza	E Emisiones de gases traza (kt C)	F Tasa de conversión	G Emisiones de gases traza de la quema de bosque talado (Gg CH_4, CO)
			CH_4	0.012	8.72	16/12	11.63
			CO	0.06	43.61	28/12	101.75
					kt N		Gg N_2O, NO_x
726.8	0.01	7.27					
			N_2O	0.007	0.05	44/28	0.08
			NO_x	0.121	0.88	46/14	2.89

Modulo		Cambio de uso de la tierra y el bosque				
Submodulo		Conversión de bosque y pastizales				
Hoja de trabajo		5.4				
Hoja		1 de 3				
Recrecimiento por tipo de bosque		A Area abandonada hace 20 años y recreciendo (kha)	B Tasa anual de crecimiento de biomasa superficial (t dm/ha)	C Crecimiento de biomasa superficial anual	D Fracción de carbón de la biomasa superficial	S Absorción de carbón de la biomasa superficial anual (kt C)
Bosque tropical	Húmedo	10.45	8	83.6	0.45	37.6
	Estacional	-	-	-	-	-
	Seco	70.25	4	281	0.45	126.40
Bosque templado	Siempreverde	-	-	-	-	-
	Deciduo	-	-	-	-	-
Bosque boreal		-	-	-	-	-
Pastizales		-	-	-	-	-
Otro						
						164.00

Modulo		Cambio de uso de la tierra y el bosque						
Submodulo		Conversión de bosque y pastizales						
Hoja de trabajo		5.4						
Hoja		1 de 3						
Recrecimiento por tipo de bosque		F Tasa anual de absorción de carbón en el suelo (t C/ha)	G Absorción de carbón total anual en suelos (- de 25 años) (kt C)	H Area total abandonada en más de 25 años (kha)	I Tasa anual de crecimiento de biomasa superficial (t dm/ha)	J Crecimiento anual de biomasa superficial (kt dm)	K Fracción de carbón de la biomasa superficial	L Absorción de carbón anual en la biomasa superficial (kt C)
Bosque tropical	Húmedo	-	-	-	-	-	-	-
	Estacional	-	-	-	-	-	-	-
	Seco	-	-	-	-	-	-	-
Bosque templado	Siempreverde	-	-	-	-	-	-	-
	Deciduo	-	-	-	-	-	-	-
Bosque boreal		-	-	-	-	-	-	-
Pastizales		-	-	-	-	-	-	-
Otro					-	-		
		Subtotal					Subtotal	-

Modulo	Cambio de uso de la tierra y el bosque
Submodulo	Conversión de bosque y pastizales
Hoja de trabajo	5.4
Hoja	3 de 3

Recrecimiento por tipo de bosque		M Tasa anual de absorción de carbón en suelos (t C/ha)	N Absorción de carbón anual total en suelos (kt C)	O Absorci2n de carbón anual total de tierras abandonadas (kt C)	P Absorción de CO2 total (Gg CO2)
Bosque tropical	Húmedo	-	-	-	-
	Estacional	-	-	-	-
	Seco	-	-	-	-
Bosque templado	Siempreverde	-	-	-	-
	Deciduo	-	-	-	-
Bosque boreal		-	-	-	-
Pastizales		-	-	-	-
Otro		-	-		
		Subtotal	-	164	257.70

Modulo	Desechos
Submodulo	Emisiones de metano de rellenos sanitarios
Hoja de trabajo	6.1
Hoja	1 de 1

A MSW anuales a relleno sanitario (Gg)	B Fracción DOC	C Relleno DOC anual (Gg)	D Fracción degradada actual	E Carbono anual liberado como biogas (Gg)	F Fracción C-CH4 a C-biogas	G Carbón anual liberado como CH4 (Gg C)	H Tasa de conversión	I CH4 liberado (Gg CH4)	J CH4 recuperado (Gg CH4)	K Emisiones netas de CH4 (Gg CH4)
GAM 99.89	0.15	14.98	0.77	11.54	0.50	5.77	16/12	7.69	0	7.69
Resto GAM 107.62	0.15	16.14	0.77	12.43	0.50	6.22	16/12	8.29	0	8.29
TOTAL										15.98

Modulo	Desechos							
Submodulo	Emisiones de metano de tratamiento de aguas domésticas y comerciales							
Hoja de trabajo	6.2							
Hoja	1 de 1							
A	B	C	D	E	F	G	H	I
Población (especificar subcategorías) (1000 personas)	Valor de DBO del agua residual (Gg DBO5/ 1000 pers/año)	DBO anual (Gg DBO)	Fracción de agua tratada anaerobica	Cantidad de DBO del agua tratada anaerobica (Gg DBO5)	Factor de emisión de metano (Gg CH4/ Gg DBO5)	CH4 total liberado (Gg CH4)	Metano recuperado (Gg CH4)	Emisiones netas de CH4 (Gg CH4)
1657.771	0.0146	24.20	0.10	2.42	0.22	0.53	0.00	0.53
TOTAL								0.53

