EGYPTIAN ENVIRONMENTAL AFFAIRS AGENCY

# The Arab Republic of Egypt: Initial National Communication on Climate Change

Prepared for the United Nations Framework Convention on Climate Change UNFCCC

June 1999

# *Preface*

According to the United Nations Framework Convention on Climate Change (UNFCCC) which was signed in Rio de Janeiro in June 1992 and entered into force the 21st of March 1994.

The parties to the Convention should take precautionary actions to prevent or minimize the emissions of greenhouse gases and consequently the causes of climate change.

Parties not listed in the Annex–I convention must make its initial communication within three years of the entry into force of the convention for that party, or the availability of financial resources in accordance with article 4 of the convention.

According to the provisions in Article 12, Egypt has elaborated the present Initial National Communication which was adopted by the Climate Change Technical Working Group, Climate Change unit in Egyptian Environmental Affairs Agency (EEAA) and the Inter- ministerial Committee of Climate Change and will be endorsed by the EEAA Board.

This initial communication includes national circumstances, GHG inventory, expected impacts of climate change, mitigation and adaptation options, and any further steps taken by Egypt to deal with climate change.

Also it presents the research gaps and needs related to the science of climate, impacts of climate change, increasing awareness , and policy oriented research.

This report prepared to be communicated to the UNFCCC during July 1999.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF ACRONYMS

| | |
|---|---|
| AMCEN | African Ministerial Conference on Environment |
| BBOE | Billion Barrel Of Oil |
| BOD | Biological Oxygen Demand |
| CFL | Compact Fluorescent Lamps |
| $CH_4$ | Methane |
| CHP | Combined Heat and Power (Co-generation) |
| CNG | Compressed Natural Gas |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| COP1 | First Conference of Parties |
| COP2 | Second Conference of Parties |
| COP3 | Third Conference of Parties |
| COP4 | Fourth Conference of Parties |
| CSC | Cost of Saved Carbon |
| DRTPC | Development Research and Technological Planning Center |
| ECEP | Energy Conservation and Environmental Protection |
| ECRI | The Environment & Climate Change Research Institute |
| EEA | Egyptian Electricity Authority |
| EEAA | Egyptian Environmental Affairs Agency |
| EES | Energy Efficiency Scenario |
| EGPC | Egyptian General Petroleum Corporation |
| ELS | Efficient Lighting System |
| EOS | Egyptian General Organization for Standardization and Quality Control |
| EUPS | Egyptian Unified Power System |
| FEI | Federation of Egyptian Industries |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| GIS | Geographical Information System |
| GOE | Government of Egypt |
| GOFI | General Organization for Industrialization |
| IPCC | Intergovernmental Panel on Climate Change |
| ISCCS | Integrated Solar Combined Cycle Systems |
| L.E. | Egyptian Pound |
| MOT | Ministry of Transportation |
| Mtoe | Million Ton Oil Equivalent |
| N.G. | Natural Gas |
| $N_2O$ | Nitrous Oxide |
| NOX | Nitrogen Oxides |
| NRC | National Research Center |
| NREA | New and Renewable Energy Authority |
| $O_2$ | Oxygen |
| OECP | Organization For Energy Conservation and Planning – (Now OEP) |
| PV | Photo Voltaic |
| RES | Renewable Energy Scenario |

| | |
|---|---|
| SCR | Steam Condensate Recovery |
| SHW | Solar Hot Water |
| SLR | Sea Level Rise |
| SNAP | Support for National Action Plan |
| TIMS | Tebbine Institute for Metallurgical Studies |
| toe | Ton Oil Equivalent |
| TOU | Time of Use |
| TWG | Technical Working Group |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environment Program |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| USCSP | United States Country Studies Program |
| US $ | United States Dollar |
| VTT | Technical Research Center of Finland |
| WHR | Waste Heat Recovery |

# LIST OF FIGURES

# LIST OF CONVERSION UNITS

| | |
|---|---|
| 1 Ton Crude Oil | = 0.995 TOE |
| 1 Ton N.G. | = 1.111 TOE |
| 1 Ton LPG | = 1.125 TOE |
| 1 Ton Fuel Oil | = 0.972 TOE |
| 1 Ton Kerosene | =1.086 TOE |
| 1 Ton Gasoline | = 1.103 TOE |
| 1 Ton Gas Oil | = 1.066 TOE |
| 1 Ton Crude Oil | = 7.3 Barrel Crude |
| 1 Ton Coal | = 0.670 TOE |
| 1 k Wh (hydro) | = 220 Gr. O.E (1996/97 –1997/98) |
| 1 Barrel equivalent N.G. | = 5000 Cubic feet N.G. |
| 1 Cubic Meter N.G. | = 35.315 Cubic feet |
| 1 Metric Ton | = 1000 kg. |
| k (kilo) | = $10^3$ |
| M (Mega) | = $10^6$ |
| G (Giga) | = $10^9$ |
| T (Tera) | = $10^{12}$ |

# EXECUTIVE SUMMARY

**Although Egypt's contribution to Green House Gases is relatively minimal, yet given Egypt's growing population, its limited fertile land, and its large area of desert, and the concentration of its economic activities in the coastal zones, the potential social and economic impact of climate change could be devastating for the country's future.**

Egypt is located in northern Africa, bordering the Mediterranean Sea between Libya and Gaza strip, with a coastal strip extending for about 3,500 kilometers, overlooking the Mediterranean Sea in the north, and the Red Sea in the east. The dominant feature of the northern coastal zone is the low lying delta of the River Nile, with its large cities, industry, flourishing agriculture and tourism. The delta and the narrow valley of the Nile comprises 5.5% of the area of Egypt, but has over 95% of its people and its agriculture. Egypt's Mediterranean coast and the Nile Delta have been identified as vulnerable to seal level rise.

Egypt's **climate** is semi-desert characterized by hot dry summers, moderate winters and very little rainfall. The country is characterized by particularly good wind regimes with excellent sites along the Red Sea and Mediterranean coasts. Egypt has only one main source of water supply, the River Nile, which supplies over 95% of the water needs of the country. There is some winter rain in the delta and along the Mediterranean coast, west of the delta. Non-renewable underground fossil water supplies are accessible outside the river valley, especially in the oases. Consequently, agricultural development is closely linked to the River Nile and its management. The Nile waters originate outside Egypt, flowing through nine countries. Egypt's use of the Nile water is controlled by international agreement. Massive projects to divert some of the Nile waters to Northern Sinai, and to Toshka depression, in the extreme south of the country, are underway. Consequently, the water needs of the country are growing rapidly.

**Economic conditions** in Egypt have improved considerably over the years since the baseline 1990/91. In that year real GDP growth rate was 3.7%. By the end of fiscal year 1998, the growth rate reached 5%, fueled primarily by private sector investment through continued rapid privatization and institution building. GOE aims to achieve a 6-7% growth rate by the turn of the century. Reserves, as of 1998, remain at US$ 20 billion. The foreign debt, about US$ 50 billion in the late 1980s, had fallen to US$ 31 billion by 1996.

Over the last decade, the **Egyptian economy** started to achieve a considerable and real improvement of its Gross Domestic Product (GDP). Total GDP has increased from nearly 50.177 LE Billion in 1990/91 to reach about 162 LE Billion by the end of the third five year national plan in 1996/97, with an average annual growth rate ranging between 2.5% and 5% during that period. The overall annual average annual GDP growth rate during that period (1991/92-1996/97) is about 4%. The inflation rate has fallen from around 14.7% in 1990/91 to around 4% in mid 1998. The economy continues to be resilient in the late 1990's in the face of a number of shocks, including the collapsing economies following the South East Asian crisis of 1997/98, the drop in oil prices (Egypt is a net importer of oil) and the temporary decline in tourism.

The **agricultural sector** contributes to the overall food needs of the country and provides the domestic industry with agricultural raw materials. Almost 50% of the Egyptian population rely on agriculture for income generation and employment opportunities. Major crops in order of acreage are wheat, maize, rice, cotton, beans and sugar cane. Egypt's agricultural production is mostly for home consumption; and Egypt is far from being self sufficient in food, importing wheat, sugar, vegetable oils and meat. Climate change would make the situation even worse as a result of its expected adverse impact on the national production of many crops.

The petroleum sector total investment has increased from nearly 153.5 LE million in 1990/91 to 6.8 LE billion in 1997/98 with an average annual growth rate of about 53.9% during that period; its share of total investments in Egypt has increased from about 1% in 1990/91 to 12% in 1997/98. A major thrust of the economic reform program is to stimulate non-oil exports, particularly manufactured goods. However, the traditional sectors of oil and cotton still dominate Egypt's **exports** which totaled $ 4.4 billion in 1994/95, and $ 4.6 billion in 1995/96. The most important Egyptian **imports** are machinery and equipment, food, fertilizers, wood products and durable consumer goods.

Egypt's **industrial base** is highly diversified and the extent of self sufficiency in industrial products between 1990 and 1998 has grown for some products like machinery and transport vehicles. Moreover, developing new industrial cities has been part of Egypt's agenda since the 1970s, as a means of developing the industrial sector. Important additional sources of foreign exchange are the Suez Canal revenues, tourism and remittances from foreign workers overseas. Most economic activities, whether in

the field of agriculture, industry or tourism, are concentrated in the Nile delta and in the coastal zones.

The **energy sector** played a substantial role during the various stages of economic development in Egypt by fulfilling the domestic energy demand for petroleum products, natural gas, and electricity. Limited primary energy resources are available in Egypt with varying potentialities. The most important of these resources are oil, natural gas, hydropower and coal. In addition, new and renewable energy resources such as solar and wind energy have a good potential. For several years, Egyptian energy policies have been developed with a focus on the enhancement of natural gas utilization, energy conservation and more energy use, energy pricing adjustment and the promotion of renewable energy utilization. One of the major objectives of these policies is to address some of the national concerns and priorities including the expansion of the life expectancy of conventional energy resources, diversifying the energy supply mix, and having a significant impact on limiting future increases in GHG emissions from most of the economic sectors.

The **transport sector** is a major consumer of fossil fuels and therefore contributes a significant share of greenhouse gases. The most common GHGs emitted from the mobile sources are carbon dioxide, nitrous oxide and methane.

**Waste production** has reached a critical point and its sound final disposal has become an imperative issue if environmental and sanitary requirements are to be respected. Solid waste management in Egypt has become an alarming national issue. It is estimated that Egypt generates 30,000 T/day of domestic garbage, 75% of which is generated from urban areas. Agricultural solid waste in Egypt is estimated by 24 million tons per year, while the industrial hazardous solid wastes are estimated at 5 million tons per year; some of it goes to planned open dump sites, while most of it is dumped haphazardly. EEAA has prepared a document entitled "The National Action Plan For Safe Handling of Solid Wastes". It will cost 3.755 LE Billion to address the problems of solid waste, which include the following issues: the collection system covers small areas of the cities, especially the affluent; the fee for collection and treatment of the waste is too low; the open burning of waste creates a lot of airborne pollutants and the mixing of pathogenic hospital waste with municipal waste creates a great risk. As for liquid waste management in Egypt, due to limited fresh water resources and increasing demand for development, Egypt is expected to face serious demands for reusing water from the drains and reducing the flow from drains to the sea. The food industry,

especially dairy products, is a source of CH4 emission. Therefore, cleaner production approaches and pretreatment technologies are viable solutions for industrial wastewater pollution problems.

Ever since 1982, the establishment of the Egyptian Environmental Affairs Agency (EEAA) signified the increasing attention directed to the issue of environmental protection by the Government of Egypt. EEAA was established as the highest national authority in Egypt responsible for promoting and coordinating all efforts related to environmental protection. Furthermore, within the context of setting up the **Climate Change institutional structure** at the national level to comply with the United Nations Framework Convention on Climate Change (UNFCCC), an inter-ministerial committee was established in October 1997. The national committee is headed by the Chief Executive Officer of EEAA and the members represent a wide range of governmental and non-governmental stakeholders. The committee aims at coordinating on a national level the participation of Egypt in the Framework Convention on Climate Change, developing an overall policy for dealing with the issue of climate change, reviewing the National Action Plan for Climate Change and following up on the implementation of the Framework Convention on Climate Change.

Over the past few years, significant progress has been made relating to national capacity building and institutional development in the field of climate change. Several organizations are extensively involved at the national level in climate change related activities. These include: environmental organizations, energy related organizations, research centers, universities, governmental organizations and non-governmental organizations. These multi-layer climate change institutional arrangements will play a leading role in integrating climate change issues in the national agendas.

As for **Greenhouse Gases inventory**, it is estimated that the total GHG emissions of Egypt in 1990 were equal to 116,608 Gg of $CO_2$ equivalent using the 1995 Global Warming Potential (GWP) of the IPCC, while the net emissions equal to 106,708 Gg of $CO_2$ equivalent. The energy sector is the main source of GHG emissions because Egypt is 92% dependent on fossil fuels (oil and natural gas). The agricultural sector is the second largest GHG source, mainly from enteric fermentation and rice cultivation; followed by industrial emissions of $CO_2$, mainly from the steel and cement industries. Methane is the main GHG produced from the waste management sector as a result of anaerobic bacterial decomposition of organic matter in landfills and open dumps. As in

most countries, CO2 is the main GHG emitted in Egypt, while methane is the second major GHG. (See table 1)

Egypt's large and dense packed population makes the country extremely **vulnerable** to climate change. Egypt does not produce enough food to feed its current population. Its water resources are rather limited. Moreover, its Nile delta is seriously threatened by sea level rise. The following document examines the potential impact on agriculture, coastal zone management, aqua culture, human habitat and settlements, and water resources. In each of those areas, the vulnerabilities are examined, according to recent studies undertaken, and possible adaptation measures are surveyed.

In the **agriculture sector**, all climate change scenarios resulted in simulated decreases in wheat and maize yields. Thus, it is possible to conclude that climate change may bring about substantial reductions in the national grain production, and since the current national grain production does not meet the local demand, any further reduction is expected to have a dire impact. As for cotton, it is clear that the seed cotton yield will be increased gradually. Changes in wheat and maize cultivars were considered as possible adaptation strategies, while changes in the crop choices in the Egyptian agricultural economy were considered as another adaptation to climate change.

The **coastal zone** of the Nile Delta in Egypt is perceived as vulnerable to the impacts of climate change, not only because of the impact of sea level rise (SLR), but also because of the impacts of climate change on water resources, agricultural resources, tourism and human settlements. Several studies were undertaken, data and maps were collected, and field visits and surveys were made to low land areas in Alexandria, Beheira, Port-Said and Damietta governorates. For Alexandria, a scenario involving a sea level rise of between 0.5 m and 1.0 m over the next century is assumed and if no action is taken, an area of about 30% of the city will be lost due to inundation. For Rosetta city, the expected economic losses as a result of an estimated 0.5 m sea level rise show that 1/3 of the employment in the city will be affected and a loss of about $2.9 billion is expected over the next century. As for Port-Said several studies point out the high vulnerability of the city to sea level rise. The most affected sectors are expected to the industrial, transportation and urban sectors. Agriculture is not affected because it is mainly found in the suburbs and thus will not be affected by sea level rise. The adaptation measures that were identified to deal with the impact of climate change on coastal zone areas include: beach nourishment, construction of groins and breakwaters, tightening legal regulations, integrated coastal zone management and introducing

changes in land use.

The **Egyptian coastal lakes** are among the most productive natural systems in Egypt and they are internationally renowned for their abundant bird life. However, the northern part of the Nile delta where most of the lakes are located, is subject to severe coastal erosion and threatened by the expected seal level rise due to the greenhouse effect and the expected warming up of the earth. Among the expected impacts of SLR on the Egyptian coastal lakes are the following: saline sea water will penetrate far into the northern delta, weed swamps will disappear, proper functioning of infrastructure facilities directly exposed to the sea will be disrupted and the natural fry supply will be affected. Among the proposed adaptation measures are protection by increasing the lakes depth, and lake closure by building dikes to store water in the lakes.

Egypt is a unique country with respect to its **water resources**. More than 95% of the water budget of Egypt is generated outside its territory. Although we can not yet predict the impact of climate change on the Nile Basin, there are indications that the impacts will be significant. Any decrease in the total supply of water, coupled with the expected increase in consumption due to the high population growth rates will have drastic impacts. Water management is thus one of the most important adaptation actions. Adaptation of supply includes measures to improve rain harvesting techniques, increase abstraction of ground water, recycle water, desalinate water, improve its transportation and rationalize its use. Meanwhile, adaptation of demand requires minimizing the need for water and optimizing the economic return of its unit volume.

As for the impact of SLR on **human habitat and settlements** based on the current population pattern, there is likely to be a migration of at least two million people from the Delta coastal areas due to the inundation and loss of fertile land. Careful assessments are required to examine the socio-economic impact of this migration and determine the costs of resettlement, finding new jobs, new habitats, etc.

Climate change is expected to have both direct and indirect adverse impacts on **human health.** Direct impacts are perceived to include physiological disorders, skin cancer, eye cataracts, damage of public health infrastructure, deaths and injuries, heat strokes and heat related phenomena. Meanwhile, the indirect impacts are perceived to include factors like demographic dislocations and socio-economic disruptions. However, comprehensive studies with detailed estimations and correlations between climate change and human health in Egypt in specific, are still lacking.

Ever since the Rio Conference in 1992, Egypt has realized the importance of international cooperation in dealing with the issue of climate change, and was one of the first Arab countries to take heed of the phenomenon. Over the past decade, many steps have been taken to capitalize on **international cooperation** in the field. The United Nations Framework Convention on Climate Change (UNFCCC) was signed by Egypt at the United Nations Conference on Environment and Development in 1992, and during the period 1995-1998, Egypt has participated in the International Conference of Parties with its four sessions. Egypt is also an active participant in both African and regional conferences and workshops related to climate change. Moreover, starting 1995, two major programs have been launched by EEAA: the Support for the National Action Plan -SNAP, and the Building Capacity for Egypt to respond to the United Nations Framework Convention on Climate Change, UNFCCC. Under the two programs sixteen studies have been executed covering the fields of GHG emissions inventory, mitigation and adaptation technology assessment, adaptation options, abatement costs, and other areas.

Within the framework of establishing the overall**national policy for climate change**, several parallel efforts were undertaken. These included the development of Egypt's Climate Change Action Plan, Egypt's National Communication on Climate Change, the National Energy Efficiency Strategy, and the National Strategy for Solid Waste Management. In addition, among the positive steps undertaken with the support of international donor agencies, are the multitude of projects in various phases of implementation.

In dealing with the issue of climate change, not only **adaptation measures** are considered, but also mitigation actions aiming basically at reducing two gas emissions namely, carbon dioxide and methane. A number of mitigation options have been assessed for Egypt through the SNAP, Global Environment Facility (GEF) and the Building Capacity Project. Mitigation actions to reduce $CO_2$ mainly cover the energy and industrial processing sectors, while those for CH4 mainly cover the agriculture/livestock and waste sectors.

For the energy sector in Egypt, several studies point to the possibility of reducing greenhouse gas emissions by improving energy efficiency and by using cleaner energy sources and technologies. Among the most important mitigation measures proposed were a fuel switch to natural gas, energy conservation and the use of renewable energy.

A set of seven energy efficiency technologies has been thoroughly evaluated in terms of costs, effectiveness and socio-economic impact. The technology assessment was followed by another study aiming at the estimation of future potential reduction in the level of $CO_2$ emissions from energy-related activities/sources for the next four National Plans till the year 2017.

Mitigation in the transport sector is based on the efficient use of energy as well as demand management. Measures include: energy efficiency through improvement of vehicle maintenance and tune up, intensifying the awareness campaign for using natural gas in commercial vehicles, re-introducing the electrified railways, intensifying the use of environmentally sound river transport, and extending the underground metro lines.

The mitigation measures for the agriculture and livestock sector deal mainly with mitigation options of methane emissions from rice cultivation, mitigation options of methane and carbon dioxide emissions from livestock and mitigation options of $CO_2$ in agriculture. There are several ways of reducing methane emissions from rice fields. In Egypt, the most promising ones are either through reduced cultivated area, or through improved management practices of rice cultivation. The later option includes the consideration of using short duration varieties, managing the use of water and fertilizers and manipulating soil temperature. As for the mitigation options of methane and $CO_2$ emissions from livestock, altering the composition of diets and/or adding chemical compounds were considered so long as these options do not adversely impact the ultimate goal of increasing meat and milk production. In the case of $CO_2$ emissions from agriculture, the mitigation options proposed included making the most of the natural sink of $CO_2$ and increasing the production ofbiogas.

However, in the waste sector, a distinction was made between options suitable for solid waste and those suitable for dealing with liquid waste. For the former, proposed measures included the establishment of a specialized administrative mechanism for solid waste management in each governorate and city, the recruitment of specialized experts for the choice of locations and the design of sanitary landfills, and the provision of financial and technical assistance to private sector companies who are interested in waste collection and waste recycling. For the liquid waste sector, studies recommend the maintenance of the newly developed primary and pre-treatment systems, clarification of lines of command and communications between different pertinent entities, and directing special attention to the new industrial cities for development of the institutional and enforcement capabilities of their local authorities.

Mitigation studies also recommend general carbon dioxide sink actions. The aim of these actions is to increase the country's $CO_2$ absorptive capacity through planting trees wherever possible. This includes planting and maintaining suitable types of trees along the sides and the middle island of all inter-city roads, as well as along the Nile banks and all water drains and canals, in addition to developing man made forests comprised of wood trees and possibly using sewage water in their irrigation.

In parallel to both adaptation and mitigation efforts, capacity building pertaining to climate change, including **training, education and awareness** is a crucial pre-requisite for any serious effort in that regard. Despite the increasing public awareness regarding environmental issues in general, yet the issue of climate change is still relatively dormant. The Egyptian National Action Plan for Climate Change identified several actions and needs, including: strengthening EEAA public relations and publicity office with media experts, organization of national campaigns for public awareness, upgrading the already ongoing climate change newsletter and cooperating with international organizations, networks and other national focal points for the purpose of exchanging information, material and promotional items.

Recognizing the importance of environmental education, EEAA, in coordination with the Ministries of Education and Higher Education, works on integrating environmental issues within the existing national curriculums, and also on establishing independent specialized degrees, diplomas and courses in the field of environmental science. However, further steps are required. At the basic education level, efforts should be undertaken to incorporate climate change issues in the appropriate regular curricula. Meanwhile, at the higher education level, support should be provided to universities and faculties which have started diploma or masters degrees on environmental studies. In addition, in terms of training, it is recommended to establish multi-disciplinary education and training institutions with an interest in climate change, enhancing on-the-job training and training of trainers programs with the aim of realizing high multiplier effects. However, the efforts realized in both environmental education and training require further development in both scope and scale.

To conclude, despite the current efforts and ongoing projects being undertaken in Egypt in the field of climate change, there are still a lot of **research needs and gaps** that need to be covered in the near future. Climate research needs to address three main issues: the science of climate, the likely impacts of climate changes, and the policy mitigation

and adaptation measures to be implemented. For research related to the science of climate, there is a need to upgrade Egypt's capacity to better understand climate change and the exact nature of its impact, aiming at the development of a regional climate change model, specifically through the combined efforts from both the remote sensing and meteorological research authorities. For research dealing with the likely impacts of climate change, there is a strong need for integrated research that assesses climate change impacts on coastal zones, water resources and human health at the same time, with specific emphasis on the potential impact on water resources. As for policy oriented research, the following were among the areas identified: mitigation modeling of GHGs emissions in the agriculture sector is needed, especially the estimation of Carbon fraction in Egyptian rice fields. In the petroleum sector, a comprehensive study for measuring and monitoring CH4 emissions from exploration, transmission, and distribution is needed.

**Table 1 Greenhouse Gas Emissions 1990/91**

| GHG Source & Sink Categories | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ |
|---|---|---|---|---|
| **Total National Emissions &Removals** | 84.459 | 9.900 | 1.029 | 34 |
| **1.All Energy (Fuel Combustion + Fugitive)** | 74.682 | | 206 | 12 |
| a. Fuel Combustion | 74.682 | | 58 | 11.66 |
| 1. Energy &Transformation industries | 25.120 | | 0.08 | 0.97 |
| 2.Industry(ISIC) | 21.120 | | 0.05 | 0.86 |
| 3.Transport | 18.189 | | 10.63 | 8.87 |
| 4.Small Combustion | 10.029 | | 0.43 | 071 |
| 5.Other | | | | |
| 6.Traditional Biomass Burned for Energy | 9.543 | | 74 | .251. |
| b. Fugitive Emissions from Fuels | | | 147.56 | |
| 1.Solid Fuels | | | | |
| 2.Oil &Natural Gas | | | 147.59 | |
| **2.Industrial Processes** | 9.777 | | 9 | 1 |
| **3.Solvent & Other Product Use** | | | | |
| **4.Agriculture** | | | 543 | 21 |
| a. Enteric Fermentation | | | 323.37 | |
| b. Manure Management | | | 23.23 | |
| c. Rice Cultivation | | | 189.9 | |
| d. Agriculture Soils | | | | 21.1 |
| e. Prescribed Burning of Savanas | | | | |
| F. Field Burning of Agric. Residues | | | 6.8 | 0.2 |
| g. Other | | | | |
| **5.Land use change & forestry** | | 9.900 | | |
| a. Change in forest &other woody Biomass stocks | | 9.900 | | |
| b. forest & grassland conversion | | | | |
| c. Abandonment | | | | |
| d. Other | | | | |
| **6.Waste** | | | 271 | |
| a. Solid waste disposal on land | | | 264.27 | |
| b. Wastewater treatment | | | 6.59 | |
| c. Waste incineration | | | | |
| d. Other waste | | | | |
| **7.Other** | | | | |

**Source:** Egypt National Greenhouse Gases Inventory 1990/91.

# 1. NATIONAL CIRCUMSTANCES

## 1.1. Geographical Setting:

Egypt is located in northern Africa, bordering the Mediterranean Sea between Libya and Gaza Strip. To the south it shares a border with Sudan. The country has a total area of 1,001,450 sq km, with 3,500 km of coastline facing the Mediterranean in the north and the Red Sea in the east. The dominant feature of the northern coastal zone is the low-lying delta of the River Nile, with its large cities, industry, flourishing agriculture and tourism (see figure 1).

The delta and the narrow valley of the Nile comprises 5.5% of the area of Egypt, but has over 95% of its people and its agriculture. With the exception of small areas of cultivated land in the oases of the western desert, the coastlands west of the delta, and in Northern Sinai, the rest of Egypt is desert.

Egypt's Mediterranean coast and the Nile Delta have been identified as vulnerable regions to sea level rise, in the second assessment report of the Intergovernmental Panel on Climate Change, IPCC (1995).

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Figure (1.1): Map of the Arab Republic of Egypt:

## 1.2. Climate:

Egypt's Climate is semi-desert, characterized by hot dry summers , moderate winters and very little rainfall. The country is characterized by particularly good wind regimes with excellent sites along the Red Sea and Mediterranean coasts. Sites with an annual average of 8.0-10.0m/sec have been identified along the Red Sea coast and about 6.0-6.5m/sec along the Mediterranean coast. The entire territory enjoys a rather high solar radiation intensity of 1.900-2.600kWh/m2/year. Further intensity up to about 2.400kWh/m2/year is observed when moving from the sea towards the desert.

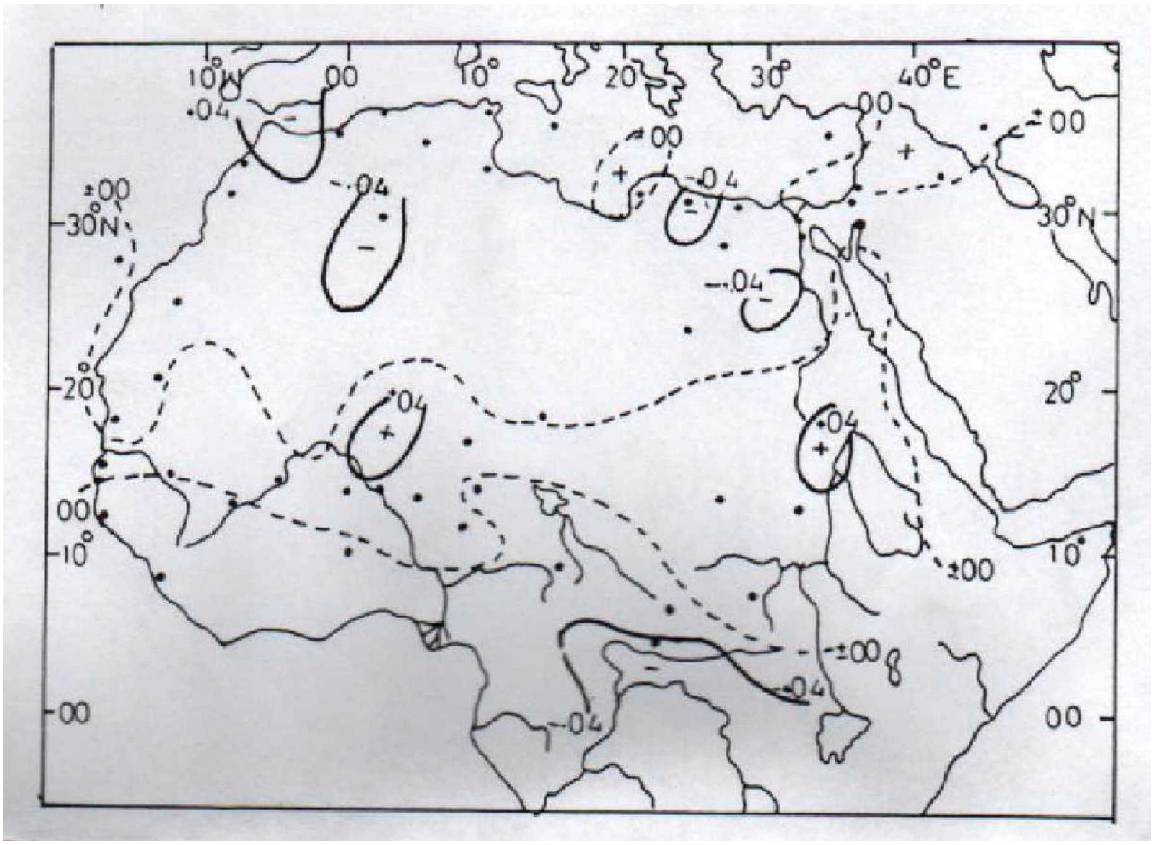


Fig. (1.2):Distribution Of The Trend Of Temperature

**Source**: The Egyptian Meteorological Authority, 1998.

The Climate in Egypt has been changing in phase with global change, but with lower rates of variation. There is a downward trend in maximum temperature over the delta, over the northern part of Upper Egypt and over the extreme south of Upper Egypt. This downward trend has ranged from -0.02 $^{0}$C to -0.06 $^{0}$C / year. Minimum temperatures have markedly increased over Egypt. An upward trend has covered most parts of Egypt except over a small area in Middle Egypt. The upward trend has culminated in increases

of +0.1 $^0$C / year over southern parts of Upper Egypt. The main contributor to rising air temperature comes from the increase in night time temperature. During the night, temperature rises at a higher rate than at any other time. This upward trend has culminated in increase of +0.05 $^0$C / year over the western part of Delta near the Mediterranean coast. This rise in night time temperature may be due to the effect of greenhouse gases and increasing water vapor in the boundary layer. Moreover the rise in surface air temperature in Egypt is about 40% of the global rise in surface air temperature (see figure 1.2).

Rainfall has increased over the western coast of Egypt, by up to 3 mm/year. This change is affected by the changes in the General Circulation of the atmosphere and some teleconnection effects such as the El Nino phenomenon. The amount of cloud cover has declined over most parts of Egypt except over western part of the North Coast. This decline has reached 0.02 Oct/ year. Relative humidity has increased in all parts of Egypt. The upward trend has reached 0.35% / year especially over southern part of Egypt. Mean-sea- level pressure has increased in recent years over most parts of Egypt. The positive trend has culminated to +0.05 hPa / year over southwest part of Upper Egypt (see figure (1.3)

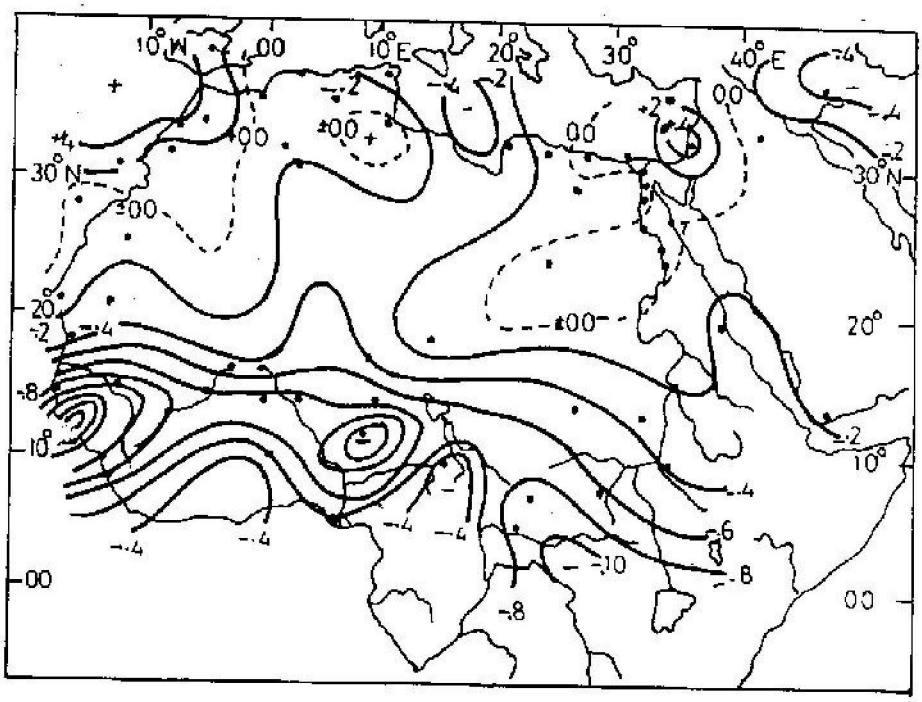


Fig.(1.3):Distribution Of The Trend Of Rainfall

**Source:** The Egyptian Meteorological Authority, 1998.

The increase in mean sea level pressure and in humidity might be caused by the southward shift of the mid latitudes pressure system. The widespread surface inversion in stable weather conditions may be the main cause of the upward trend in relative humidity in recent years over Egypt. Ozone level declined by -2.5 Dubson over Cairo and increased by 16.3 Dubson over Aswan. External factors or local physical factors may cause this difference where Aswan atmosphere is regarded as a source region of global ozone that is mainly created in the lower stratosphere by photochemical reactions. The depletion of ozone over Cairo may reflect general circulation changes as well as human and industrial activities in Greater Cairo.

At Cairo, global radiation has decreased since 1981 by a rate of -0.018 mg Joule/ hour. It has also decreased at Aswan, but by a faster rate of -0.046 mg Joule / year. The decrease in both locations may be due to an increase in turbidity or to other external factors related to outer space.

## 1.3. Population:

Egypt is the second most populous country in Africa. The population of Egypt was 55 million in 1990, the baseline date for this study. It increased to around 65 million by 1998. Almost fifty per cent of the population live in the urban areas and the rest in compact rural settlements surrounded by intensively cultivated irrigated land. This growing urban population has exerted a lot of pressure on both demand and supply for electricity, water and waste management.

The urban focus of Egypt, the Cairo metropolitan area, had a population of 12 million in 1990, and 16 million in 1998. Lying just south of the point at which the Nile divides to form the delta, Cairo is densely settled and overcrowded, with new residential and industrial areas expanding into the desert, and into cultivated land.

According to the 1986 census, Egypt's population was growing at a rate of 2.8% a year, with 34% below 12 years of age. By 1998, however, the population growth rate had declined to 2%. Life expectancy at birth is 65.6 years for females and 63.1 years for males. Only 38% of adult females are literate, compared to 62% of adult males. However, literacy levels are improving, and the gap between the number of school years completed by young females, as compared to young males, is growing smaller.

The coastal delta zone is the site of Egypt’s second city, Alexandria, with a population of 2.9 m in 1986, and 3.3 million in 1996. Alexandria is the main harbor of Egypt and has

around 40% of the country's industrial capacity, in addition to being an important summer resort. Other large cities in the northern, low-lying delta include the rapidly growing city of Damietta, and the old-established city of Rachid (Rosetta). Port Said and Suez are important regional and trading centers on the Suez Canal.(see table 1.1)

**Table 1.1: Population in the Coastal Delta Zone**.

| City | Population (million) | |
|---|---|---|
| | **1986** | **1996** |
| Alexandria | 2.9 | 3.3 |
| Damietta | 0.186,722 | 0.946,14 |
| Port said | 0.401,172 | 0.469,533 |
| Suez | 0.327,717 | 0.417,610 |

**Source:** Central Agency For Public Mobilization and Statistics (CAPMAS)

Given Egypt's growing population, its limited fertile land, its large area of desert, and the concentration of its economic activities in the coastal zones, the potential social and economic impact of climate change could be devastating for the country's future.

## 1.4. Water resources:

Egypt has only one main source of water supply, the River Nile, which supplies over 95% of the country water needs. There is some winter rain in the delta and along the Mediterranean coast, west of the delta. Non-renewable underground fossil water supplies are accessible outside the river valley, especially in the oases. Consequently, agricultural development is closely linked to the River Nile and its management.

The Nile waters originate outside Egypt, flowing through nine countries to the south - Kenya, Burundi, Uganda, Rwanda, Zaire, Tanzania, Ethiopia, Eritria, and Sudan. Egypt's use of the Nile water is controlled by international agreement. The Aswan High Dam, completed in 1971, has created one of the largest man-made lakes in the world, Lake Nasser. The dam provides hydroelectricity, as well as controlled water supply for year round irrigation and reclamation. Harnessing the Nile has, however, reduced silt deposits downstream, thus increasing erosion and soil salinity. The availability of reliable water supply from the Aswan High Dam is governed by the existing water sharing agreement with Sudan, under which 55.5 BCM are allocated to Egypt. Currently, as a result of high rainfall in the Nile headwaters, the level of water behind the High Dam is high, thus ensuring sufficient water for domestic irrigation and industrial use in the immediate

future. Massive projects to divert some of the Nile waters to Northern Sinai, and to Toshka depression in the extreme south of the country, are underway. Consequently, the water needs of the country are growing rapidly.

**Table 1.2: National Circumstances**

| **Criteria** | **90/91** | **97/98** |
|---|---|---|
| Population (million) | 55 | 65 |
| Area (square kilometers) | 1.001.450 | 1.001.450 |
| GDP (million US$) | 35.607* | 74.106 |
| GDP-real growth rate "%" | 3.7 | 5.3 |
| GDP Per Capita "US$" | 638.81* | 1,095.73 |
| Employment in Formal Sector(million) | 13.376 | 16.344 |
| Share of Industry in GDP"%" | 16.57 | 18.50 |
| Share of Services in GDP"%" | 18.0 | 18.0 |
| Land Area Used for Agricultural Purposes" sq. km" | 3 % | 4% |
| Urban Population as Percentage of Total Population | 44%¦ 12 million | 43%? 16 million |
| Live Stock Population (thousands ) | | |
| Cattle | 2993 | 2737 |
| Buffalo | 2792 | 2302 |
| Sheep | 4147 | 7346 |
| Goats | 4446 | 3570 |
| Camels & limas | 197 | 454 |
| Swine | 102 | 39 |
| Poultry | 42 | 83,099** |
| Forest Area ( sq Km) | 0% | 0% |
| Population in Absolute poverty | N.A | N.A |
| Life Expectancy at Birth Years | | |
| Total | 61.75 years | 64.35 |
| Females | 63.8 years | 65.6 years |
| Males | 59.8 years | 63.1 years |

*1992 ¦ 1986 ?? 1999 **1995 ?

**Sources**: Ministry of Finance, Ministry of Planning, Central Bank of Egypt and CAPMAS

## 1.5. Macroeconomic overview: The economy: past, present and future:

### 1.5.1. Gross Domestic Product (GDP):

Economic conditions in Egypt have improved considerably over the years since the baseline 1990/91. In that year real GDP growth rate was 3.7%. By the end of fiscal year 1998, the growth rate reached 5%, fueled primarily by private sector investment through continued rapid privatization and institution building (see table 1.2). GOE aims to achieve a 6-7% growth rate by the turn of the century. Reserves, as of 1998, remain at US$20 billion. The foreign debt, about $US 50 billion in the late 1980s, had fallen to $US 31 billion by 1996.

Over the last decade, the Egyptian economy started to achieve a considerable and real improvement of its Gross Domestic Product (GDP).

As shown in table (1.3) total GDP has increased from nearly about 50.177 LE billion in 1990/91 to reach about 162 LE billion by the end of the third five year national plan in 1996/97, with an average annual growth rate ranging between 2.5% and 5% during that period. The overall average annual GDP growth rate during the period (1991/92-1996/97) is about 4%. .

**Table 1.3 Gross Domestic Product at Factor Cost according to the Economic Sectors (1990/91-1997/98)**

(Unit: Million LE)*

| Sector/Year | 1990/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|---|
| **Total GDP** | 50177 | 131057 | 134335 | 139180 | 146133 | 163369 | 162146 | 1609866 |
| **Commodity:** | 21388 | 50145 | 47380 | 53360 | 73203 | 76361 | 79589 | 79589 |
| **Agriculture** | 9820 | 21680 | 22220 | 22975 | 23741 | 24470 | 25338 | 43905 |
| **Industry** | 9054 | 21730 | 222360 | 23275 | 25087 | 26970 | 299228 | 65356 |
| **Housing** | 2514 | 6735 | 2800 | 7110 | 7485 | 7898 | 8571 | |
| **Petroleum** | 1896 | 13008 | 13210 | 13694 | 14365 | 14365 | 13650 | 16948 |
| **Electricity** | 664 | 2220 | 2296 | 2390 | 2525 | 2658 | 2830 | |
| **Productive Services** | 17054 | 43606 | 44494 | 45782 | 47860 | 50674 | 53923 | 81241 |
| **Social Services** | 9202 | 22078 | 22955 | 23954 | 25068 | 26334 | 27976 | 45639 |

*Includes industry, electricity and housing

At:1991/92 fixed prices for the period (1991/92-1994-95); At:1996/97 fixed prices for the period (1991/98)

**Sources**: Ministry of Planning and Ministry of Economy.

Figure 1.4 shows the composition of the GDP in 1990,while figure 1.5 shows the composition of GDP commodity sector in 1997/98.

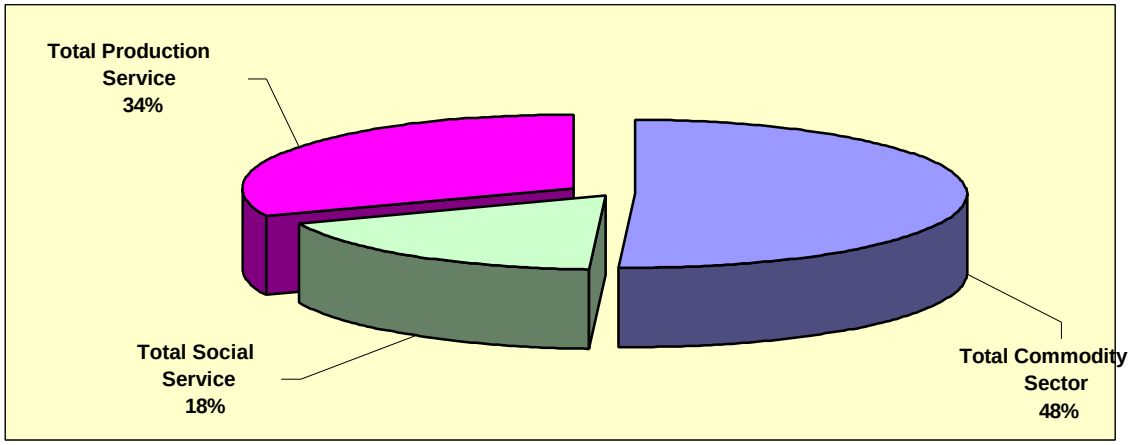


Figure1.4: Composition of GDP 1990/91:

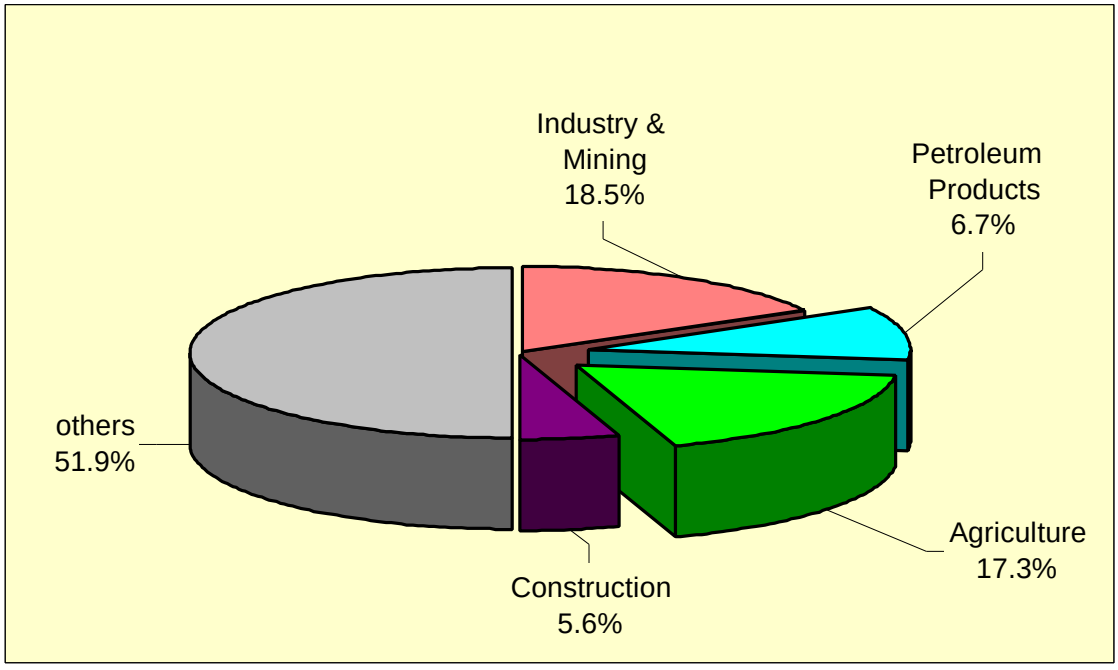


Figure 1.5: Composition of GDP Commodity Sector 1997/98.