	Modulo	Desechos					
	Submodulo	Emisiones de metano del tratamiento de aguas industriales					
	Hoja de trabajo	6.3					
	Hoja	1 de 2					
		A Flujo de anual (Mlitros)	B Concentración de DBO (kg/l)	C DBO total generado (Gg DBO)	D Fracción de agua tratada anaerobica	E Cantidad de DBO del agua tratada (Gg DBO)	F Factor de emisión de metano (Gg CH4/ Gg DBO5)
Hierro y acero		-	-	-	-	-	-
Metales no ferrosos		-	-	-	-	-	-
Fertilizantes		-	-	-	-	-	-
Alimentos y bebidas	Conservas	341.768	0.003	1.02	0.1	0.1	0.22
	Cerveza	821.232	0.085	69.8	0.1	6.98	0.22
	Vino	-	-	-	-	-	-
	Empaque de carne	67.131	0.02	1.34	0.1	0.13	0.22
	Productos lácteos	-	-	-	-	-	-
	Azúcar	-	-	-	-	-	-
	Procesamiento de pescado	-	-	-	-	-	-
	Aceite y grasa	3102.018	0.019	58.94	0.1	5.89	0.22
	Café	-	-	-	-	-	-
	Bebidas gaseosas	-	-	-	-	-	-
	Otro	23683.857	0.002	47.37	0.1	4.74	0.22
Pulpa y papel	Pulpa	-	-	-		-	-
	Papel	71.504	0.004	0.29	0.1	0.03	0.22
	Otro	-	-	-	-	-	-
Refinación de petróleo		-	-	-	-	-	-
Textiles sólidos	Blanqueo	-	-	-	-	-	-
	Teñido	-	-	-	-	-	-
	Otro	-	-	-	-	-	-
Caucho		-	-	-	-	-	-
Otro		1224.261	0.002	2.45	0.1	0.24	0.22
Total		29311.771					

Modulo		Desechos		
Submodulo		Emisiones de metano del tratamiento de aguas industriales		
Hoja de trabajo		6.3		
Hoja		1 de 2		
		G Metano Total liberado (Gg CH4)	H Metano Recuperado Gg CH4 Gg CH4	I Emisiones netas de metano Gg CH4
Hierro y acero		-	-	-
Metales no ferrosos		-	-	-
Fertilizantes		-	-	-
Alimentos y bebidas	Conservas	0.02	0	0.02
	Cerveza	1.54	0	1.54
	Vino	-	-	-
	Empaque de carne	0.03	0	0.03
	Productos lácteos	-	-	-
	Azúcar	-	-	-
	Procesamiento de pescado	-	-	-
	Aceite y grasa	1.3	0	1.3
	Café	-	-	-
	Bebidas gaseosas	-	-	-
	Otro	1.04	0	1.04
Pulpa y papel	Pulpa	-	-	-
	Papel	0.01	0	0.01
	Otro	-	-	-
Refinación de petróleo		-	-	-
Textiles	Blanqueo	-	-	-
	Teñido	-	-	-
	Otro	-	-	-
Caucho		-	-	-
Otro		0.05	0	0.05
Total				3.99

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (SHEET 2) Gg							
Greenhouse Gas Source and Sink Categories	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC
4 Agriculture	-	-	124.52	0.48	0.55	14.26	-
A Enteric Fermentation	-	-	111.66	-	-	-	-
B Manure Management	-	-	3.54	-	-	-	-
C Rice Cultivation	-	-	8.67	-	-	-	-
D Agricultural Soils	-	-	0	0.465	-	-	-
E Prescribed Burning of Savannas	-	-	0.1	0.00	0.05	2.62	-
F Field Burning of Agricultural Residues	-	-	0.55	0.014	0.5	11.64	-
G Other	-	-	-	-	-	-	-
5 Land Use Change & Forestry	3310	1140.93	11.63	0.08	2.89	101.75	-
A Changes in Forest and Other Woody	-	883.23	-	-	-	-	-
Biomass Stocks					2.89	101.75	-
B Forest and Grassland Conversion	3310	-	11.63	0.08	-	-	-
C Abandonment of Managed Lands	-	257.7	-	-	-	-	-
D Other	-	-	-	-	-	-	-
6 Waste	-	-	20.5	-	-	-	-
A Solid Waste Disposal on Land	-	-	15.98	-	-	-	-
B Wastewater Treatment	-	-	4.52	-	-	-	-
C Waste Incineration	-	-	-	-	-	-	-
D Other Waste	-	-	-	-	-	-	-
7 Other	-	-	-	-	-	-	-
International Bunkers	-						-