The inflation rate, a measure that affects the wellbeing of Egyptians, and the health of the overall economy, has fallen from around 14.7% in 1990/1991 to around 4% in mid-1998. These and other economic improvements have been the result of a stabilization and reform program launched in April 1991. The first phase, involving fiscal and monetary tightening, exchange rate liberalization, and price deregulation, yielded impressive results. Phase two of the program has also seen further deregulation of prices, markets,

investment, private sector and financial sector reform. The challenge now is to consolidate these reforms and extend the ongoing recovery, particularly in view of global changes.

The economy continued to be resilient in the late 1990s, in the face of a number of shocks; the collapsing economies following the South East Asian crisis of 1997/8; the drop in oil prices (Egypt is a net exporter of oil); and the temporary decline in tourism since late 1997.

In 1997, a comprehensive development strategy for Egypt for the next twenty years was launched. It was divided into four 5-year plans, and is seeking to coordinate the available and potential development resources, as well as improving the quality of life through population redistribution away from the heavily populated areas of the Nile delta and valley. Development objectives include:

1- Resettling millions of Egyptians beyond the narrow Nile valley, so that the populated areas will cover 25% of Egypt's land area, rather than 5% at present;
2- Increasing the annual growth rate from 4.8% (the average of the 15 years prior to 1997) to an annual average of 6.8% in the fourth 5-year plan, to reach 7.6% in the last five year period;
3- Increasing the GDP to four times the level of 1997;
4- Increasing the average per capita income, reaching a minimum of $4100 in 2017.
5- Keeping the inflation rate below 5% per year;
6- Creating 550,000 job opportunities annually to accommodate the annual population growth and gradually absorb those currently unemployed.

### 1.5.2. Exports Composition Development:

The composition of Egypt's merchandise exports has changed markedly in the past few years. Manufactured goods have also increased their export share, due mainly to increase production of textiles and clothing, which accounted for about 33% of exports in 1997/98 compared to 30% in 1990/91. A major thrust of the economic reform program is to stimulate non-oil exports, particularly manufactured goods. However, the traditional sectors of oil and cotton still dominate Egypt's exports which totaled $4.4 billion in 1994/95, and $4.6 billion in 1995/96. Tables (1.4) and (1.5) show exports development according to the main commodity groups during the period (1990/91- 1995/96 and 1990/91- 1997/98) and figures (1.6) and (1.7) show exports by commodity groups in 1990/91 and 1997/98.

The significant share of petroleum in the commodity exports, fell in 1997/98, and reached 33.7%, compared to 48.2% in 1996/97, due to the decline in oil prices.

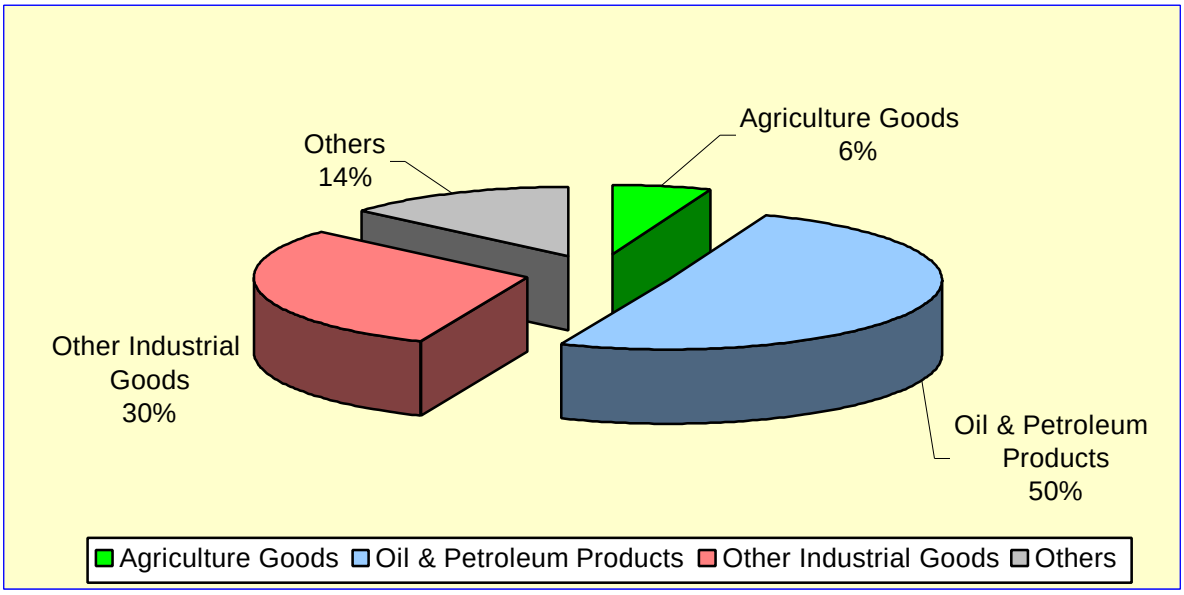


Fig.1.6: Exports by commodity groups 1990/91

Fig.1.7: Exports by commodity groups 1997/98

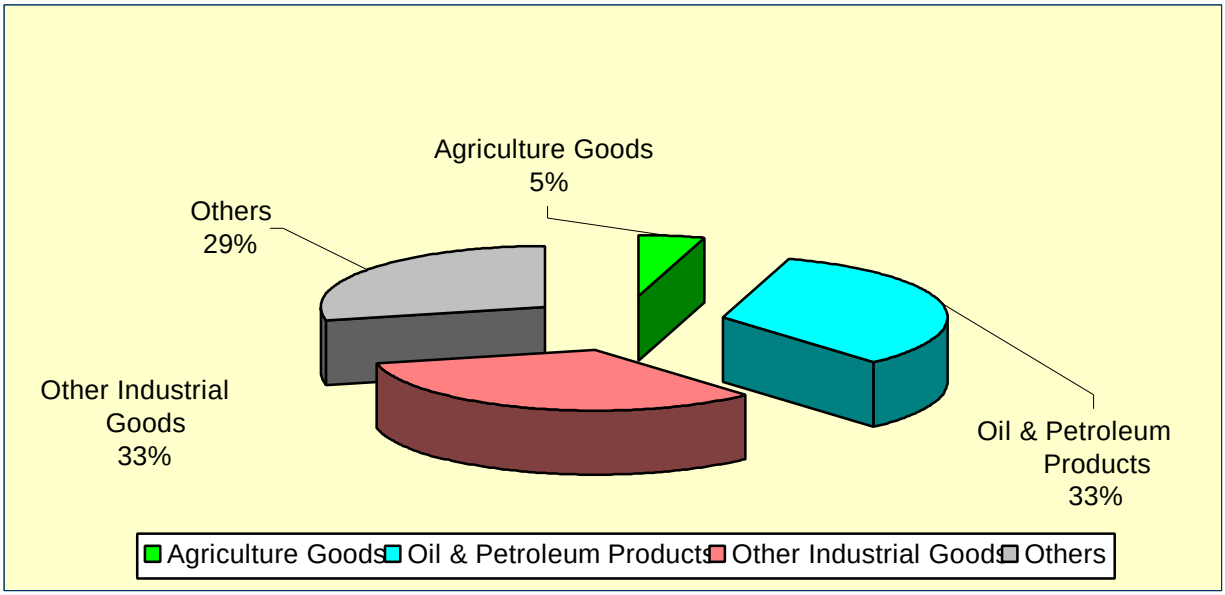

**Table 1.4 Exports By Commodity Group (1990/91-1997/98)**

(Unit: $ Million)

| Commodities/year | 90/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|---|
| Agriculture Goods | 226 | 275.5 | 199.4 | 175.1 | 615.5 | 320.7 | 270.3 | 243.5 |
| Oil & Petroleum Products | 2539 | 1651.1 | 1802.9 | 1362.2 | 1629.2 | 1848.7 | 2577.8 | 2600 |
| Other Industrial Goods | 1163.1 | 1461.1 | 1167.4 | 1233.3 | 2202 | 1691.1 | 1301.7 | 1684.6 |

**Source:** Ministry of Economy.

**Table 1.5 Exports By Commodity Group (1990/91-1997/98)**

(Unit: %)

| Commodities/year | 90/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|---|
| Total: | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Of which: | | | | | | | | |
| Agriculture Goods | 5.8 | 7.6 | 5.8 | 6.1 | 13.8 | 7 | 5.1 | 4.7 |
| Oil & Petroleum Products | 50.7 | 45.4 | 52.8 | 47.5 | 36.6 | 40.3 | 48.2 | 33.7 |
| Other Industrial Goods | 29.9 | 40.2 | 34.2 | 43 | 49.5 | 36.8 | 24.4 | 32.8 |

**Source:** Ministry of Economy.

### 1.5.3. Investment:

Total investment in Egypt has increased from nearly 16.100 LE billion in 1990/91 to about 57.9 LE billion in 1997/98, an average annual growth rate of 21.6% during that period.

Petroleum sector total investment has increased from nearly 153.5 LE million in 1990/91 to 6.8 LE billion in 1997/98 with an average annual growth rate of about 53.9% during that period; its share of total investments in Egypt has increased from about 1 % in 1990/91 to 12% in 1997/98. Electric sector total investment has increased from 1.6 LE billion in 1990/91 to 3.03 LE billion in 1997/98 with an average annual growth rate of about 15.3% during that period; yet its share of total Egyptian investments has decreased from 10% in 1990/91 to 5% in 1997/98 (see figures 1.8 and1.9).

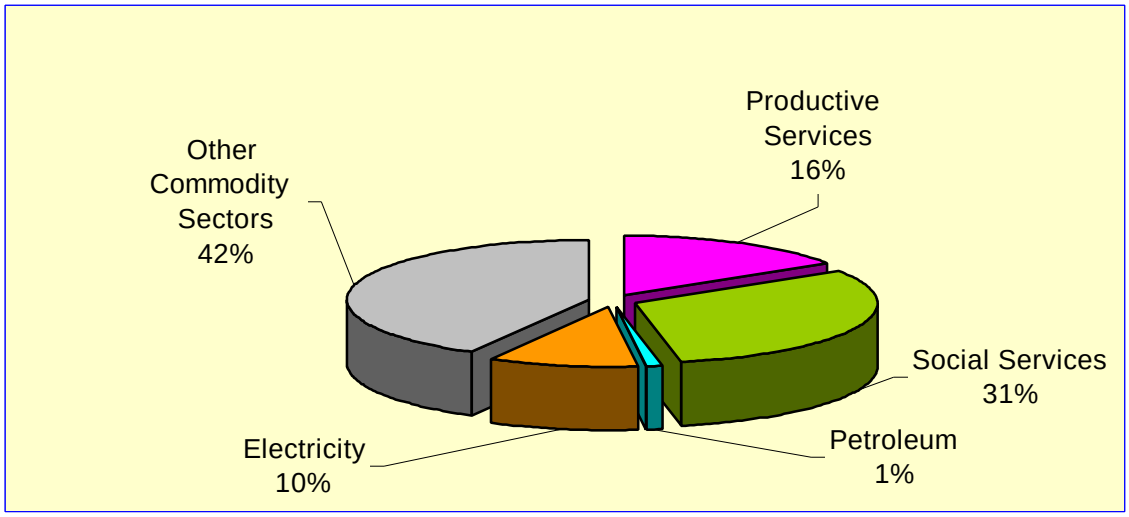


Fig.(1.8) Fixed investment by Sector (1990/91)

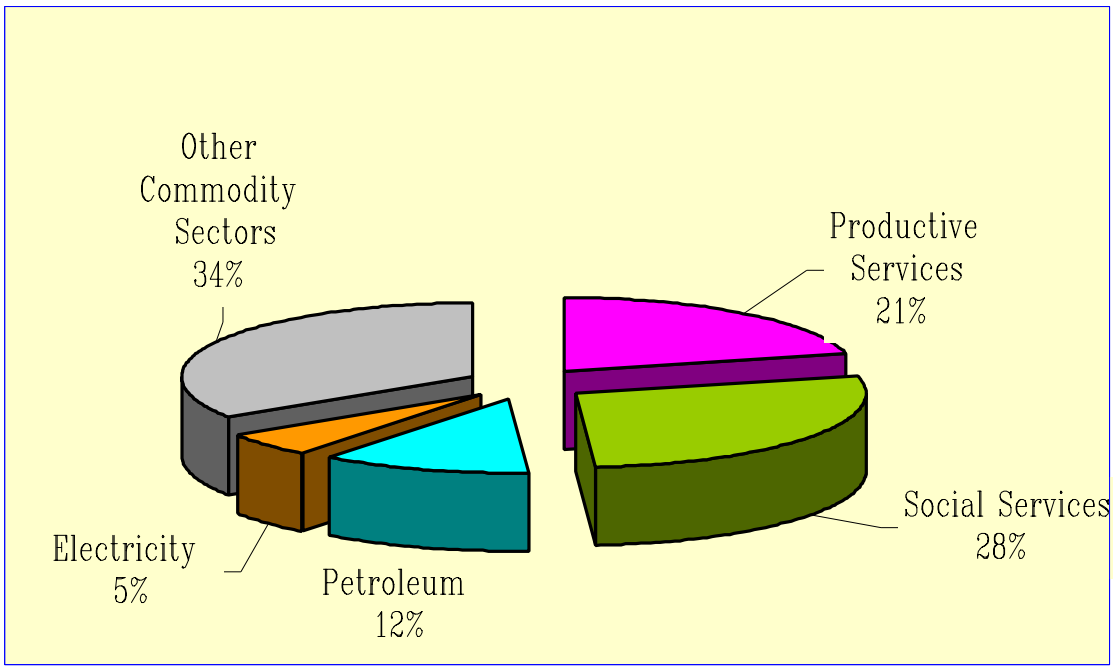


Fig. (1.9) Fixed investment by sector (1997/98)

According to recent figures, the total investment in Egypt reached about 58 billion LE in 1997/98, with 10.5% in the petroleum sector and 5% in the electricity sector.

Table (1.6) shows investment development in (1990/91-1997/98).

**Table 1.6 Investment Development (1990/91-1997/98)**

(Unit: LE Million)

| Sector/Year | 90/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|---|
| Productive Services | 2524 | 5192 | 7087 | 7423 | 9306 | 10033 | 12863 | 12248 |
| Social Services | 4958.6 | 6934 | 9511 | 11395 | 12575 | 12161 | 15146 | 16030 |
| Commodity Sectors: Of which; | 8414.7 | 12981 | 15046 | 14634 | 17531 | 19912 | 22167 | 29670 |
| Petroleum | 153.5 | 3333 | 3094 | 2941 | 3151 | 4075 | 4464 | 6784 |
| Electricity | 1582.6 | 1656 | 4018 | 3188 | 3116 | 3027 | 3060 | 3031 |
| Total | 16100 | 25107 | 31644 | 33452 | 3912 | 42106 | 50176 | 57948 |

**Source**: Central Bank of Egypt.

### 1.5.4. Agriculture:

The government of Egypt places great importance on the agricultural sector, recognizing its significant role in the national economy. In 1990/91 agriculture was the most important commodity sector in Egypt, comprising 17.6% of Egypt's GDP, followed by mining and industry, with 16.6% of GDP ( figure 4 shows the composition of GDP in 1990/91). By 1997/98 the share of agriculture had fallen very slightly to 17.3%, being overtaken marginally by mining and industry, at 18.5% of GDP(see fig.5). Almost 50% of the Egyptian population rely on agriculture for income generation and employment opportunities.

The agricultural sector contributes to the overall food needs of the country and provides the domestic industry with agricultural raw materials. It promotes industrial development through expanding the market for industrial goods such as pesticides, chemical fertilizers, equipment and machines. Also, agriculture helps in financing economic and social development through the net capital outflow from agriculture to other sectors of the economy.

In 1997/98, 29.5% of the economically active population was engaged in agriculture, the largest single employment sector. In terms of numbers employed, this represents a slight increase since 1990/91, with a figure of 4,533,000, compared to 1997/98, with 4,820,000 persons employed in agriculture. However, these figures do not include women who work on family farms and the growing number of people who work part-time to augment their meager wages from formal sector employment.

Egypt grows a wide variety of crops; winter crops are wheat, barley and onions, and main summer crops are cotton, rice and sugar cane. Major crops in order of acreage are wheat, maize, rice, cotton, beans, sugar cane. The acreage of vegetables and fruits is now greater than that of cotton.

The current agricultural economic policy reform program has significant positive impacts on the agricultural sector performance. For example, the cultivated area increased from 6.2 million feddans in 1982 to 7.8 million feddans in 1995, and the cropped area increased from 11.2 million feddans in 1982 to 14.4 million feddans in 1995. Moreover the total value of agricultural production increased from L.E.5.8 billion in 1982 to L.E. 41.5 billion in 1994.

Egypt's agricultural production is mostly for home consumption; agricultural exports represented only 4.7% of total exports in 1997/98. Egypt is far from being self sufficient in food, importing wheat, sugar, vegetable oils and meat. The most important shortfall occurs in wheat production; there is a high per capita consumption of bread, which is subsidized. Climate change would make the situation even worse as a result of its expected adverse impact on the national production of many crops.

The livestock sector has expanded to meet the growing urban demand for red meat, chicken, milk and eggs. (Table 1.2). New crops being encouraged include strawberries (mostly for export) and sugar- beet to supplement supplies of sugar cane for the domestic market.
The annual fish catch, estimated at 140,000 metric tons, comes principally from the Mediterranean, and the northern delta lakes, some of which are suffering from serious pollution problems.

### 1. 5. 5 Industry:

Egypt's industrial base is highly diversified, and activities include transport vehicles, textiles, consumer electronics, consumer goods, pharmaceuticals, cement, iron and steel, and aluminum industries. The extent of self sufficiency in industrial products between 1990 and 1998 has grown for machinery and transport vehicles, remained the same for chemicals, but has fallen markedly for wood and wood products.

**Table 1.7 : New Industrial Cities (1998)**

| City | Number of Factories (Productive) | Number of Factories (Under Construction) | Labor |
|---|---|---|---|
| th of Ramadan10 | 891 | 318 | 162.83 |
| 6th of October | 562 | 343 | 67.500 |
| Sadat | 158 | 75 | 18.449 |
| Borg El-Arab | 314 | 117 | 17.509 |
| New Salhiya | 37 | 42 | 2.905 |
| New Damietta | 96 | 108 | 2.735 |
| New Beni-Souef | 11 | 47 | 200 |
| Badr | 59 | 110 | 3000 |
| Noubariya | 16 | 23 | 243 |
| New Minya | .. | 4 | .. |
| Obour *1 | 16 | 112 | 2.790 |
| Al-Amal*2 | - | - | - |
| New Assiut*3 | - | - | - |
| Total | 2.160 | 1.299 | 3,717.718 |

*1 In addition to 31 productive factories, and 32 under at Belbeis

*2 the industrial zone of the city has not started yet.

*3 the industrial zone of the city has not started yet.

**Source**: Ministry of Housing, Utilities and Urban Communities

As shown from table (1.7) developing new industrial cities has been part of Egypt's agenda since the 1970s, as a means of developing the industrial sector. In 1991, twelve new industrial cities were developed. To date around 3,500 factories have been established in these cities, providing employment for almost 280,000 workers.

### 1.5.6 Trade:

Egyptian exports include crude oil and petroleum products, cotton yarn and raw cotton, textiles, chemicals and metal products. These are shown, by sector, for 1990/91 and 1997/98, in table 1.8.

**Table 1.8: Egyptian exports - in US$M**

| The product | 1990/91 | 1997/8*1 |
|---|---|---|
| Oil & Petroleum Products | 2539 | 2600 |
| Foodstuffs | 86 | 147 |
| Chemical industries | 180 | 173 |
| Metal industries | 198 | 179 |
| Mining industry | 18 | 32 |
| Building materials | 5 | 46 |
| Other | 594 | 1,146 |

*1 provisional

**Source:** Ministry of Economy

The most important Egyptian imports are machinery and equipment, food, fertilizers, wood products and durable consumer goods. Imports by commodity groups for the years 1990/91 and 1997/98 are shown in table 1.9.

Trade is an important source for foreign exchange in addition to Suez Canal revenues, tourism and remittances from foreign workers overseas. Remittances from Egyptians working abroad fell sharply in the early 1990s due to the repatriation of Egyptian workers from Iraq and Kuwait.

**Table 1.9: Egyptian imports - in US$M**

| The product | 90/91 | 97/98* |
|---|---|---|
| Livestock, food | 1,808 | 2,506 |
| Fats, greases, oil, metallic products & fuel | 1,062 | 2,188 |
| Chemical, rubber and leather products | 1,162 | 1,840 |
| Wood, cork, paper, textiles | 1,155 | 1,566 |
| Machines and transport equipment | 2,330 | 4,530 |
| Base metals and manufactures | 812 | 1,414 |
| Miscellaneous | 378 | 914 |
| Unclassified | 2,724 | ,805 |
| Total | 11,425 | 15,753 |

*Provisional

**Source:** Ministry of Economy.

### 1.5.7 Energy:

The energy sector plays a substantial role in the economic development of Egypt by fulfilling the domestic energy demand for petroleum products, natural gas, and electricity. It also has an indirect role through contributing in the macroeconomics variables, as will be demonstrated later.

The petroleum sector surplus represents a significant contribution in the state budget. This surplus reached about 6.73% of the total governmental revenues in 1997/98.

#### *1.5.7.1 Share of the Energy Sector in Employment:*

As shown in table (1-10) and figures (1-10) and (1-11), the total number of employees in the energy sector (petroleum plus electricity) has increased from about 135,000 in 1990/91 to about 168,000 in 1997/98, with an average annual growth rate of about 4.4% during that period. Meanwhile, the energy sector share of total employees in the whole country is estimated to be constant, at about 1% on the average, during that period. Employees in the energy sector represented only about 1.22% of the total Egyptian employees in 1997/98.

**Table 1.10 Number of Employees Development (98/97-91/90)**

Unit: 000 Employees

| Sector/Year | 90/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|---|
| **Total:** | 13527 | 13742 | 14011 | 14432 | 11879 | 15340 | 15825 | 16344 |
| **Petroleum** | 37 | 37 | 38 | 40 | 41 | 42 | 43 | 44 |
| **Electricity** | 98 | 104 | 109 | 110 | 114 | 118 | 120 | 124 |
| **Others** | 13392 | 13601 | 13864 | 14282 | 11724 | 15180 | 15662 | 16176 |

**Source:** Organization for Energy Conservation and planning.

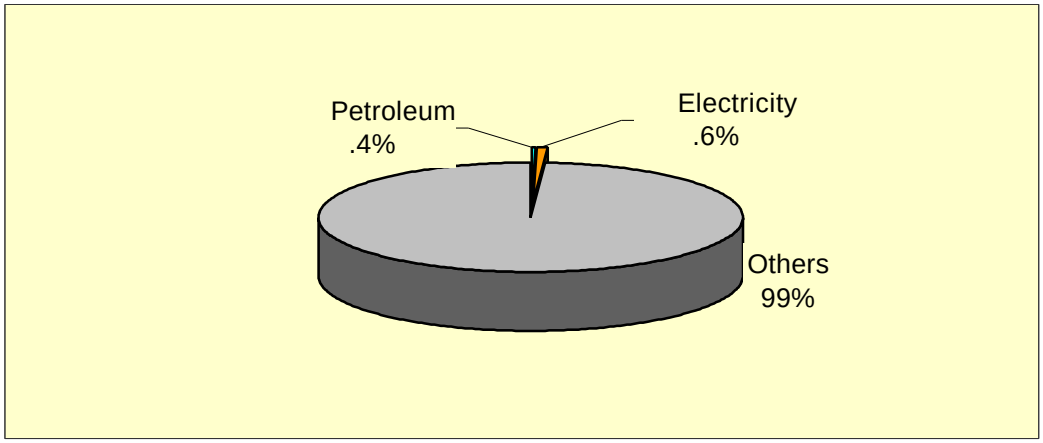


Fig.(1.10) Energy Sector share of Total Employees(1990/91)

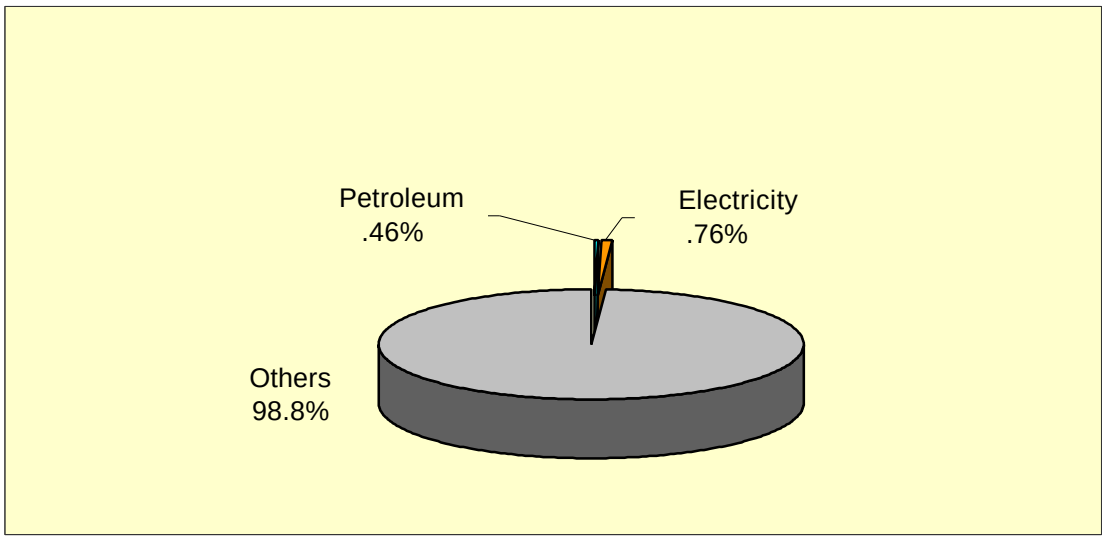


Fig.(1.11) Energy Sector Share of Total Employees (1997/98)

### *1.5.7.2 Energy And The Main Economic Indicators:*

The per capita primary energy consumption is considered one of the economic welfare indicators. The energy intensity is one of the economy efficiency indicators. It is defined as the energy units required to add one unit (in real money terms) to GDP. The per capita primary energy consumption has increased, in spite of the population growth, due to the increase in the primary energy consumption between 1996/97 and 1997/98. At the same time, energy intensity increased as the energy consumption increased by a greater rate compared to that GDP. This was noticeable in the industry and transport sector (78% of the total final consumption) and the electricity sector (19% of the total petroleum

products consumption and 62% of the total natural gas consumption). The per capita electricity generation has also increased, reflecting a better standard of living.

Figure (1.12) shows the sectorial consumption of petroleum 1997/98,while figure (1.13) shows the natural gas sectorial consumption in 1997/98.

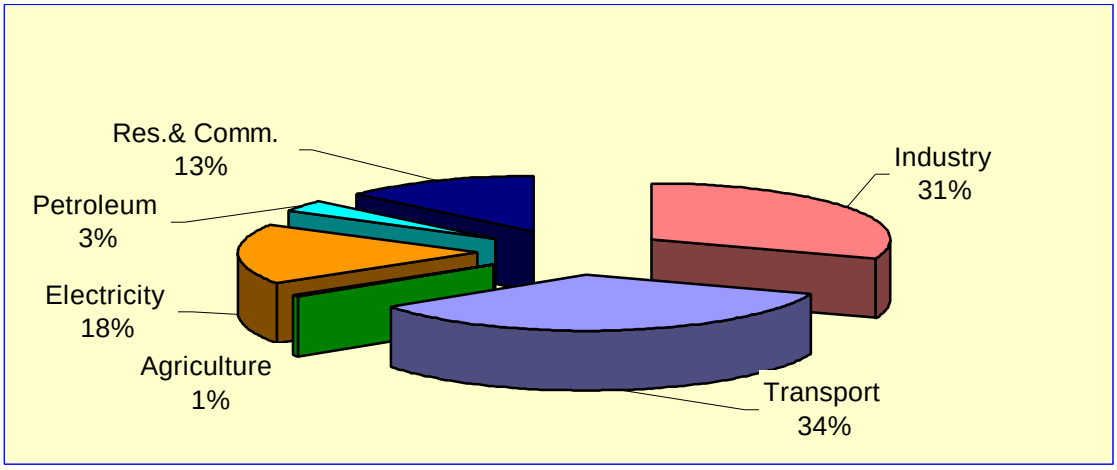


Fig.(1.12) Sectorial consumption of petroleum (1997/98)

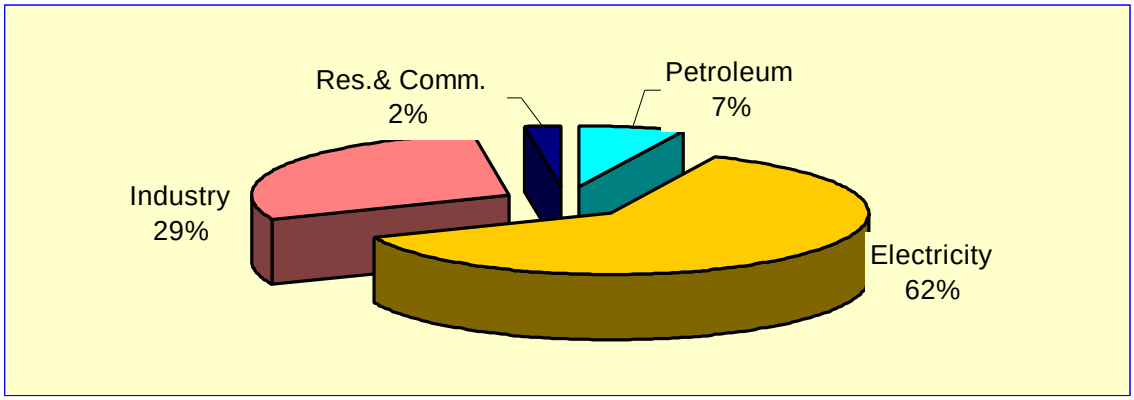


Figure (1.13) Natural Gas Sectorial Consumption (1997/98)

### *1.5.7.3 Energy Resources:*

Limited primary energy resources are available in Egypt with varying potentialities. The most important of these resources are oil, natural gas, hydropower and coal.
In addition, new and renewable energy resources such as solar and wind have a good potential.

**a. Crude oil:**

Crude oil is considered as the most important available source of energy in Egypt with a about 3 billion barrels proven reserves in 1997/98. Meanwhile, the present level of production of crude oil is about 44 Mtoe.

**b. Natural Gas:**

Natural gas is currently considered the main source of energy in Egypt, with estimated reserves of about 7 billion barrels as of the end of 1997/98. Production is estimated at about 14.8 Mtoe in 1997/98. It is anticipated that natural gas will play an increasingly important role in energy production and the country's future fuel mix. A gas substitution policy has been adopted and implemented to promote the use of natural gas in electricity generation, industry, residential and commercial sectors.

Within the same policy framework, the petroleum sector has taken a new initiative to use natural gas in the transport sector, as a fuel for vehicles in the form of Compressed Natural Gas (CNG).

**c. Hydropower:**

The river Nile is the only significant source of surface water in Egypt. About 90% of the Nile hydropower potential has already been utilized with the installation of just over 2800 MW, of which 2715 MW is at the Aswan Dam and High Dam, in addition to other small hydropower stations at several sites along the River Nile, as for example the new Esna Barrage with 90 MW. The total available hydropower energy is about 2.7 Mtoe (12.2 TWh) in 1997/98. Some of the remaining available hydropower resources are expected to be utilized in the future through hydropower stations at Nag Hamadi and Assiut Barrages, with a total estimated value of 165 MW.

**d. Coal Resources:**

Coal deposits have been discovered in Sinai Peninsula, with estimated reserves in the range of 80 Mt. Of these, only the Maghara deposits have been commercially developed. The deposits in Maghara are estimated at only about 36 Mt of workable recoverable reserves, with the possibility of reaching about 55 Mt in a future Maghara extension. The first shipment of this coal was exported in July 1996.

**e. New and Renewable Energy Resources:**

In addition to its limited commercial energy resources, Egypt has also good potential renewable resources. Due to its geographic location, Egypt enjoys sunshine all year around. Direct solar intensity ranges between 260 and 710 cal/cm2. Wind speed mapping

showed that Egypt has some good locations with an average annual wind speed of about 10 m/s capable of producing competitive wind energy from wind turbines.

Biomass has long been used in rural areas to meet some energy demands. It is estimated that about 1 Mtoe in the form of vegetal fuel is consumed annually. However, due to limited cultivated area, the potential for expanding the use of biomass in Egypt is limited.

In a significant move, the Egyptian Government has launched a program to apply new and renewable energy technologies. A New and Renewable Energy Authority (NREA) was established in 1986. NREA's objectives are to introduce renewable energy technologies to Egypt on a commercial scale. The Egyptian Renewable Energy Development Organization ( EREDO) was established in 1992 by mutual financing from Egypt and European Communities; covering renewable energy technologies, testing and endorsing certificates of components.

The government program includes the following resources of renewable energy: solar, wind, biomass and geothermal. These technologies will supply energy to remote areas, which are located far from the grid, or directly to the grid in case of large solar and wind power generation. Generally, these operations are small in scale and decentralized. They are expected to supply about 5% of the total energy requirements of Egypt in the year 2005.

#### *1.5.7.4. Primary Commercial Energy Production:*

Total primary energy production is about 57.6 Mtoe in 1997/98, of which 40.1 Mtoe is in the form of crude oil with a share of about 69.6% , 14.8 Mtoe as natural gases with a share of about 25.6%, about 2.7 Mtoe as hydropower with a share of about 4.7%, and about 0.07 Mtoe as coal with a share of only 0.1%.

Table 1.11 shows the petroleum products production in the period 1996-1998, while Figure 1.14 shows the primary energy production pattern 1997/1998.

**Table 1.11 Petroleum Products Production 96-98**

(1000 Ton)

| Item | 1997/98 | 1996/97 | Growth rate (%) |
|---|---|---|---|
| Refinery capacity | 29800 | 29000 | 2.76 |
| Oil throughput | 29489 | 28273 | 4.30 |
| Petroleum products: | | | |
| LPG | 461 | 445 | 3.60 |
| Gasoline/Naphtha | 5220 | 4934 | 5.80 |
| Kerosene/Turbine | 2027 | 2120 | 4.39 |
| Gas oil/ Diesel | 6119 | 5759 | 6.25 |
| Fuel oil | 13287 | 12686 | 4.74 |
| Coal | 157 | 148 | 6.08 |
| Other | 1270 | 1168 | 8.73 |
| Total products | 28541 | 27260 | 4.70 |

**Source:** Organization for Energy Conservation and planning.

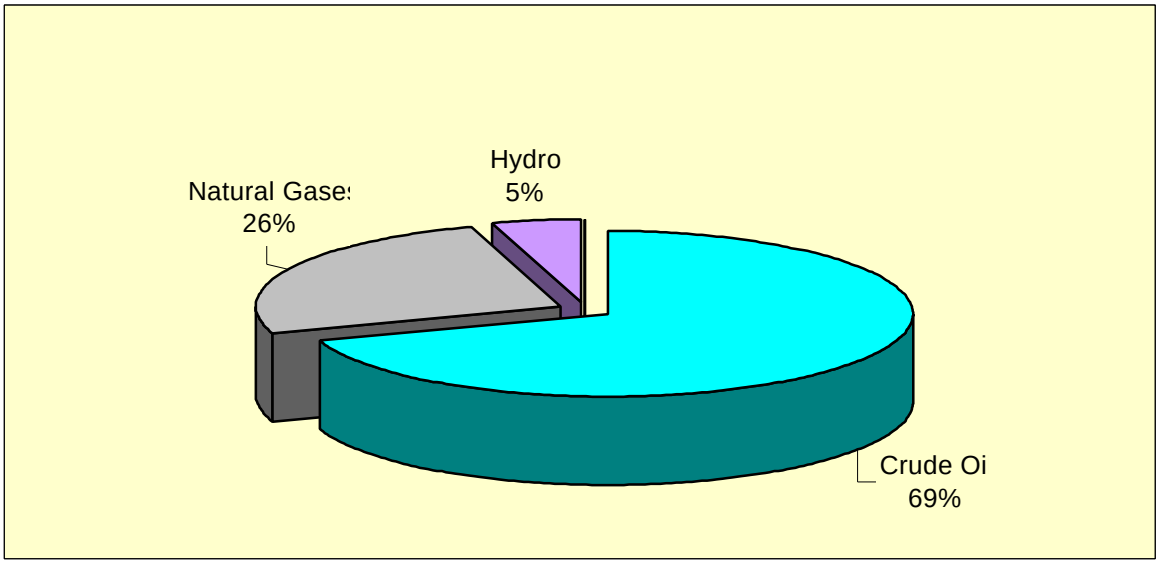


Figure (1.14): Primary Energy Production Pattern 1997/1998

### *1.5.7.5. Total Energy Consumption:*

According to 1997/98 figures total primary energy consumption is about 39.9 Mtoe of which about 1.1 Mtoe is coal, about 11.7 Mtoe natural gas, about 24.5 Mtoe crude oil and about 2.7 Mtoe hydropower. As shown in figure (1.15), the share of crude oil, natural gas and hydropower is about 63%, 30% and 7% respectively of total primary energy consumption (excluding coal).

The transport sector is considered the major oil consumer, with about 35.5% of total oil consumed in 1997/98, followed by the industrial sector with a share of about 27.8%, electricity 18.7%, residential and commercial 14.2%, and finally the agriculture sector with only 0.4%. The electricity sector is considered the major consumer of natural gas with about 61.9% of total natural gas consumption in 1997/98, as shown from figure (1.13), followed by industry with 29.3%, the petroleum sector with 6.8% and finally the residential sector with only about 2%.

**Table 1.12 Sectorial Consumption of Petroleum Products**

(Mtoe)

| **Sector** | | **97/98** | **96/97** | **Growth rate** | **Share of total consumption (97/98)** | **Share of total energy use(97/98)** |
|---|---|---|---|---|---|---|
| Industry | Energy | 6.248 | 5.866 | 6.51 | 26.15 | 27.77 |
| | Non energy | 1.085 | .978 | 10.92 | 4.54 | |
| | Total | 7.333 | 6.844 | 7.14 | 30.69 | |
| Transport | Energy | 7.986 | 7.347 | 8.70 | 33.42 | 35.49 |
| | Non energy | .25 | 0.229 | 9.08 | 1.05 | |
| | Total | 8.236 | 7.576 | 8.71 | 34.47 | |
| Agriculture | Energy | .093 | 0.099 | 6.06 | 0.39 | 0.41 |
| | Non energy | .0408 | 0.038 | 7.72 | 0.17 | |
| | Total | 0.134 | 0.137 | 2.19 | 0.56 | |
| Residential & Commercial | Energy | 3.195 | 3.019 | 5.82 | 13.37 | 14.20 |
| Electricity | Energy | 4.208 | 3.04 | 38.42 | 17.61 | 18.70 |
| | Non energy | .0117 | 0.011 | 6.36 | 0.05 | |
| | Total | 4.220 | 3.051 | 38.31 | 17.66 | |
| Petroleum | Energy | .772 | 0.681 | 113.37 | 3.23 | 3.34 |
| | Non energy | .0068 | 0.006 | 13.33 | 0.03 | |
| | Total | 0.779 | 0.287 | 13.40 | 3.26 | |
| Total | Energy | 22.502 | 20.052 | 12.222 | 94.17 | 100 |
| | Non energy | 1.394 | 1.262 | 10.50 | 5.83 | |
| | Total | 23.896 | 21.314 | 12.12 | 100 | |

**Source**: Organization for Energy Conservation and Planning.

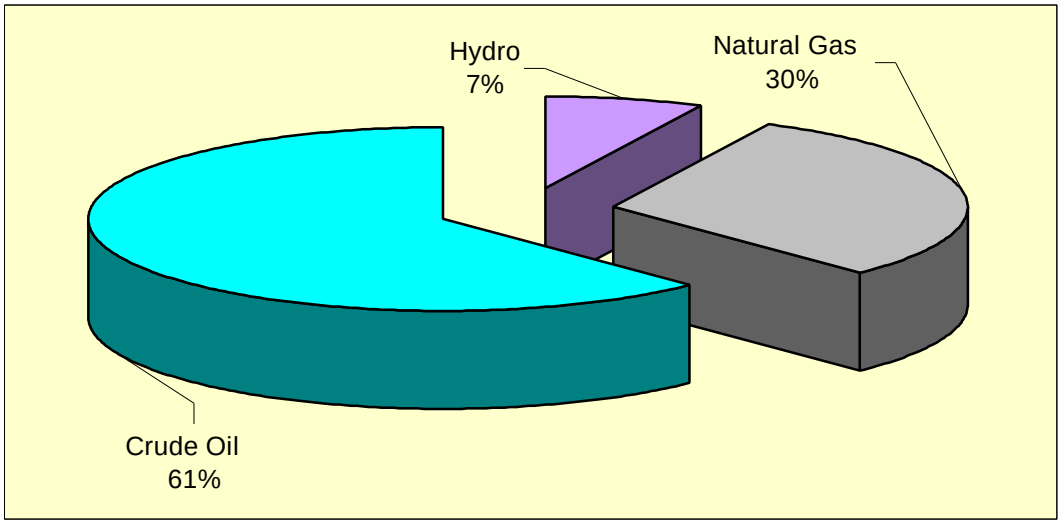


Fig. (1.15) Primary Energy Consumption Pattern (1997/1998)

### *1.5.7.6. Electricity Sector:*

Electrical energy-production has increased from nearly 18.4 TWh in 1980/81 to 62.3 TWh in 1997/98 with an average annual growth rate of 7.4% during that period.
On the other hand, electricity sales for different economic sectors has increased from about 15.6 TWh in 1980 to about 53 TWh in 1997/98, with an average annual growth rate of about 7.5% during that period.

As shown in figure ( 1.18 ), the industrial sector is considered the major consumer of electricity with a share of about 41.7% of in 1997/98, followed by the residential and commercial sector with about 38.6%, the governmental public utilities with 15.7%, then the irrigation and agricultural sector with about 4%. This last figure is relatively low but likely to increase with the planned strategy of land reclamation and mechanization projects.

**Table 1.13 Development of Electricity Generation AND Installed Capacity**

| | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 |
|---|---|---|---|---|---|---|---|
| Energy generation | | | | | | | |
| -Hydro | 10204 | 10485.8 | 10971.2 | 11413.1 | 11554.5 | 11986.6 | 12222 |
| -Therml | 35277.7 | 36610.5 | 37633 | 39914.8 | 42889.7 | 45669.5 | 50114 |
| -Total | 45481.7 | 47096.3 | 48604.2 | 51327.9 | 54444.2 | 57656.1 | 62336 |
| Installed Capacity | | | | | | | |
| -Hydro | 2715 | 2715 | 2715 | 2715 | 2805 | 2805 | 2805 |
| -Therml | 8820.5 | 9195.5 | 9331.3 | 10262.9 | 10222 | 110498 | 10498 |
| -Total | 11535.5 | 11910.5 | 12046.3 | 12977.9 | 13027 | 13303 | 13303 |

**Source:** Organization for Energy Conservation and Planning.

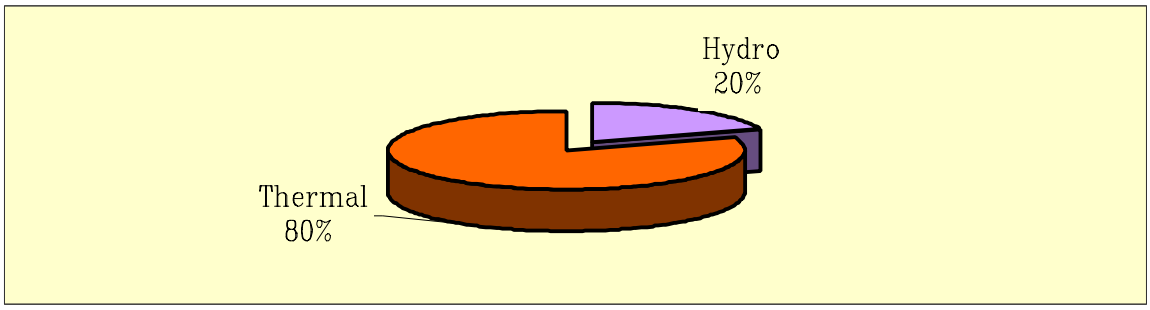


Fig.(1.16) Electricity Generation pattern(1997/98)

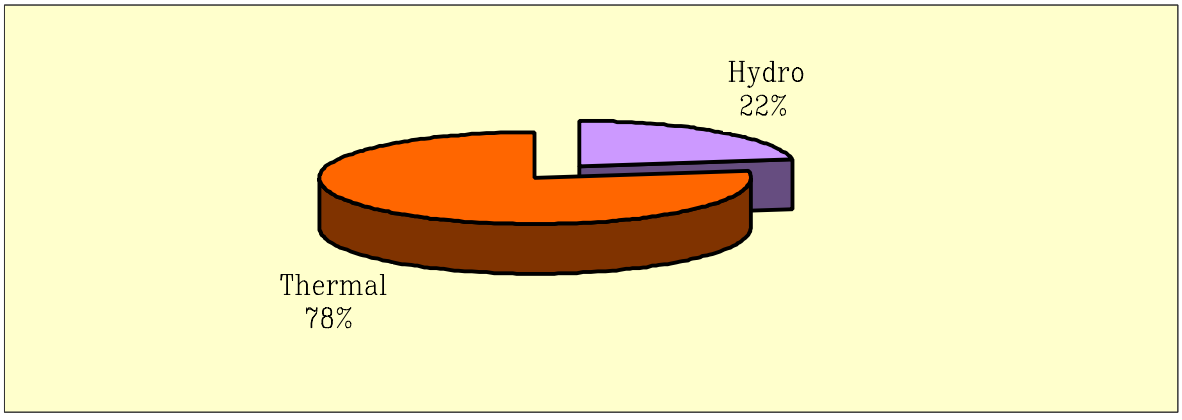


Fig.(1.17) Electricity Generation Pattern (1991/92)

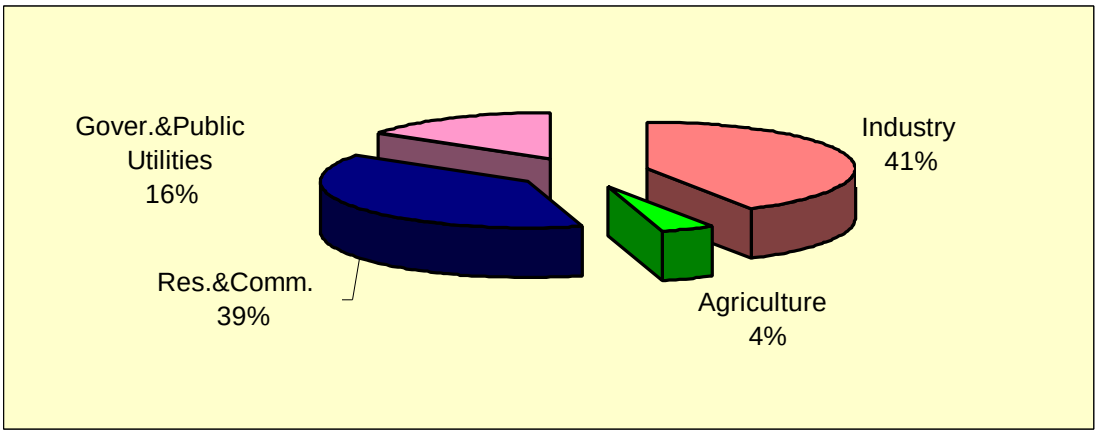


Fig.(1.18) Sectorial consumption of electricity(1997/98)

As shown from the above figures the share of hydropower in the generation of electricity decreased from 22% in 1991/92 to 20% in 1997/98. (See tables 1.13 and 1.14)

### *1.5.7.7. Final Energy Demand:*

As a result of the social and economic development of the Egyptian economy, total commercial energy demand has achieved a high average annual growth rate of about 6.3% during the 1980's. Hydropower played a significant role in satisfying Egypt's energy needs in the 1970's by providing more than two thirds of the electricity demand. By the late 1980's the situation was completely reversed with oil and natural gas providing more than two thirds of the electricity demand.