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (SHEET 1) Gg							
Greenhouse Gas Source and Sink Categories	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC
Total National Emissions and Removals	6059.30	1140.93	161.97	0.68	33.49	331.41	33.33
1 All Energy (Fuel Combustion + Fugitive)	2381.40	-	5.32	0.12	30.05	215.40	33.33
A Fuel Combustion	2381.40	-	-	-	-	-	-
1 Energy & Transformation Industries	-	-	-	-	-	-	-
2 Industry (ISIC)	-	-	-	-	2.06	0.15	0.11
3 Transport	-	-	1.00	0.07	26.18	172.63	33.23
4 Small Combustion	-	-	-	-	-	-	-
5 Other	-	-	-	-	-	-	-
6 Traditional Biomass Burned for Energy	-	-	4.31	0.05	1.81	42.63	-
B Fugitive Emissions from Fuels	-	-	0.02	-	-	-	-
1 Solid Fuels	-	-	-	-	-	-	-
2 Oil and Natural Gas	-		0.02	-	-	-	-
2 Industrial Processes	367.90	-	-	-	-	-	-
3 Solvent and Other Product Use	-	-	-	-	-	-	-

TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (SHEET Gg							
Greenhouse Gas Source and Sink Categories	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC
Total National Emissions and Removals	6059.3	1140.93	161.97	0.68	33.49	331.41	33.33
1 All Energy (Fuel Combustion + Fugitive)	2381.4	-	5.32	0.12	30.05	215.4	-
A Fuel Combustion	2381.4	-	5.32	0.12	30.05	-	-
B Fugitive Fuel Emission	0	-	0.02	-	-	-	-
2 Industrial Processes	367.9	-	-	-	-	-	-
3 Solvent and Other Product Use	-	-	-	-	-	-	-
4 Agriculture	-	-	124.52	0.48	0.55	14.26	-
5 Land Use Change & Forestry	3310	1140.93	11.63	0.08	2.89	101.75	-
6 Waste	-	-	20.5	-	-	-	-
7 Other	-	-	-	-	-	-	-
International Bunkers	123.38	-	-	-	-	-	-

ANNEX 2

GLOSSARY

Biomass: Organic material both above ground and below ground, and both living and dead, as for example: trees, crops, pasture, tree litter, roots, etc. When burned for energy purposes these are referred to as biomass fuels.

Bio-degradable Waste: Solid organic waste which may react to aerobic and anaerobic bacteria and thus many generate methane.

BOD: Biochemical Oxygen Demand, the amount of oxygen consumed by organic material in waste water during decomposition.

BOD_5: Biochemical Oxygen Demand, on a five-days test, expressed in milligrams per liter.

Calcination: Chemical process by which cement industry processing obtains lime and carbon dioxide by heating raw material (calcium carbonate) in furnaces.

CFCs: Chloroflourocarbons. A set of chemical substances which have been used in refrigeration, foam blowing, etc. CFCs contribute to the depletion of the earth's ozone layer in the upper atmosphere. Even though they are greenhouse gases, they are not included in this guidelines because they are already being regulated under the Montreal Protocol.

CH_4: Methane.

CO: Carbon Monoxide.

CO_2: Carbon Dioxide.

Emission Factor: The coefficient that associates real emissions with activity data, as a standard emission unit per activity unit.

Enteric Fermentation: The byproduct of ruminant animals digestion, which outputs as methane.

GAM: The Greater Metropolitan Area.

GEF: Global Environment Fund.

Gg: Mass measurement unit, it means Giga-grams and is equivalent to 1 E9 grams.

International Deposited Fuels: Fuels utilized in the international sea and air transportation and which are not assigned to a particular country of origin.

IPCC: Intergovernmental Panel on the Climatic Change.

kha: Kilo-Hectares, a thousand hectares.

kton: Kilo-Ton, a thousand tons.

LPG: Liquefied Petroleum Gases, fractions of light hydrocarbons of the paraffine types, which are derived from refinement process and from stabilization plants of crude oil. They are mainly propane and butane, or a mix of those two hydrocarbons.

Ml: Mega-liters, a million liters.

MONTREAL PROTOCOL: An international agreement which requests from its members the reporting and controlling of CFC's and other chemical substances emissions which are depleting the ozone layer. The Montreal Protocol was undersigned in 1987, following the guidelines for protection of the ozone layers adopted in the Vienna Convention (1985). The Protocol was enforced in 1989 and has since established requisites and regulations on the control and reporting of chemical substances that deplete ozone in the atmosphere.

Municipal Solid Waste: Solid waste which is regularly collected by the municipality (City Authorities), as for example garbage collection.

NMVOC: Non Methane Volatile Organic Compounds.

N_2O: Nitrous Oxide.

NOX: Nitrogen Oxides.

OECD: Organization for Economic Cooperation and Development. A regional organization of 24 free-marketing democratic nations from North America, Europe and the Pacific.

Other Gases' Emissions Rates: The rates for carbon compounds as the carbon mass released as CH_4 or CO (in C units), as related to the total carbon mass released by combustion (in C units). The two nitrogen compounds are expressed as the rates for nitrogen which is released as N_2O and NOx, in relation to the nitrogen contents of fuel (in N units).

Stored Carbon: The non-burned amount of a fuel utilized as an energy source, which must subtracted from the apparent consumption before the calculation of emissions.

TJ: An energy measurement unit, it means TeraJoules.

UNEP: United Nations Environment programme.

Project No. GF/0103-92-42

Global
Environment
Facility

UNEP
United Nations
Environment Programme

undp
United Nations
Development Programme

World Bank