As shown from fig. (1.19 ), the industrial sector is considered as one of the major energy consuming sectors in Egypt with 48.8% of total final energy consumed in 1997/98, followed by transport with 29.2%, residential and commercial with 18.4%, governmental and public utilities with 2.5% and finally agriculture with only about 1.1%.

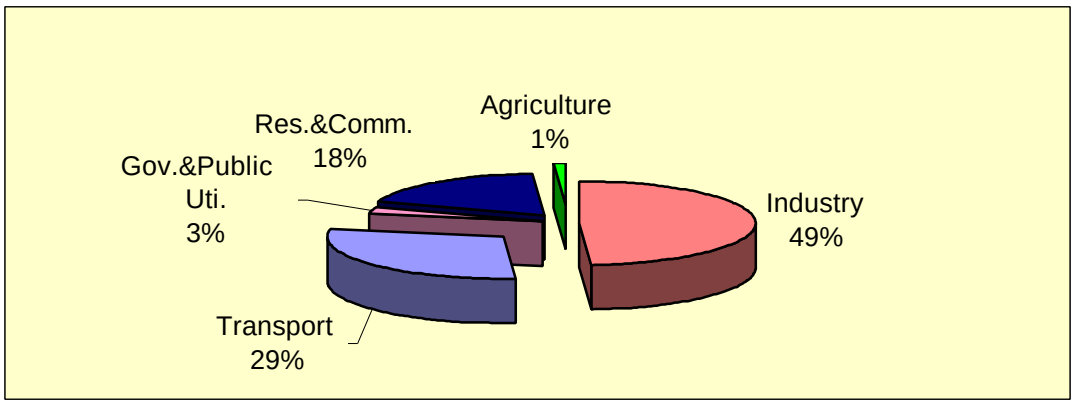


Fig.(1.19) Energy Demand by Sector (97/98)

### *1.5.7.8. Energy Pricing Policy:*

### *1.5.7.8. Energy Pricing Policy:*

Energy pricing is one of the most important and critical issues that Egypt is facing today. For several years energy prices have been subsidized, to the extent that its real value continued to decrease over time, as noted in table (1.14). Low energy prices have contributed to inefficient use of energy in different consuming sectors. This leads to a high rate of growth in demand.

Within the economic adjustment program, the government decided to increase the energy prices gradually to their economic levels. A program was established to increase prices and it is revised annually taking into consideration the economic and social impact resulting from price increases of energy, in order to ensure the viability of the program.

By 1986/87 the government had started to take steps to correct the costly subsidization by increasing the energy prices gradually, but since 1993/94 no more price increases have been imposed due to social and political reasons. However, the expected effect of the pricing policy on slowing down the growth in demand has been obvious in the last few years.

**Table 1.14 Energy Current Prices Development (90/91-97/98)**

(Unit: LE/ TON)

| Year | LPG | Gasoline 80 | Gasoline 90 | Keros-ine | Gas oil | Fuel oil | Diesel | Natural Gas | Electri-city(PT /KWH) |
|---|---|---|---|---|---|---|---|---|---|
| 90/91 | 120 | 770 | 840 | 126 | 120 | 50 | 105.3 | 60.71 | 4.33 |
| 91/92 | 250 | 980 | 1120 | 252 | 240 | 80 | 210.6 | 97.50 | 6.10 |
| 92/93 | 250 | 980 | 1120 | 378 | 360 | 100 | 315.9 | 122.20 | 9.68 |
| 93/94 | 250 | 1260 | 1400 | 504 | 480 | 130 | 421.2 | 159.25 | 11.20 |
| 94/95 | 250 | 1260 | 1400 | 504 | 480 | 130 | 421.2 | 159.25 | 11.20 |
| 95/96 | 250 | 1260 | 1400 | 504 | 480 | 130 | 421.2 | 159.25 | 11.20 |
| 96/97 | 250 | 1260 | 1400 | 504 | 480 | 130 | 421.2 | 159.25 | 11.20 |
| 97/98 | 250 | 1260 | 1400 | 504 | 480 | 130 | 421.2 | 159.25 | 11.20 |

**Source**: Organization for Energy Conservation and Planning.

### *1.5.7.9. Energy Policy:*

For several years, Egyptian energy policies have been developed, and focused on the following:

- Enhancement of natural gas utilization.
- Energy conservation and more efficient energy use.
- Energy pricing adjustment,
- Promotion of renewable energy utilization.

One of the major objectives of these policies is to address some of the national concerns and priorities, among which are: expanding the life expectancy of conventional energy resources, particularly diversifying the energy supply mix, and having a significant impact on limiting the future increase in GHG emissions from most of the economic sectors.

**a. Enhancement of Natural Gas Utilization:**

Recently, natural gas has been playing a key role in Egypt's energy policy. Given its unique economic and environmental advantages, increased use of natural gas would improve the overall energy efficiency and environmental quality of Egypt. As a versatile source of energy, natural gas offers a number of economic and environmental advantages over competing fuels.

It is well recognized that primary energy resources in Egypt are mainly petroleum based with some other limited resources. Therefore, the energy policy of Egypt has been developed to promote the expansion of natural gas utilization as a substitute for liquid fuels in various economic sectors. This policy should achieve the following objectives:

- Increasing exports of oil and oil products especially fuel oil, and maintaining petroleum export revenues as an important source for foreign currency needed for development.
- Achieving self sufficiency in LPG .
- Establishing important strategic industries relying on natural gas as a raw material and fuel such as fertilizers and steel industries.
- Reducing petroleum imports of some products, such as gas oil used in power generation.
- Reducing environmental pollution.

To realize those objectives, a set of strategies have been pursued which includes:

- Developing gas infrastructure, by expanding the natural gas pipeline grid from 1000 to more than 2700 km.
- Expanding the local gas market and developing gas demand; the market share of natural gas in the total hydrocarbon consumption has increased to reach 35%. In addition, the substitution of fuel oil by natural gas in power generation currently exceeds 73%.
- Making use of the economic and environmental benefits of natural gas, by promoting unconventional applications.
- Using Compressed Natural Gas (CNG) as a transport fuel to replace gasoline and diesel is one of these applications. A number of demonstration projects are now underway to assess the feasibility of this emerging technology under local operating conditions.
- Promoting foreign investments in gas exploration and production.This is implemented through the addition of gas clauses to the concessions agreements in 1987 which allowed foreign companies to share gas discoveries with the government of Egypt in the same manner used in oil, and,
- Encouraging private sector participation in different aspects of the gas industry: Recently, a number of private firms have been formed to participate in the construction of gas pipelines, building CNG fueling stations and converting vehicles to use CNG.

It should be emphasized that the policy of maximizing natural gas use in thermal power stations to replace liquid fuels, together with other actions, such as rehabilitation of old power stations, conversion of open cycle gas turbines to more efficient combined cycle units and building large new modern generating facilities, which mainly use natural gas as a fuel, has led to the following:

- A decrease in the amount of oil imported.
- An improvement in the overall efficiency of thermal power generation as the average rate of fuel consumption has declined from 346 gm/kwh in 1981/82 to only 241 gm/kwh in 1992/93 and 223 gm/kwh in 1997/98.
- An increase in the electricity sector share of total natural gas consumption from 33.3% in 1980/81 to about 62% in 1997/98.

**b. Energy Conservation and More Efficient Energy-Use:**

Energy efficiency is an important strategy that has been adopted and promoted throughout the Egyptian Economy. Several organizations in Egypt are currently conducting energy conservation programs in different sectors of the economy .

Having determined the critical energy situation in Egypt, the high level of energy consumption and the limited energy resources, it is imperative to conserve energy in the various economic sectors. This is an essential part of the integrated energy planning process and policies that the government considered after the 1973 crisis.

The Organization for Energy Planning (OEP) and other concerned agencies that tackle the problem of inefficient energy use in Egypt have moved aggressively in all areas of energy conservation such as fuel switching, combustion efficiency improvement, and efficient use of household appliances, specific energy consumption standards for industrial products, power factor improvement, use of efficient lighting systems, energy pricing policies, dedicated compressed natural gas (CNG), etc.

One of the most important energy conservation activities that have been considered as first priority by various agencies in Egypt is the Industrial Energy Conservation Program. The objective of this program is to plan and implement energy conservation measures in the various economic sectors in Egypt, in order to achieve measurable energy savings at reasonable cost.

The energy audits identify the energy saving potentials, the low cost/no cost (housekeeping) energy conservation opportunities (ECO's), together with the capital investment required and the payback period. The audits in the industrial sector showed an average potential saving of about 25% of the energy consumed in the audited plants. About 10% of these saving are housekeeping items.

**c. Energy Pricing Adjustment:**

From the early 1960s to the early 1980s, energy prices in Egypt have been kept relatively constant, and considerably lower than the international market prices, to match local incomes and the relatively low cost of living in Egypt during that time.

The lower energy prices together with the development needs of the Egyptian economy have encouraged consumers to consume more energy. The result was a high energy

consumption growth rate, as mentioned earlier, and an increase in national energy subsidy. As an example, the petroleum products subsidies reached of $ 3.5 billion in 1985.

By the end of the 1980s and the early 1990s, energy prices started to increase slightly, though their constant or fixed prices have not changed very much. This explains why energy consumption has achieved lower levels of average annual growth during the period 1990-1993/94 compared to the previous thirty years.

**d. Promoting Renewable Energy Utilization**

Since the early 1980's renewable energy has been considered as an integral part of the Egyptian policy. The strategies called for its development to satisfy about 3% and 5% of the primary energy by the years 2000 and 2005 respectively. Such saving, accounting for 1.4-2.5 MTOE annually will be basically from solar, wind and biomass resources. Recent achievements have been realized in the areas of institutional building, field testing, technology adoption and development of local solar and wind industries.

The primary energy savings from renewable energy are estimated by almost 38 thousand TOE, annually. Over 80% of this is due to the commercialization of domestic solar water heaters (DSWH), with over 100,000 families currently using them, particularly in the new cities.

More rapid penetration of different applications in many sectors is expected over the next few years, particularly for the well -established DSWH, solar Industrial Process Heat (IPH), and the extension of wind and solar thermal electricity generation. Today a wind farm of 6 MW is operative on the Red Sea Coast. The first large commercial wind farm of 60 MW is contracted for; and its first phase is expected to be operative in 1997. Moreover, a large- scale thermal power plant is being developed.

Moreover, the government of Egypt encourages the utilization of agricultural residues in the production of cheap and environmentally friendly sources of energy.

### 1.5.8. Transportation:

#### *1.5.8.1 Existing transportation system in Egypt:*

The transport sector is a major consumer of fossil fuels and therefore contributes a significant share of "greenhouse gases (GHGs). The most common GHGs emitted from the mobile sources are carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$). Some minor atmospheric constituents, such as the nitrogen oxides (NOX) and carbon monoxide (CO), although not important GHGs in their own right, can influence the concentration of the GHGs through atmospheric chemistry.

As shown in figure 1.20 highways are the most important mode of transport system in terms of freight and passengers carried. In 1990, the inter-city highways, with about 12,000 kilometers of paved roads and 14,000 kilometers of unpaved, carried approximately 158 million tonnes of freight and 692 million passengers with a corresponding performance of 23.820 billion tonne-km, and 540 billion passengers-km. These represented 83 % of the total ton kilometers transported by all forms of transport and 66 % of the total passenger- kilometers.

In 1995 the inter-city highways, with about 30, 000 kilometers of paved roads and 10,000 kilometers of unpaved, carried approximately 178.348 million tonnes of freight and 834.482 million passengers with a corresponding performance of 33.886 billion tonne-km, and 65.731 billion passengers-km. These represented 87 % of the total ton kilometers transported by all forms of transport and 57% of the total passenger- kilometers.

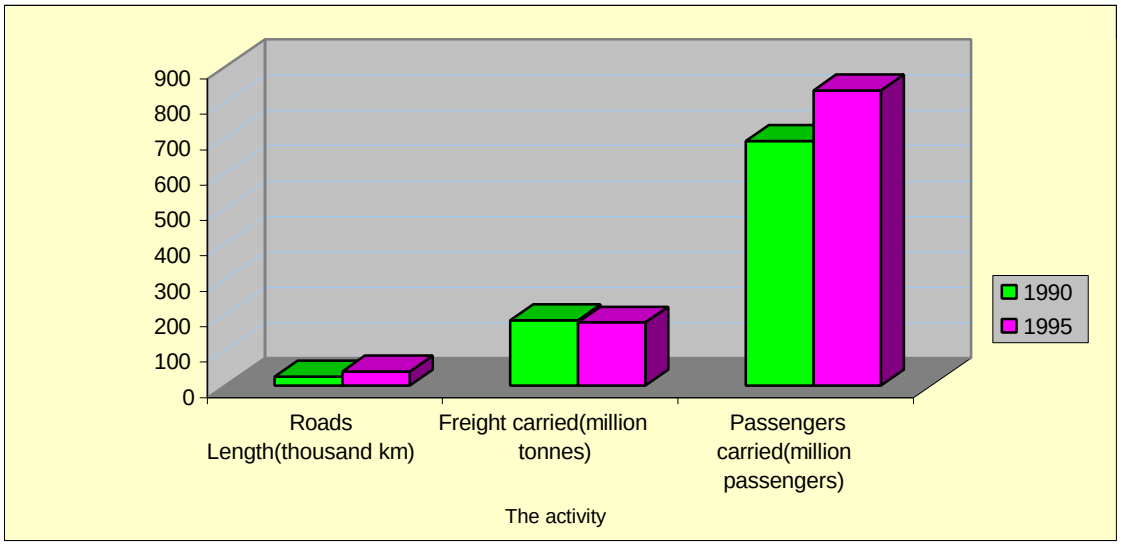


Fig.(1.20 ) Egypt Highways activities.

In 1995, the railway system consisted of 4,260 route kilometers compared to 3,905 in 1990. It carried approximately 11.553 million tons of freight and 492.199 million passengers accounting for 9.3 % of ton kilometers and 43% of passenger-kilometers in 1995. In 1990, the railway system carried approximately 8 million tons of freight and 627 million passengers with a corresponding performance of 2.900 billion ton kilometers and 34. 870 billion passenger kilometers, accounting for 10% of ton kilometers and 34% of passenger kilometers compared to 87% and 57% respectively for road transport. (figure 23 ).

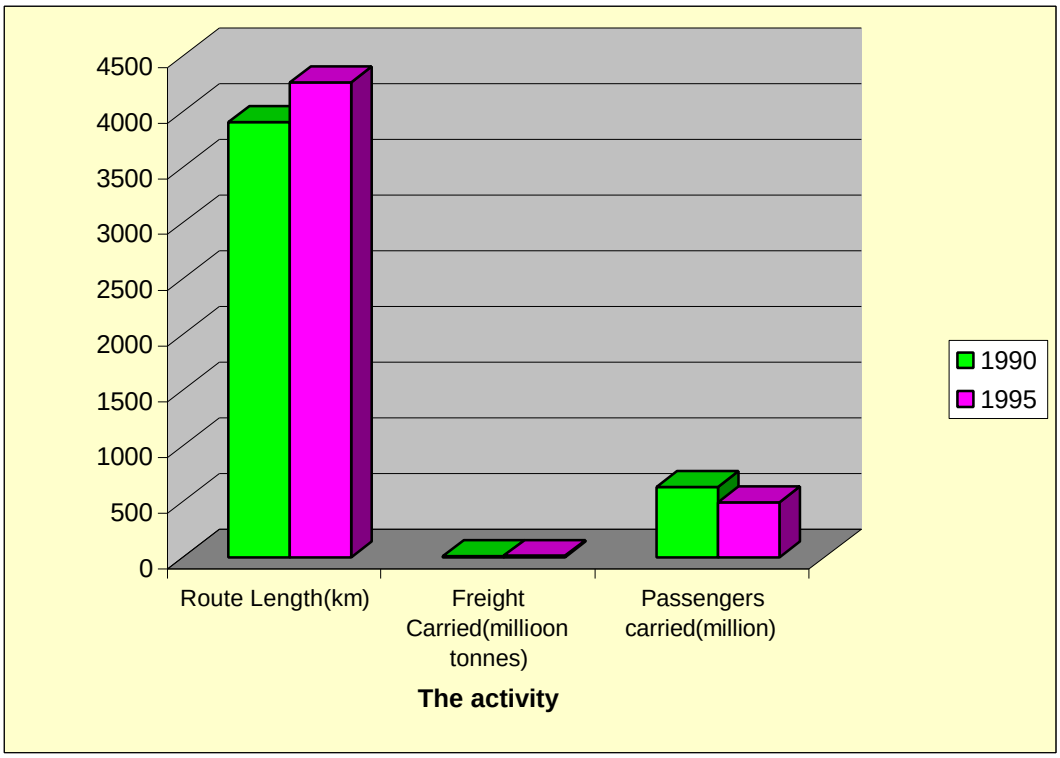


Fig.(1.21) Egypt Railway System Activities

The inland waterway system in Egypt is primarily an irrigation system and its physical characteristics are basically determined by the irrigation requirements of the area served. From the transportation point of view, the link between the port of Alexandria and Aswan is the most important axis. The rest of the network is occasionally used for transporting relatively small quantities of goods. In 1990, the inland waterway system carried approximately 5 million tons and performed almost 2.050 billion ton-km. The inland waterway system, thus accounted for 7% of the total ton-kilometers. In 1995, the inland

waterway system carried approximately 3.619 million tons and performed almost 1.270 billion ton-km, only 3.3% of the total ton-kilometers transported (figure 1.22).

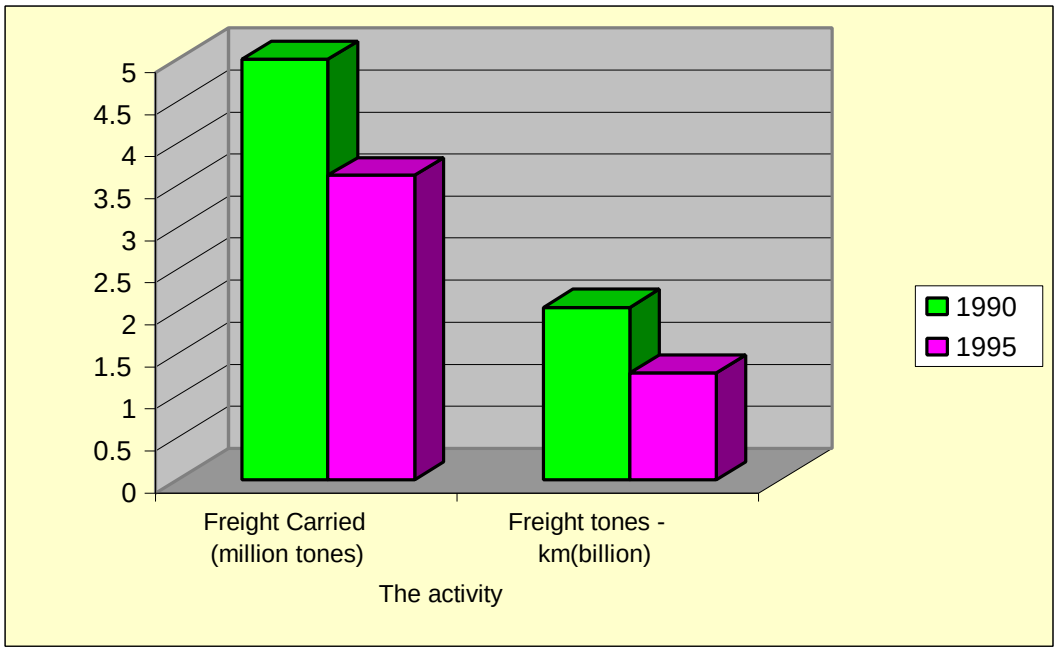


Fig.(1.22) Egypt Inland Water Ways activities.

In 1990, the Egyptian port system handled approximately 25.5 million tons compared to 51.0 million tons in 1995. In 1990, civil aviation system consisted of 15 airports and approximately 60,000 aircraft, and carried about 6 million passengers. In 1995, the civil aviation system had approximately 77,000 aircraft and carried about 10 million passengers, of which Cairo airport handled approximately 6.7 million passengers.

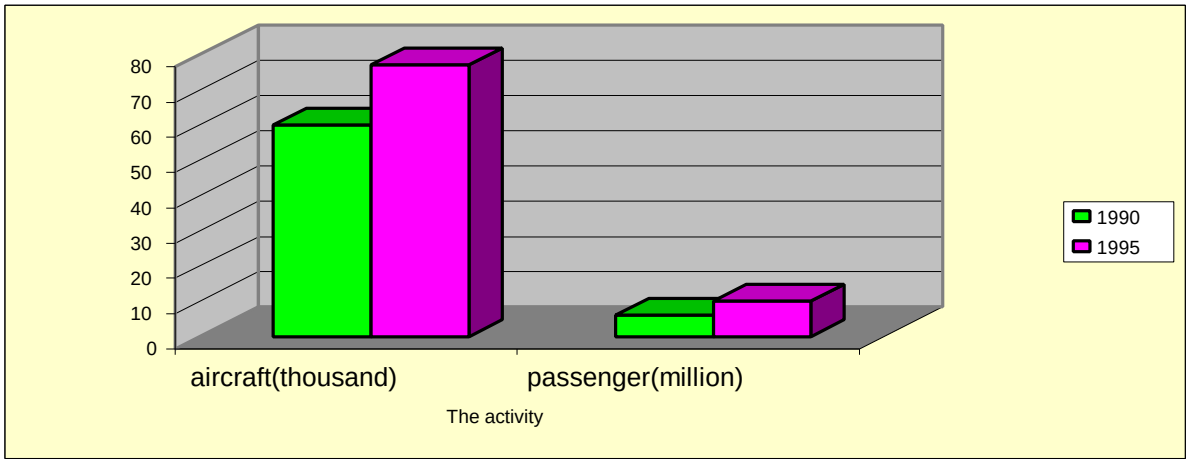


Fig (1.23) Egypt Civil Aviation System Activities

Table (1.15) shows statistics describing the existing transportation system in 1995 compared with the situation in 1990.

**Table(1.15) Egypt Transportation Activities**

| **1995/96** | **1990/91** | **Transport mode** |
|---|---|---|
| | | **Inter-city Highways** |
| 40.000 | 26.000 | Kilometers |
| 178.348 | 158 | million tonnes |
| 834.482 | 692 | million passengers |
| 33.886 | 23.820 | billion tonne-km |
| 65.731 | 67.540 | billion passenger-km |
| 87% | 83.% | rate of total ton-km |
| 57% | 66% | rate of total passenger-km |
| | | **Railway system** |
| 4260 | 3905 | route km. |
| 11.553 | 8 | million tonnes |
| 492.199 | 627 | million passengers |
| 3.616 | 2.900 | billion tonne-km |
| 49.220 | 34.870 | billion passenger-km |
| 93% | 10%. | rate of total ton-km. |
| 43% | 34% | Rate of total passenger-km |
| | | **Inland water ways** |
| 3.619 | 5 | million tones |
| 1.270 | 2.050 | billion tone-km |
| | | **Port system** |
| 51 | 25.5 | million tones |
| | | **Civil Aviation system** |
| 77.000 | 60.000 | aircraft |
| 10 | 6 | million passengers |

**Source**: EEAA. Building Capacity for Egypt to Respond to UNFCCC Communication Obligations.

### *1.5.8.2. Energy Consumption of the Transport Sectors in Egypt:*

In 1990, the prime energy consumed by the transport sector (including the fuel consumption at ports and airports) was about 6.182 thousand TOE. In 1995, the transport sector consumed about 6.971 thousand TOE. It thus consumed 37.4 % of the total energy consumption in all different economic sectors (Figure1.24).

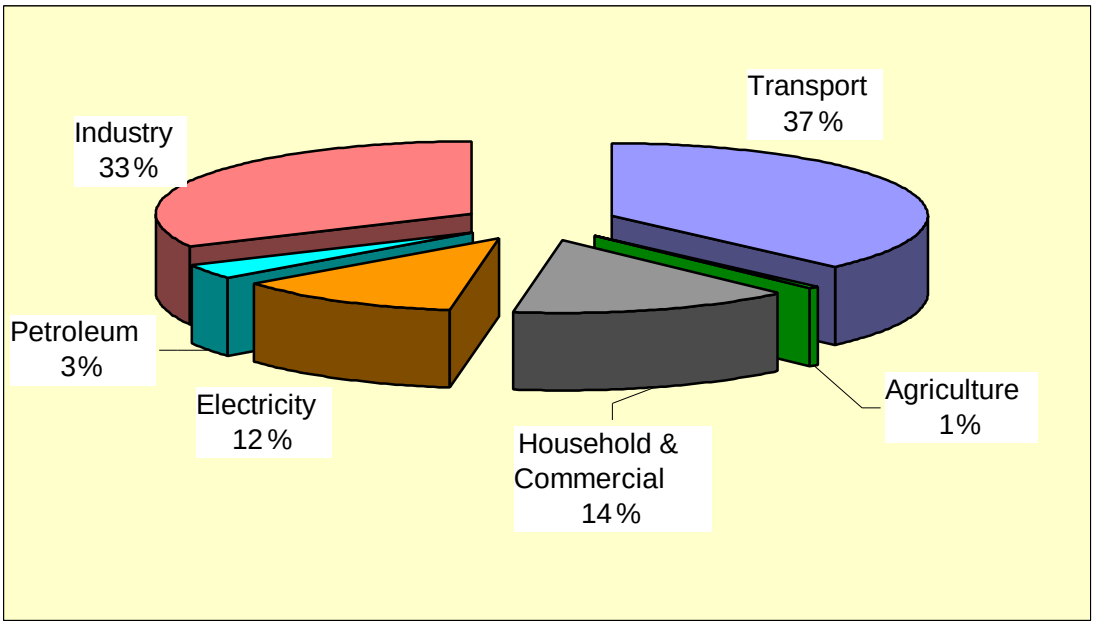


Fig.(1.24) Energy Consumption of the different Economic Sectors in Egypt(95)

The road transport is the major consumer of fossil fuels, with 3727.473 thousand tons. (Table (1.16) & (figure 1.25).

**Table( 1.16 ) Distribution of fuel consumption in thousand tons in 1990&1995**

| **1995** | **1990** | **Fuel** |
|---|---|---|
| 1865.062 | 2416 | **Gasoline** |
| 2512.097 | 2872 | **Gas oil** |
| 2164.869 | 167 | **Fuel oil** |
| 425 | 727 | **Other** |
| 6971.028 | 6182 | **total** |

**Source**: EEAA. Building Capacity for Egypt to Respond to UNFCCC Communication Obligations.

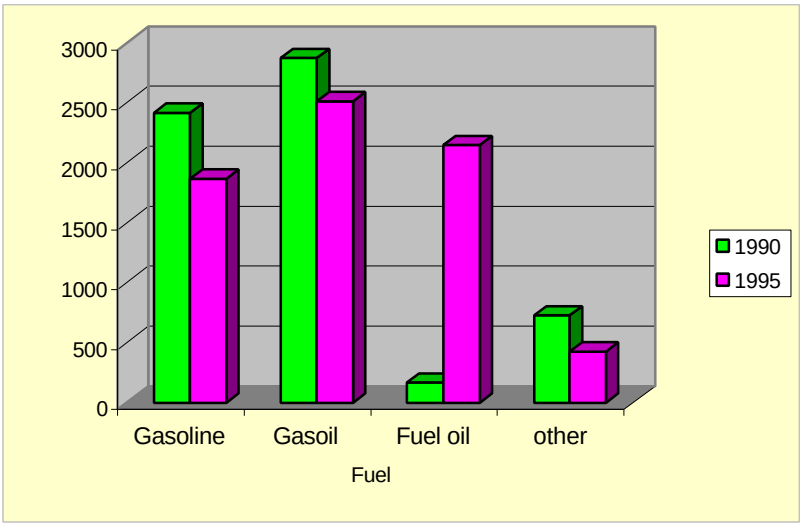


Fig.(1.25) Distribution of fuel consumption (thousand tons)

### *1.5.8.3. Specific Energy Consumption of Different Transport Modes in Egypt:*

Specific Energy Consumption is calculated in terms Mega Joule per passenger-km(MJ/pkm) for passenger transport and ton-km(MJ/tkm) for freight transport.
Tables (1.17) and (1.18), and figures (1.26) and (1.27), show the transport sector fuel consumption in 1990 and 1995.

Private cars have the highest specific energy particularly for short distance transport. Intercity trains and buses are the most efficient mode for passenger transport. In the case of freight transport, intercity trains and boats are again the most efficient energy consumers. Small trucks represent the least efficient mode for freight transport.

**Table (1.17 ) Specific energy consumption of different transport modes1990**

**A-Passenger transport**

| Specific energy consumption | | occupancy | | Vehicle capacity (pass) P | conditions | Transport mode |
|---|---|---|---|---|---|---|
| **MJP Km** | **L/100 km** | **p** | **%** | | | |
| | | | | | | **Road** |
| 1.79 | 14.5 | 2.5 | 62.5 | 4 | Short distance | **-Private car** |
| 1.27 | 12.3 | 3 | 75.0 | 4 | Inter-city | |
| 1.52 | 14.8 | 3 | 75.0 | 4 | Short distance | |
| - | - | - | - | - | Inter-city | **-Taxi** |
| 0.90 | 15.3 | 5.25 | 75.0 | 7 | Short distance | **-Collective taxi(minibus)** |
| 0.61 | 13.8 | 7 | 100.0 | 7 | Inter-city | |
| 0.22 | 55.5 | 90 | 85.7 | 105 | Short distance | **-Bus** |
| 0.33 | 41.5 | 45 | 81.8 | 55 | Inter-city | |
| 0.39 | 302 | 1000 | 80 | 800 | Inter-city | **Railways** |

**B-Freight transport**

| Specific energy consumption | | occupancy | | Vehicle capacity (t) | Transport mode |
|---|---|---|---|---|---|
| **MJP Km** | **L/100 km** | **t** | **%** | | |
| 6.26 | 18.25 | 1.05 | 60.0 | 1.75 | **Road -Semi truck** |
| 1.71 | 71.30 | 15.0 | 75.0 | 20.00 | **-Light truck** |
| 1.85 | 115.7 | 22.5 ? | 75.0 | 30.00 | **-Heavy truck** |
| 0.39 | 1082 | 1000 | 100 | 1000 | **Railways** |
| 0.60 | 852 | 511.9 | 50 | 1023 | **Inland waterways** |

**Source:** EEAA Building Capacity for Egypt to Respond to UNFCCC Communication Obligations.

**Table(1.18) Specific energy consumption of different transport modes1995**

**A-Passenger transport**

| Transport Mode | Operating Conditions | Capacity | Occupancy | Specific Energy Consumption | |
|---|---|---|---|---|---|
| | | (passengers) | | Liter/100 km | MJ/km |
| Passenger Car | Urban | 4 | 2.5 | 12.70 | 1.57 |
| | Rural | 4 | 2.5 | 11.28 | 1.39 |
| | Inter-city | 4 | 2.5 | 10.72 | 1.32 |
| Taxi | Urban | 4 | 4 | 15.40 | 1.19 |
| | Rural | 4 | 3 | 17.90 | 1.84 |
| | Inter-city | 7 | 6 | 17.34 | 0.89 |
| Microbus | Short distance | 14 | 12 | 20.50 | 0.62 |
| | Inter-city | 14 | 12 | 18.20 | 0.55 |
| Public Bus | Short distance | 105 | 68 | 48.97 | 0.26 |
| | Inter-city | 55 | 45 | 33.28 | 0.27 |
| Private Bus | Short distance | 45 | 45 | 41.50 | 0.33 |
| | Inter-city | 45 | 45 | 33.33 | 0.27 |
| River Bus | Cairo | 140 | 13.27 | 163.88 | 4.45 |
| Railways | AbouKir Line | 1500 | 533 | 558.64 | 0.38 |
| | Inter-city | 1500 | 1247 | 580 | 0.16 |

**B-Freight transport**

| Specific energy consumption | | occupancy t % | Vehicle capacity (t) | Transport mode |
|---|---|---|---|---|
| MJP Km | L/100 km | | | |
| 6.26 | 18.25 | 1.05 | 1.75 | Semi truck (short distance) |
| 0.80 | 33.33 | 15.0 | 20.00 | Truck (intercity) |
| 0.39 | 1085 | 1000 | 1000 | Railways(intercity) |
| 0.60 | 852 | 511 | 1023 | Inland waterways (intercity) |

**Source:** EEAA. Building Capacity for Egypt to Respond to UNFCCC Communication Obligations.

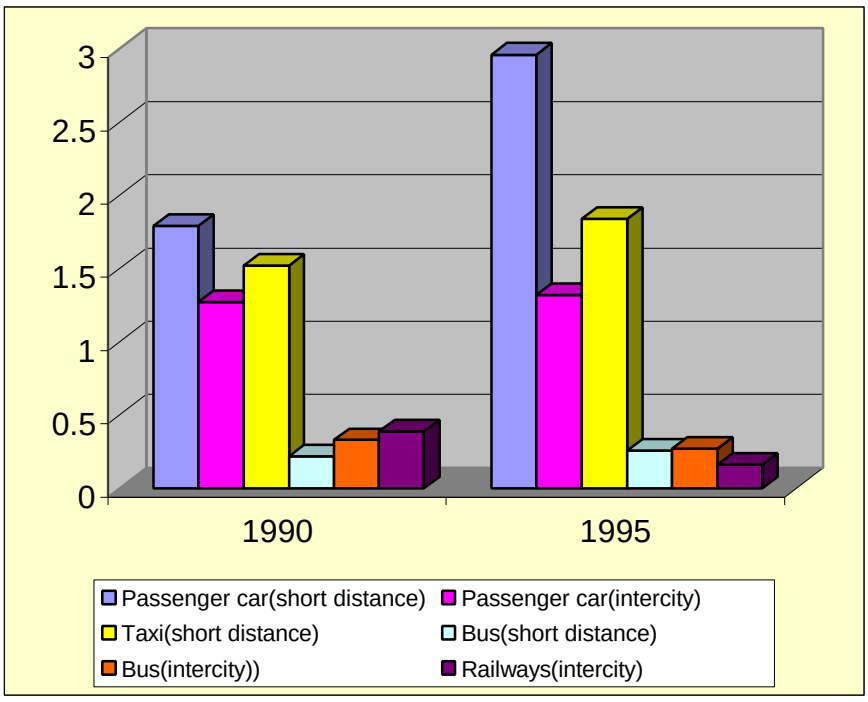


Fig.(1.26 ) Specific Energy Consumption of Different Transport Modes (Passenger Transport) 1990/1995.

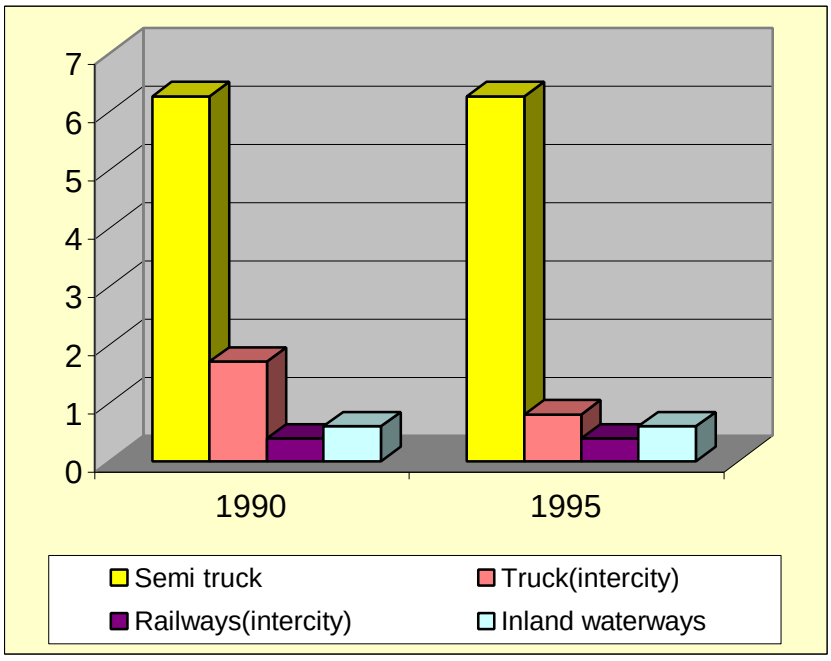


Fig.(1.27) Specific Energy Consumption of Different Transport Modes (Freight Transport) 1990/1995.

## 1.6. Waste Management:

Waste management in Egypt has reached a critical point and is the center of attention of various stakeholders in Egypt.

### 1.6.1. Solid Waste Management:

Solid waste management in Egypt has become an alarming national issue. It is estimated that Egypt generates 30,000 T/day of domestic garbage, 75% of which is generated from urban areas. The average composition of the waste is: 60% food, 13% paper, 3% metallic, *2.5%* glass, *2.5%* plastics, *2.5%* textile, and the rest is from demolition and construction. There are three systems for collection and transportation of municipal waste; either through the municipality, the informal sector scavengers (Zaballeen), or through the private companies.

Egypt generates an estimated 24 Million tons of agricultural solid waste per year; two thirds of which is used as fuel while most of the rest is used as fodder. The industrial non-hazardous solid wastes are estimated at 5 Million tons per year; some of it goes to planned open dump sites, while most of it is dumped haphazardly.

Between 1947 and 1994, a number of laws and regulations have been passed in order to cope with the increasing need to control and manage solid wastes in Egypt, with special focus on municipal garbage, especially in Cairo, Giza, and Alexandria. Law 4/1994, the Environmental Protection Law, complemented and did not negate, the previous laws.

Almost all the garbage collected by the municipalities goes as is to open dump sites at the outskirts of the cities. Meanwhile, the Zaballeen transport the garbage to their homes to segregate it in preparation for recycling. The Zaballeen communities in Cairo and Giza are operating highly efficient recycling operations.

Hazardous solid wastes represent a real problem in Egypt. Hazardous hospital wastes are, in general, mixed with non-hazardous municipal waste; these are far from being hygienic and therefore represent a danger to scavengers and collectors. There have been some recent attempts to install incinerators in some large hospitals. However, more still needs to be done.

Hazardous municipal sludges should be no real problem if existing laws and regulations are strictly applied. They now contain high ratios of heavy metals, coming from untreated effluents, which minimizes their use, after composting, as fertilizers or land conditioners.

Industrial hazardous sludges are generated at an increasing rate due to the high pace of building on-site pretreatment units. There is no estimate for the sludges. However, there is an ongoing preliminary study to establish a landfill for hazardous solid wastes in Helwan. It is estimated that industrial hazardous wastes are generated at the rate of about 50,000 tons per year, and are increasing due to the rapid rate of industrialization. For large companies, they are disposed of in assigned disposal sites. However, in an industrial park, such as the City of the l0th of Ramadan, there is no apparent policy enforced by the Authority in that direction.

The problems related to management of solid waste can be summarized in the following issues:

- The collection system covers small areas of the major cities, especially the affluent areas. The garbage in the streets is causing health problems and creating a latent risk for the spread of epidemic diseases and infections;
- The fee for collection and treatment of waste is too low to cover the necessary management and there is no adequate system for fee collection;
- The open burning of waste, in general, results in the spread of airborne pollutants in residential areas;
- Pathogenic and infectious hospital waste is currently mixed with municipal waste creating a great risk to the companies and individuals dealing with the latter, or living on or near the dumping sites.

EEAA has prepared a document entitled "The National Action Plan For Safe Handling of Solid Wastes". In this document, an ambitious ten-year program is presented. It will cost L.E. 3.755 Billion to address this problem at 1996 prices. It encourages the participation of private sector organizations and community NGOs. It also recommended that:

- The current lack of information of industrial hazardous waste necessitates a comprehensive inventory and the formulation of a strategy to facilitate future decisions concerning accurate and safe treatment;
- The large amounts of municipal waste can be utilized as soil conditioners or fertilizer;
- The current burning of agricultural waste should be prevented as this waste can be used as a fertilizer or soil conditioner;

### 1.6.2. Liquid Waste Management in Egypt:

Egypt is expected to face a serious water problem due to its limited fresh water resources. There is a pressing need for reusing water from the drains and reducing the flow from drains to the sea. This calls for a serious examination of the quality of Egypt's fresh and waste waters.
The socio-economic costs of poor water quality are enormous: almost 100,000 recorded deaths every year are due to water-born diseases, with unrecorded figures several times higher. Over 2.4 million feddans of irrigated land are suffering from salination; fishing output is decreasing in both quantity and value; and clean urban drinking water treatment is becoming more expensive.

Egypt enjoys a good set of laws and regulations that govern wastewater, potable water, and sea water; in addition to the Environmental Protection Law #4 of 1994. For example, Law 93/1962 deals with disposal of wastewater in public sewers, and requires that facilities provide samples to the Ministry of Health for analysis. Decree 643-1962 of the Minister of Housing and Utilities deals with the standards, specifications, and methods of analysis needed to implement this law. In addition, Law 48/1982 deals with the protection of the River Nile from pollution.

It is reported that 77% of the urban population is connected to public sewers. However, the sewage systems in most cities and towns are not efficient. In rural areas, only 5% of the population is connected to sewers and only about 25% are considered as having some sanitary facility.

The government of Egypt planned to invest about L.E 11 billion, during the period 1985-2002, in municipal liquid waste management projects that covers all urban and some rural areas. Proven technologies are used for the primary treatment of sewage before disposal. It is planned that, by year 2002, municipal wastewater treatment services will be extended to 56% of the population instead of 37% today. It is worth noting that Cairo has the lion's share of these projects, followed by Lower Egypt, and with Upper Egypt ending up with the smallest portion of the pie.

Basic barriers to the implementation of these ambitions include: shortage of land, design barriers, high level ground water in the Delta region, haphazard settlements, and lack of staff training.

The Egyptian industry uses 638 Mm3/y of water, of which 549 Mm3/y are discharged to the drainage system. The River Nile supplies 65% of the industrial water needs and receives more than 57% of its effluents. Industrial effluents usually contain pollutants in fluctuating concentrations. US Environmental Protection Agency (EPA) specified 129 priority pollutants to be regulated according to specific discharge procedures. Hazardous materials in Egypt are regulated by Law 4/1994.

Five categories of industrial activities are identified as the major industrial wastewater polluters in Egypt. These industries are food, drinks, textiles, chemicals, and electroplating. The food industry, especially dairy products, is a source for $CH_4$ emission. Therefore, cleaner production approaches and pretreatment technologies are viable solutions for industrial wastewater pollution problems.

According to the latest study by the National Research Center ( NRC), a total of 73 plants are involved in needs assessment studies to identify the industrial wastewater treatment system suitable for their needs. According to the same study, only 33 plants have so far implemented, or planned to implement, the treatment procedures. Knowing that the number of plants in Egypt with more than 200 workers is more than 1,200, one can conclude that there are very few plants that have started implementing measures that will make them in compliance with Law 4/1994, and before that with Laws 48/1982 and Law 93/1962.

This review provides the following conclusions and recommendations:

- Needs assessment of capacity building in various areas related to compliance machinery is needed, followed by the required training programs;

- Maintenance of the newly developed primary and pretreatment systems should be given the highest priority;

- Lines of command and communications should be established and clarified between various entities pertinent to liquid waste management systems;

- Until 1997, fewer than 10% of the plants in Egypt are engaged in implementing procedures and processes that will eventually lead to their compliance with the existing laws that govern wastewater management, with only one year left before the full enforcement of the law starts;

- There is a strong need to have a clearer, more realistic and more accurate industrial map of Egypt.

- The Ministry of State for Environmental Affairs has successfully managed to stop 34 factories from discharging their industrial effluents into the Nile waters.

- Special attention should be drawn to the Industrial Parks, eg.. 10th of Ramadan, October 6th, and Bourg El-Arab, for further development of the institutional and enforcement capabilities of their local authorities in order to avert the dangers of contaminating underground water and corroding the sewage networks.

## 1.7. Climate Change Institutional Framework

The establishment of the Egyptian Environmental Affairs Agency (EEAA) in 1982 signified the increasing attention directed to environmental protection by the Government of Egypt. EEAA was established as the highest authority in Egypt responsible for promoting and coordinating all efforts related to environmental protection. In July 1997, with the appointment of a special Minister for Environmental Affairs, the GOE demonstrated yet further commitment.

The Environmental Protection Law, Law 4/1994, describes the diverse mandates of the Agency. They include:

- Developing and following up on policies, plans and standards for environmental protection;
- Running pilot projects and promoting economic incentives, which respectively demonstrate and facilitate improved environmental performance;
- Conducting studies, monitoring, and supporting other bodies in their environmental monitoring duties;
- Preparing an Environmental Contingency Plan for confronting environmental disasters;
- Implementing a national system of Environmental Impact Assessment;
- Establishing Natural Protectorates, and managing bio-diversity within and outside these areas;
- Coordinating and following up on international environmental relations and obligations;
- Preparing programs for environmental education.

Within the context of setting up the institutional structure at the national level to comply with the UNFCCC, an inter-ministerial committee was established on the 20th of October 1997 by a decree issued by H. E. Minister of State for Environmental Affairs. The National Committee is headed by the Chief Executive Officer of the Egyptian Environmental Affairs Agency. The Committee members represent a wide range of governmental and non-governmental stakeholders, including private sector, scientific community and international organizations. The Committee aims at:

- Coordinating on a national level, regarding the participation of Egypt in the Framework -Convention for Climate Change;
- Developing an overall picture of the Egyptian policies and strategies for dealing with the issue of climate change;
- Reviewing the National Action Plan for Climate Change;

. Following up the implementation of the Framework Convention for Climate Change.

As of 1996, Egypt participated in the Climate Change Info / Web with UNFCCC secretariat. Moreover, in October 1997 a special unit was established within the Egyptian Environmental Affairs Agency that is solely responsible for climate change issues. It represents the national focal point for climate change. Over the past few years, significant progress has been made relating to national capacity building and institutional development in the field of climate change. Several organizations are extensively involved at the national level in climate change related activities. These include:

. Environmental organizations, such as the Egyptian Environmental Affairs Agency;
. Energy related organizations, such as the Organization for Energy Planning, the Egyptian Electricity Authority, the New and Renewable Energy Authority;
. Research Centers: such as the Agriculture Research Center, and the National Research Center;
. Universities: such as the Institute of Graduate Studies and Research in Alexandria University, the Faculty of Engineering in Cairo University, the Faculty of Engineering in Alexandria University, the Faculty of Veterinary Medicine in Zagazig University, and the Faculty of Economics and Political Science in Cairo University;
. Governmental Organizations and national laboratories: such as the General Organization for Industrialization, the Central Laboratory for Agriculture Climate, the General Organization for Sanitary Drainage, the Tebbin Institute for Metallurgical Studies, and the Soil Water and Environmental Institute;
. Non-Governmental Organizations: Nowadays we have more than 200 NGOs that work in environmental protection in general, and a few of these organizations have started to tackle climate change issues. For example, the Integrated Rural Technology Center for Training and Production and the Productive Cooperative of Basaisa in Sharqia governorate are interested in issues of solar and wind energy. Meanwhile, the Arab Office for Youth and Environment (AOYE) organized a national workshop to spread awareness regarding climate change issues.

These multi-layer climate change institutional arrangements will play a leading role in integrating climate change issues in the national agendas.

# 2. GHG INVENTORY

## 2.1 Introduction:

The total GHG emissions of Egypt in 1990 are equal to 116,608 Gg of CO2 equivalent using the 1995 Global Warming Potential (GWP) of the Intergovernmental Panel on Climate Change (PCC). Total GHG sinks in the land use sector equal 9,900 Gg of CO2 equivalent which makes the net emissions equal to 106,708 Gg of CO2 equivalent. Table (2.1) and Figure (2.1) show the percentage share of emissions of each of the greenhouse gases in Egypt.

**Table 2.1: GHG Emissions Fiscal Year 1990 /1991**

| Gas | Emissions Gg | GWPs | $CO_2$ Equ.Gg | % of total Emissions |
|---|---|---|---|---|
| $CO_2$ | 84.459 | 1 | 84.459 | 72 |
| $CH_4$ | 1.029 | 21 | 21.609 | 19 |
| $N_2O$ | 34 | 310 | 10.540 | 9 |
| Total | | | 116.608 | |

**Source:** IPCC Assessment Report of Working Group1,1995.

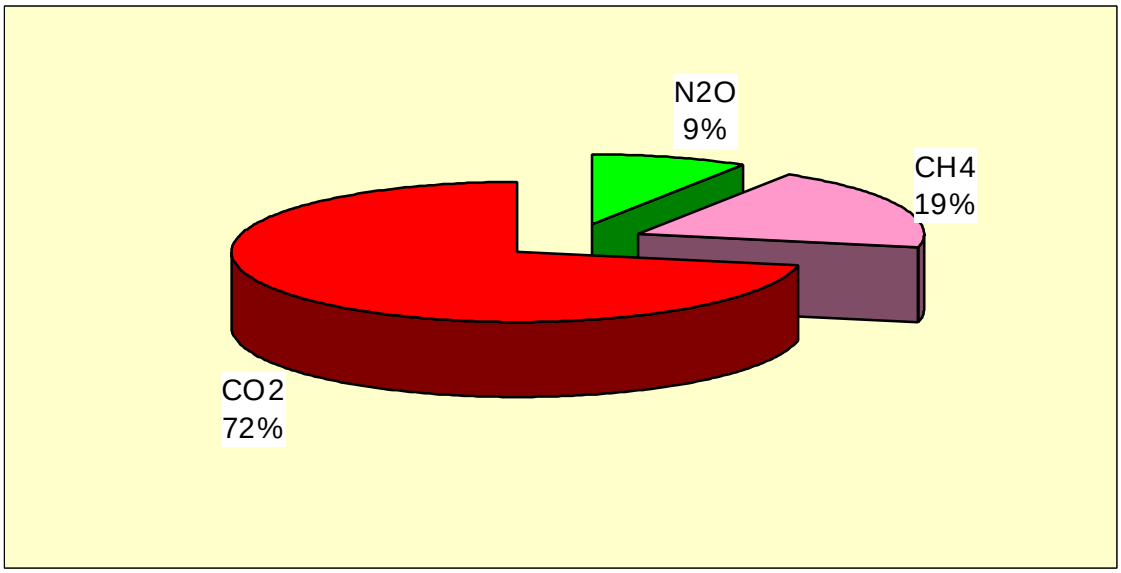


Figure (2.1): Percentage Share of Major GHG

The relative contributions of greenhouse gases, in the total emissions, by sector, are presented in table (2.2) and figure (2.2), showing that the energy sector is the main

sources of GHG emissions. This is due to the fact that Egypt is 92% dependent on fossil fuels (oil and natural gas). The agriculture sector is the second largest GHG source, mainly from enteric fermentation and rice cultivation, followed by the industrial emissions of $CO_2$ , mainly from the steel and cement industries. Table (2.2) summarizes emissions of the main three GHG from different sources\ sectors.

**Table 2.2 : Contribution of GHG from Different Sectors 1990 /1991**

| Sector | Emissions in $CO_2$,Equ.Gg | % of total emissions |
|---|---|---|
| **All Energy** | 82.726 | 71 |
| **Industry** | 10.276 | 9 |
| **Agriculture** | 17.913 | 15 |
| **Wastes** | 5.691 | 5 |
| **Total** | 116.608 | 100 |

Source: Egypt National Green House Gases Inventory 1990/91.

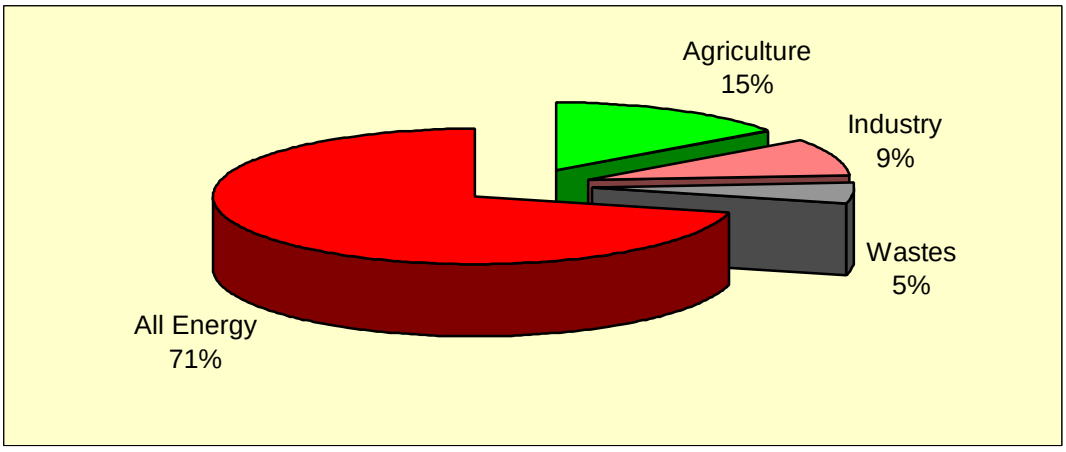


Figure: (2.2): Sectorial Emissions as % of Total Emissions 1990 /1991

## 2. 2. Methodology:

This inventory of greenhouse gases emissions and sinks for Egypt has been compiled for the fiscal year 1990/1991 (July 1st 1990 to 30th June1991). The fiscal year is used because the principal activity data are reported nationally on the basis of fiscal years, statistical data and industrial outputs. This is the second attempt to develop the inventory, the first was a part of the UNEP Greenhouse Gas Abatement Costing Studies, Case Study on Egypt in 1995. The methodology used to develop the inventory presented here is the default one developed by the Intergovernmental Panel on Climate Change (1995 IPCC

guidelines) which takes into account the Egyptian conditions with respect to agriculture, land use, industry and waste sectors. Given the current availability of data, it should be noted that the inventory has included only the three main GHG, namely $CO_2$, $CH_4$, and $N_2O$.

This inventory has been developed with some support from the United States Country Study Program. The inventory is consistent with the international requirements regarding transparency consistency and compatibility. Table 2.6 presents the Emissions of $CO_2$ equivalent for each sector and the total GHG for year 90/91 using GWP. GHG emissions and removal for each sector sub activities are presented in table 2.7.

## 2. 3. GHG Inventory By Sector:

### 2. 3.1. Emissions from the Energy Sector:

The energy sector is the largest contributor to greenhouse gas emissions in Egypt. This is mainly because Egypt is highly dependent on fossil fuels, namely oil and natural gas; thus carbon dioxide is the main GHG emitted. The emissions from the energy sector are estimated excluding $CO_2$ emissions from biomass burned for energy. Emissions from international bunkers and fugitive emissions are reported separately according to the IPCC guidelines. All coal is used in the industrial processes, so its emissions are not included in the energy sector.

Activity data used for the calculation of greenhouse gas emissions from the energy sector are those reported by the Egyptian General Petroleum Corporation (EGPC), the Egyptian Electricity Authority (EEA), the Organization For Energy Conservation and Planning (OECP), and other main energy players. The emission factors used for calculating $CO_2$ emissions are those from the 1995 IPCC Guidelines.

In the bottom-up technology based calculations the classification of data and the $CO_2$ emission factors are based on the IPCC guidelines, while emission factors for $CH_4$ and $N_2O$ gases are obtained from the Greenhouse Gases Abatement Costing Studies - Case Study of Egypt. For estimating emissions from natural gas, the quantities of the gas vented and flared are excluded from the production data of the natural gas. Also the natural gas used for ammonia preparation is also subtracted from apparent consumption.
When using the reference approach, the carbon stored values are estimated depending on the use of half quantity of the lubricants and zero quantity of bitumen production. The

natural gas used in industrial processes is all used for ammonia production, so it is oxidized easily giving zero value for carbon stored.

Activity data for the estimation of emissions of non- $CO_2$ gases from biomass burned for energy are estimated using the potential of biomass resulting from agriculture residues and livestock. Emissions of $CO_2$ from the energy sector are 74,682 Gg. Methane emissions are 206 Gg, and $N_2O$ emissions are 12 Gg.

### 2.3.2. Emissions from the Industry Sector:

Emissions from the industrial sector are those generated during the industrial process itself and do not include emissions resulting from energy use in industry. Emission factors are estimated for some Egyptian industries namely, iron and steel, aluminum and ammonia production. Activity data are obtained from the Ministry of Industry and some holding industrial companies.

The figures for lime production exclude the lime used to produce iron and steel, and cement. The type of cement produced in Egypt is mainly Portland cement; the IPCC default emission factors for $CO_2$ are appropriate for estimating the $CO_2$ emissions for cement production. Carbon dioxide emissions from the Egyptian industrial processes are 9,777Gg, methane emissions are 9 Gg , while $N_2O$ emissions are 1.0Gg.

### 2.3.3. Emissions from the Agriculture Sector:

The agriculture sector is the second largest source of GHG emissions in Egypt. It is the main source of methane emissions, mainly from rice cultivation and animal wastes. Rice is one of the main crops in Egypt. Livestock populations are relatively small.

Methane emission from livestock is produced as a by-product of microbial fermentation associated with the digestion of feed. The IPCC methodology indicates that animal type and number are the main determinants of methane generation. Emission factors used for estimating emissions from livestock are those of the IPCC Guidelines. For enteric fermentation for cattle the emission factors used are those of Africa and the middle east, while for other animals the emission factors used are those of developing countries.

For manure management, emission factors for warm regions of developing countries are used for all animals except for cattle, swine and buffalo for which emission factors for the middle east warm regions are used.

Methane is also generated in rice cultivation when fields are flooded. In Egypt all rice fields are irrigated by continuous flooding for a period of around 120 days, at a temperature of 19$^{o}$C. This results in an emission factor of 3.68 Kg/ha-day, as per the IPCC guidelines. The agriculture sector is also considered as the main source of $N_2O$ emissions from soils due to the use of nitrogen fertilizers (mainly inorganic fertilizers), and the cultivation of nitrogen fixing plants which cause increase of $N_2$ level in soils. $N_2O$ emissions are calculated for fertilizers, manure and biological fixation.

Biological fixation of nitrogen occurs during the cultivation of leguminous crops. Table 2.3 shows the area of cultivated legumes in Egypt for 1989 to 1991.

**Table 2.3 The Area of Cultivated Legumes 89-91**

| **Year** | **1989** | **1990** | **1991** |
|---|---|---|---|
| Area (1000ha) | 1323.6 | 1355 | 1308.3 |

**Source**: Egypt National Green House Gases Inventory 1990/91.

According to the Egyptian Agriculture Research Center, the $N_2$ fixation rate has an average value of 12 Kg/ha/year6.Table 2.5 shows the $N_2$ fixation values.

**Table 2.4 the N2 Fixation Values 89-91**

| **Year** | **1989** | **1990** | **1991** |
|---|---|---|---|
| N2 Fixation (KtN2/Year) | 158.5 | 162.6 | 157 |

With an average value 159 KT N2/Year

Nitrogen Fertilizers Used in Egypt7 in 1000 metric

Total nitrogen applied in fertilizer = 719,000 metric ton

$N_2$ Applied in Manure

Total manure fertilizer7 used in Egypt = 27.56 X 106 Ton (N2 content = 0.008), i. E. total **N2** 220480 Ton

**Source:** Egypt National Green House Gases Inventory 1990/91.

Field burning of agriculture residues is considered as a source of methane and nitrous oxide emissions. The calculation of these emissions was based on the IPCC guidelines, actual activity data, default emission factors, and fractions of burned residues in the field.

Total methane emissions from the agriculture sector are 543 Gg, of which 323.37 Gg

result from enteric fermentation, 23.23 Gg from manure management, 189.9 Gg from rice cultivation, and 6.8 Gg from field burning of agriculture residues as presented in table 2.5.
This sector also emits 21.3 Gg nitrous oxide out of which 21.1Gg results from agricultural soils and 0.2 Gg from field burning of agriculture residues. (See table 2.5)

### 2.3.4. Emissions from Land Use Change & Forestry:

In Egypt, the Land Use Change sector was found to be a net sink of $CO_2$. It should be noted here that a high degree of uncertainty is associated with this conclusion, mainly due to lack of reliable data. This sector is normally considered as an unimportant source of GHG emissions in Egypt.

The wood used in the biomass harvest is imported wood so there are no emissions from the biomass harvest. In Egypt there is no record of traditional fuel wood or other wood consumed, thus the solid biomass consumed and appearing in the energy sector consists solely of agricultural residues and dung.

Based on the available data, land use change results in a carbon dioxide sink of 9,900 Gg, from the annual growth of the non forests trees.

### 2.3.5. Emissions from waste management:

Methane is the main GHG produced from this sector. In Egypt methane is produced from solid wastes, as a result of anaerobic bacterial decomposition of organic matter in landfills and open dumps. It is also produced in the treatment of industrial and domestic wastewater.

#### *2.3.5.1. Solid Wastes:*

- It is generally assumed that landfill disposal emits double the quantity of methane that is emitted from open dumps. Two Egyptian governorates out of 26 are using landfill disposal systems, while the rest are using open dumps.
- The average solid waste generation rate was taken as 0.7Kg/cap/day according to National Research Center (NRC) studies of solid waste management for eleven cities (Cairo, Giza, Port Said, Zagazig, Shebin El-Kom, Dametta, Tanta, Kafr El-Shaeikh,

Kalubbia, Ismaillia).

- The amount of solid waste generated is estimated based on the total urban population. The national average per-capita waste generation rate is equal to 6120Gg.
- The landfill fraction for solid waste is 0.15 for all cities except Cairo and Giza, which have special landfills.The estimated fraction of solid waste dumped in the open is 0.82 for all cities assuming that the efficiency of solid waste collection is 97%.
- Net methane emissions were 193.59 Gg.

### *2.3.5.2. Waste Water Treatment:*

**a. Domestic & Commercial**

- BOD values are taken as 0.025 Gg/year/1000capita for the capital (Cairo), 0.037Gg/year/1000capita for the coastal zones, and 0.039 Gg/year/1000capita for other governorates. National average BOD is assumed to be equal to 0.035 Gg/year/1000capita according to the urban population ratio.
- The water consumption/cap/day was estimated as 270 lit, and the domestic wastewater was assumed as the rate of water consumption.
- The BOD5 for Cairo is 260 mg/lit taken from drainage station. BOD is equal to 0.0256 Gg/ 1000Cap/Yr. For other cities the value of BOD was estimated and the average was taken according to population distribution.
- The methane emission factor for domestic & commercial wastewater is 0.22.

**b. Industrial Wastewater**

Due to lack of data, emissions from some food and beverage industries are not included in this inventory.

Methane emissions from the waste management sector amounted to 271Gg of which nearly 98% was produced from solid wastes, mainly from open dumps.

**Table 2.5 Emissions of $CO_2$ Equivalent For Each Sector (1990 /1991 GWPs)**

| Sector | Gas | Emissions(Gg) | GWPs | $CO_2$ Equ.(Gg) |
|---|---|---|---|---|
| All Energy | $CO_2$ | 24682 | 1 | 74682 |
| | $CH_4$ | 206 | 21 | 4326 |
| | $N_2O$ | 12 | 310 | 3720 |
| | Total | | | 82728 |
| Industrial Processes | $CO_2$ | 9777 | 1 | 9777 |
| | $CH_4$ | 9 | 21 | 189 |
| | $N_2O$ | 1 | 310 | 310 |
| | Total | | | 10276 |
| Agriculture | $CO_2$ | | 1 | |
| | $CH_4$ | 543 | 21 | 11403 |
| | $N_2O$ | 21 | 310 | 6510 |
| | Total | | | 17913 |
| Wastes | $CO_2$ | | 1 | |
| | $CH_4$ | 271 | 21 | 5691 |
| | $N_2O$ | | 310 | |
| | Total | | | 5691 |
| Grand Total | | | | 116608 |

**Source:** Egypt National Greenhouse Gases Inventory 1990/91.

## 2.4. GHG Emissions By Gas:

### 2.4.1. Emissions of Carbon Dioxide:

As in most countries, carbon dioxide is the main GHG emitted in Egypt. Total emissions were 84,459 Gg. Figure (2.4) illustrates the contribution of the various sectors to carbon dioxide emissions. The energy sector is the main sources of $CO_2$ emissions, totaling 74,682 Gg representing nearly 88% of the total. The remaining 12%, 9,777 Gg, was contributed by industrial processes, as shown in figure (2.4). Within the energy sector, energy production and transformations produced 30% of total $CO_2$.

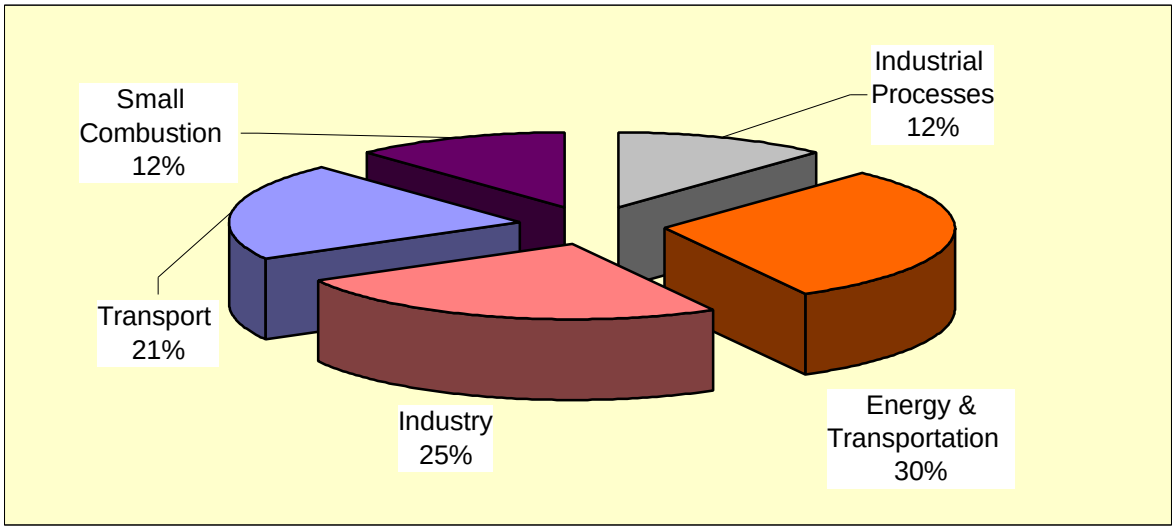


Figure: (2.3) $CO_2$ Emissions from Main Sectors:

### 2.4.2. Emissions of methane:

Methane is the second major GHG in Egypt. The agriculture sector is the major methane source of emissions, followed by waste management activities. Figure (2.4) illustrates the relative sector contributions to methane emissions. Total methane emissions in Egypt for the year 1990/1991 amounted to 1,029 Gg. Livestock and rice cultivation were the largest contributors to methane emissions representing 53% of the total methane emissions in Egypt.

Methane emissions from waste management activities represent 26% of the total, followed by the energy sector which contributes 20 % of the total. Details of the methane emissions, by sector, are shown in table (2.7).

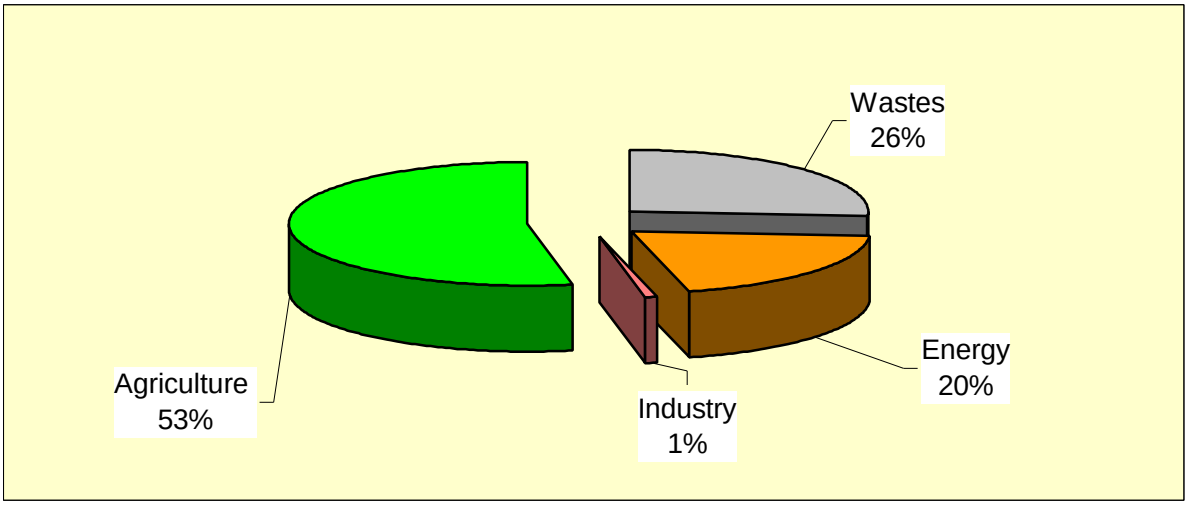


Figure (2.4): $CH_4$ Emissions By Sectors

### 2.4.3. Emissions of Nitrous Oxide:

Nitrous Oxide emissions in Egypt total 34 Gg.. Figure (2.5) illustrates the relative sector contributions of $N_2O$ total emissions. Main sources are agriculture, energy and industrial processes.

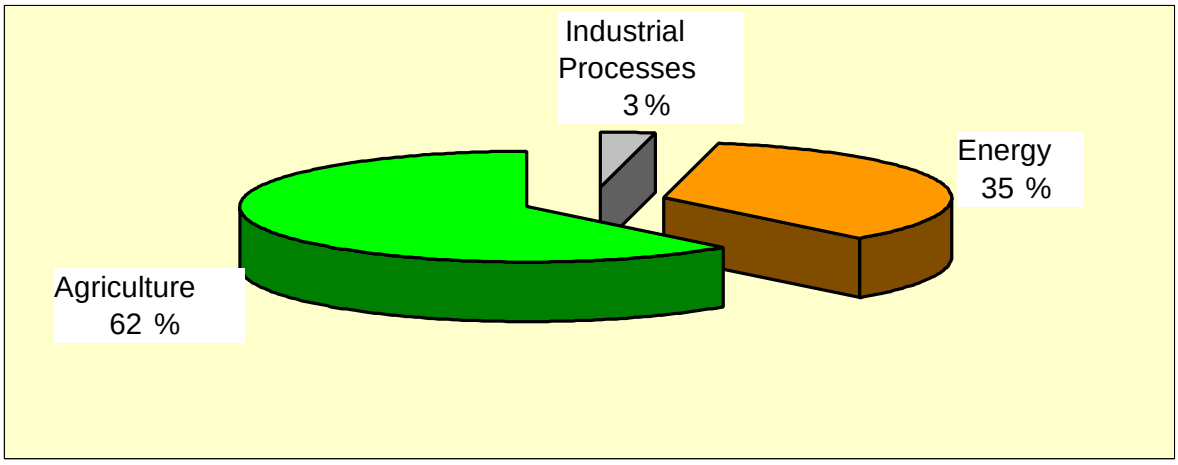


Figure (2.5): $N_2O$ Emissions From Main Sectors

**Table 2.6 Greenhouse Gas Emissions 1990/91**

| GHG Source & Sink Categories | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ |
|---|---|---|---|---|
| **Total National Emissions &Removals** | 84.459 | 9.900 | 1.029 | 34 |
| **1.All Energy (Fuel Combustion + Fugitive)** | 74.682 | | 206 | 12 |
| a. Fuel Combustion | 74.682 | | 58 | 11.66 |
| 1. Energy &Transformation industries | 25.120 | | 0.08 | 0.97 |
| 2.Industry(ISIC) | 21.120 | | 0.05 | 0.86 |
| 3.Transport | 18.189 | | 10.63 | 8.87 |
| 4.Small Combustion | 10.029 | | 0.43 | 071 |
| 5.Other | | | | |
| 6.Traditional Biomass Burned for Energy | 9.543 | | 74 | .251. |
| b. Fugitive Emissions from Fuels | | | 147.56 | |
| 1.Solid Fuels | | | | |
| 2.Oil &Natural Gas | | | 147.59 | |
| **2.Industrial Processes** | 9.777 | | 9 | 1 |
| **3.Solvent & Other Product Use** | | | | |
| **4.Agriculture** | | | 543 | 21 |
| a. Enteric Fermentation | | | 323.37 | |
| b. Manure Management | | | 23.23 | |
| c. Rice Cultivation | | | 189.9 | |
| d. Agriculture Soils | | | | 21.1 |
| e. Prescribed Burning of Savanas | | | | |
| F. Field Burning of Agric. Residues | | | 6.8 | 0.2 |
| g. Other | | | | |
| **5.Land use change & forestry** | | 9.900 | | |
| a. Change in forest &other woody Biomass stocks | | 9.900 | | |
| b. forest & grassland conversion | | | | |
| c. Abandonment | | | | |
| d. Other | | | | |
| **6.Waste** | | | 271 | |
| a. Solid waste disposal on land | | | 264.27 | |
| b. Wastewater treatment | | | 6.59 | |
| c. Waste incineration | | | | |
| d. Other waste | | | | |
| **7.Other** | | | | |

**Source:** Egypt National Green House Gases Inventory 1990/91.

## 2.5. International Bunkers and Biomass Emissions:

Emissions from international bunkers are excluded from the total emissions according to

the IPCC guidelines. The total $CO_2$ emissions from bunkers amounted to 7253 Gg. These are mainly from fuel oil and aviation gasoline.

$CO_2$ emissions from biomass are estimated as 9,543 Gg. This total is excluded from the total emissions of the energy sector according to the IPCC guidelines.

# 3. Impacts Of Climate Change: Vulnerability Assessment And Adaptation Measures:

## 3.1. Introduction:

According to the IPCC report, the Earth's average temperature has risen about 0.5? C during the past century and is expected to increase another 1.0 –3.5? C over the next century if no actions are taken to reduce GHG. The negative impact of climate change, the doubling of $CO_2$ concentration, will, most likely, result in a rise in sea level by about 50 centimeters. In addition, global climate change is likely to result in changes in the hydrological cycle including increases in storms and droughts, changes in both the amount of and geographical distribution of precipitation and rainfall. This in turn shall affect agricultural cropping patterns and production, having a severe effect on food intake per capita, particularly in the developing countries of the world.

Egypt's large and dense packed population makes the country extremely vulnerable to climate change. Egypt does not produce enough food to feed its current population. Its water resources also are rather limited. Moreover, its densely populated Nile delta is seriously threatened by sea level rise. Climate change will also have its impact on citizens' health, and studies have been undertaken in an attempt to analyze possible adaptation measures. Vulnerability assessment studies in priority sectors have been undertaken as part of the process of developing the national action plan. The studies have indicated that the following areas are the most vulnerable in order of severity and certainty of results: agriculture, coastal zones, aqua-culture and fisheries, water resources, human habitat and settlements, and human health.

## 3.2. Agriculture:

Major crops in Egypt include wheat, maize, clover, cotton, rice, sugar-cane, fava bean, sorghum and soybean. National wheat and maize production do not meet the current demand for these crops, and each year additional amounts have to be imported. The rapid growth of the country's population, the economic stress of reliance on food imports, and the limited area for agriculture require Egyptians to find new ways to increase agriculture productivity.

In Egypt, several studies have been undertaken to attempt to evaluate the potential impact of climate change on the agriculture sector. For wheat and maize production this was evaluated by simulating crop production under different climatic scenarios. The potential impact on cotton was evaluated by analyzing sensitivity to temperature in three main agroclimatological regions: the Central Delta region, represented by

Sakha, the Middle Egypt region represented by Giza, and Upper Egypt represented by Shandaweel.

### 3.2.1. Vulnerability of Agriculture Sector:

Because of the uncertainties associated with predicting climate change, researchers commonly use climate change scenarios to estimate how climate affects a system. Scenarios derived from the General Circulation Models (GCMs) and arbitrary sensitive tests (e.g. +2 and +4 C temperature changes, +/- 10 –20% precipitation changes) are recommended to estimate potential future change in yield and other agronomically important variables.

All climate change scenarios considered resulted in simulated decreases in wheat and maize yields in the three sites. Thus, it is possible to conclude that climate change may bring about substantial reductions in the national grain production. As for cotton, it is clear that seed cotton yield will be increased gradually to arrive at its maximum by the year 2050 due to the expected impact of climate change (i.e. when temperatures increase +2C and +4C) under the normal $CO_2$ concentration.

If climate change as projected by atmospheric scientists (IPCC 1990, 1992a,b and 1994) adversely affected crop production, Egypt would have to increase its reliance on costly food imports.

**Table ( 3.1 ); Simulated maize grain yield for different cultivars and nitrogen amounts at Sakha, Giza and Shandaweel regions.**

| Region | Cultivar | Nitrogen Kg/ha | Base Yield (330 ppm) (t/ha) | Av.3GCMs (555 PPm) (t/ha) | Change % | Change Rate% |
|---|---|---|---|---|---|---|
| Sakha | Giza2 | 252 | 7.90 | 6.85 | -13 | +3 |
| | | 288 | 7.90 | 6.81 | -14 | |
| | | 336 | 8.20 | 6.81 | -17 | |
| | TWC 310 | 252 | 8.82 | 7.65 | -13 | 0 |
| | | 288 | 8.82 | 7.64 | -13 | |
| | | 336 | 8.82 | 7.65 | -113 | |
| | Pioneer | 252 | 8.15 | 7.01 | -14 | +2 |
| | | 288 | 8.16 | 7.01 | -14 | |
| | | 336 | 8.16 | 7.16 | -12 | |
| Giza | SC10 | 252 | 11.69 | 9.48 | -19 | 0 |
| | | 288 | 11.64 | 9.43 | -19 | |
| | | 336 | 11.64 | 9.46 | -19 | |
| Shandaweel | Giza2 | 252 | 6.07 | 5.06 | -17 | +2 |
| | | 288 | 6.20 | 4.95 | -20 | |
| | | 336 | 6.09 | 4.96 | -18 | |
| | TWC 310 | 252 | 6.77 | 5.21 | -23 | -1 |
| | | 288 | 6.47 | 5.27 | -19 | |
| | | 336 | 6.49 | 5.22 | -20 | |
| | Pioneer | 252 | 6.77 | 5.21 | -23 | -1 |
| | | 288 | 6.47 | 5.27 | -19 | |
| | | 336 | 6.49 | 5.22 | -20 | |
| Average | | | | | | +1 |

**Source:** Soils and Water Research Institute (SWRI) ARC, Ministry of Agriculture,1996.

As seen in the previous table, the values for the maize grain yield for different cultivars and nitrogen amounts are estimated at Sakha, Giza and Shandaweel regions.

### 3.2.2. Proposed Adaptation Measures:

Adaptation strategies to mitigate the negative impacts of increasing Greenhouse Gases (GHGs) need to be evaluated, especially for the three major crops: wheat, maize and cotton. Adaptation in the agricultural sector was evaluated through two models: through DSSAT3 and COTTAM models, and through the adaptation strategy evaluation (ASE) TEAM decision model.

According to the DSSAT3 and COTTAM models, changes in wheat and maize cultivars were considered as possible adaptation strategies to climate change. Egypt must develop new cultivars that are more adapted to higher temperatures. Growing the high yielding cultivars in the most suitable agroclimatological region and at optimum sowing date will increase crop production and this will reduce the adverse impact of the expected climate change on crop production.

**Table(3.2): Change in major production (surplus or deficit) in Egypt by the year 2050 due to climate change**

| Crop | Base Yield (t/fed) | Area(Mfed) | Yield (Mt) | Change % | Deficit or Excess(Mt) |
|---|---|---|---|---|---|
| Wheat | 2.175 | 2.123642 | 4.629216 | -18 | -0.833259 |
| Maize | 2.718 | 1.683108 | 4.576779 | -19 | -0.869588 |
| Cotton | 1.099 | 0.815350 | 0.903090 | +17 | +0.153525 |
| Sorghum | 2.086 | 0.33868 | 0.705404 | -19 | -0.134027 |
| Barley | 0.888 | 0.179792 | 0.124212 | -18 | -0.022358 |
| Rice | 3.263 | 1.291342 | 4.241457 | -11 | -0.466560 |
| Soybean | 1.167 | 0.050381 | 0.058888 | -28 | -0.016488 |
| Dry bean | 0.837 | 0.332692 | 0.268181 | … | … |
| Lentil | 0.656 | 0.016729 | 0.011101 | … | … |
| Berseem | 0.920 | 0.050079 | 0.051729 | … | … |
| Sunflower | 0.679 | 0.079557 | 0.117870 | … | … |
| Peanut | 25.300 | 1.723456 | 43.493176 | … | … |
| Sugar beet | 19.600 | 0.040208 | 0.787664 | … | … |
| Sugar cane | 44.600 | 0.283286 | 12.647140 | … | … |
| Onion | 0.416 | 0.27865 | 0.011603 | … | … |

**Source:** Soils and Water Research Institute (SWRI) ARC, Ministry of Agriculture, 1996.

According to the TEAM model, changes in the crop choices in the Egyptian agricultural economy were also considered as another adaptation measure to climate change. Under climate change growing incrementally more cotton could have strong economic benefits. The economic justification is based on the following expectations:
Cotton productivity may increase relative to other crops, and also in absolute terms
Cotton prices are currently strong and are projected to remain so. Moreover, if wheat prices are projected to decline on a global basis, income from cotton may be enhanced. Cotton production involves more jobs, both in the agricultural sector, and in the textiles industry.

Other recommended strategies based on the results obtained both from the DSSAT3, COTTAM, and TEAM models and the overall comparison of results include the following:

- improving wheat and maize cultivars and continuing as normal,
- shifting from maize to cotton, and using more winter crops to replace some wheat,
- shifting to a mix of cotton/sunflowers in the summer, and continuing to grow an improved wheat cultivar in the winter to the extent that is feasible,
- changing certain agricultural practices (optimum sowing date, cutlivar, water and nitrogen amounts and plant population density);
- modification of cropping patterns through the cultivation of cotton after wheat in the same year and on the same land and modifying the cropping pattern accordingly;
- reducing the area under cultivation with crops (i.e. rice and sugar cane) which consume large amounts of water.

Ultimately, whatever crop plan is decided upon, a unified annual cycle should be used that carefully takes into consideration the effects of water shortages, evaluates weighting options, and integrates the recommendations of other adaptation and mitigation measures.

Much can be done to mitigate the dire consequences of climate change and the earlier the task is recognized and undertaken, the more likely it is to succeed. Some overall recommended changes in resource management that would lead not only to adaptation to climate change, but also to the overall improvement of the Egyptian agriculture system include the following:

- **Adapted Crops:** These include measures for the careful selection and/or breeding of heat tolerant, salinity tolerant water conserving crops, as well as controlled environmental production methods that minimize water use.

- **Water Management:** Here the first imperative is to improve both the technical water application efficiency and the agronomic water use efficiency. This involves revamping the entire system of water delivery and control, and in this respect the authorities should provide farmers with explicit guidance regarding optimal crop selection, irrigation, and fertilization, and should institute strong incentives to avoid excessive water use. Moreover, a strong system of rewards and

penalties should be established to create incentives for water conservation and the installation of modern irrigation technology.

- **Land Management:** A further set of adaptation measures involves the management of low lying lands on the northern fringe of the Delta, where the consequences of sea-level rise (submergence and salinization) are expected to have the most damaging effects. Some of those lands must be retired from agriculture and the amount of water made available could then be used to irrigate New Lands outside the New Valley and the Delta.

## 3.3. Coastal Zones Management:

The coastal zone of the Nile Delta in Egypt is perceived as vulnerable to the impacts of climate change, not only because of the impact of sea level rise, but also because of the impacts on water resources, agricultural resources, tourism and human settlements. Several studies were undertaken, data and maps were collected, and field visits and surveys were made to low land areas in Alexandria, Behaira, Port-Said and Damietta governorates. Satellite images and Geographical Information Systems (GIS) provide the best tools for identifying land use patterns and future changes in low lying areas of the coastal zone. (See figures 3.1, 3.2, and 3.3)

### 3.3.1. Vulnerability:

**Alexandria City:**

A scenario involving a Sea Level Rise (SLR) of between 0.5m and 1.0 m over the next century is assumed. If no action is taken, an area of about 30% of the city will be lost due to inundation, almost 2 million people will have to abandon their homes, 195,000 jobs will be lost and an economic loss of over $ 35.0 billions can be expected over the next century. The most severely impacted sectors are agriculture, industry and tourism, respectively.

**Rosetta City:**

The expected economic losses in land cover of Rosetta for a sea level rise of 0.5 m were estimated (using 1995 –1996 prices). Studies showed that about 1/3 of the employment in the city will be affected and a loss of about $ 2.9 billion is expected over the next century.

**Port-Said City:**

Several studies point out the high vulnerability of the city to sea level rise. The most affected sectors are expected to be the industrial, transportation and urban sectors. Agriculture is not affected, because it is mainly found in El Dawahy district which is not affected by the rise in sea level. A loss of employment of 6,759 jobs is expected due to a SLR of 50cm.

**Coral Reefs:**

Moreover, coral reefs projected to be among the most sensitive ecosystems to long term climate change. Corals are specially sensitive to elevated sea surface temperatures. When physiologically stressed, corals may lose much symbiotic algae, which supply nutrients and colours. In this stage corals appear white and are referred to as bleached. Corals can recover from short term bleaching. However, prolonged bleaching can cause irreversible damage and subsequent mortality.

### 3.3.2. Adaptation Measures:

Studies have identified a number of policy options that can be undertaken as adaptation measures:

- **Beach nourishment and groins:** Beach nourishment strategies include depositing sand onto the open beach and beach scraping, building artificial dunes as storm buffers and beach sand reservoirs, and laying pipes underneath the beach to suck in the water and trap

sand. Groins trap sand, which covers the beach. This strategy is very cheap compared to other strategies.

- **Breakwaters:** Break-waters are hard structures used to reduce the wave energy reaching the shoreline. This strategy is relatively very expensive. The net benefit of this strategy is only along the coastline, not on the social community or ecosystem. The environmental impact of this strategy is fair, but it is considered to be the best available tool for protection of lowland areas.

- **Legal Development Regulation**: Legal development regulation means taking legal or regulatory actions to restrict development or prohibit development in a hazard-prone area. In Egypt, this strategy is not perceived as effective. The chance for success is poor, considering difficult socio economic conditions and problems of implementation. Regulations have no active enforcement particularly in prone areas. This strategy has no effect on fishermen, farmers and industrial workers, but may affect businessmen. An institutional capability for monitoring and assessment, such as a remote sensing system is necessary for implementation of this option.

- **Integrated Coastal Zone Management (ICZM):** Redirecting growth away from sensitive lands and towards less vulnerable areas is one option to reduce the risks associated with a sea level rise, and also to reduce vulnerability to other problems of the coastal zones. ICZM involves the best possible use of resources under multi-criteria analysis. For example, the ICZM Action Plan for the Egyptian Red Sea sets out a process for determining options and priorities for the use and management of coastal and marine resources along the Egyptian Red Sea coast over the next 5-10 years. The plan provides guidelines and proposes what actions are needed to put tourism and other human uses of the Egyptian Red Sea coast onto a more ecologically and economically sustainable basis. The plan is structured around distinct components, including: integrated coastal marine planning requirements and approaches, environmentally sustainable tourism, risk assessment and management, information management, environmental awareness and preliminary zoning proposals.

- **Land Use Change**: The option of change of land use in vulnerable lands is still an open one. The objective is to change to a less

vulnerable land use, or to another land use which makes better use of the lowland, such as aquaculture. A slight or moderate SLR may be quite beneficial for development of aquaculture on the coastal areas.

## 3.4. Aquaculture and Fisheries:

The Egyptian coastal lakes are among the most productive natural systems in Egypt, and they are internationally renowned for their abundant bird life. Moreover, over 25% of all Mediterranean wetlands are situated along the Mediterranean coast of Egypt. The most important coastal lakes are: Lake Mariout, Lake Manzala, Lake Edku, Lake Bourollos, and Lake Bardaweel. Thus, the Egyptian lakes and wetlands serve both as an economic resource for the country, providing it with nearly 65% of its total fish production, and also on an international level, they are valued as being bountiful wetlands attractive to migrating birds.


Figure (3.1): Map of the Egyptian Lakes

### 3.4.1. Vulnerability:

The Northern part of the Nile delta is subject to severe coastal erosion. In addition, and due to the greenhouse effect and the associated warming of the earth, sea level is expected to increase . That, combined with the expected subsidence of the Nile delta, may result in a higher relative sea level rise by the end of the next century.

Furthermore, the delta lakes are suffering from several other severe problems. Foremost among these, are the following:

- A continuing decrease in the open water area, due not only to land reclamation, but also to the increase in aquatic vegetation. The latter problem is a result of the common practice of building Hoshas, basins to isolate water bodies to catch fish, a local custom of isolating water bodies to catch fish.
- A high level of lake water pollution, due to the industrial, agricultural and sewage wastes poured into the lakes through the drains.
- A deterioration of the fisheries in the lakes, due to over fishing and the use of illegal fishing methods. It is estimated that the lost catch from the lake Manzala open fisheries under the existing fishing methods is about 67,000 ton/year (estimated as worth 255.8 million L.E. at market prices).

A study concerning the effects of sea level rise on the delta lakes, focused on only lake Manzala and Edku, which represent two extreme examples in lake management in Egypt. Similar results are expected from SLR on the other delta lakes. However, it should be noted that the impact of SLR on different parts of the lakes may be influenced by various inter-related factors. Among these factors are: land reclamation, reduction of drainage water inflows, change in fishing practices, infrastructure works and the erosion of the coasts, and various other human activities.

Among the major expected impacts of SLR are the following:

- Saline sea water will penetrate far into the northern delta, turning the current lakes into shallow saline lagoons and bays.
- Weed swamps will disappear, but instead large areas of salt marshes might be created.
- The proper functioning of infrastructure facilities directly exposed to the sea will be disrupted.
- The water balance in the lakes will be affected causing a possible extension of the lake boundaries southwards.
- A slight to moderate SLR may be quite beneficial. Fish production may go up due to an increase in lake area and in more valuable marine fish species. However, there is an expected serious negative effect on birds.

- The expected submerged wetland will form grounds for an increase in rooted aquatic plants, will increase the wintering grounds for migrating birds and can also be used for aquaculture activities.
- Increasing the salinity of the lake will also result in the dying off and decomposition of aquatic plants which play an important role in decreasing the heavy metal concentration of the water coming in from the drains.
- Deterioration of coastal water quality that attract marine fry to the direction of the lakes will affect natural fry supply for the aquaculture activity in Egypt.

### 3.4.2. Adaptation Measures:

The supply of natural marine fry for the aquaculture activity in the lakes will be adversely affected by the deterioration of coastal water quality. Should SLR take place in presence of some response strategies, the following are some proposed adaptation measures:

- Flooding protection is the expected response from the peasants to protect their property against slow flooding. The result should favor fisheries by increasing the lake depth by more than 55%.

- Another adaptation measure is lake closure, by building dikes to store water in the lakes. It was proposed to enclose lake Borollus by a dike of 20 meter wide and 4 meter height for Borollus, to store the water up to 2.5 meters in depth. For Lake Manzalla, a dike the height of 3 meters would store water up to 1.5 meters. The expected impacts of lake closure include effects on the water table with a possible change in the low lying lands into swamps; an increase in pollution levels, an increase in the submersion of lake islands, and a change in the available fisheries. The expected impact on fisheries may include failure to attracting fish fry at the fry collection sites, a change in fish species composition, a disruption in the life cycle of marine varieties in the lake, a disruption of fish culture activities around the lakes, an increase in weed density, and a negative effect on fishermen who will find it difficult to divert to another trade.

## 3.5. Water Resources:

Egypt is a unique country with respect to its water resources. More than 95% of the water budget of Egypt is generated outside its territory. This is represented by the flow of the River Nile which originates partially from the Equatorial Lakes and

partially from the Ethiopian Highlands. Thus, our priorities for water resources lie in the rainfall changes outside Egypt.

A recent study concerning fresh water resources in Egypt, including vulnerability assessment concluded that we couldn't yet predict the impact of climate change on the Nile Basin, but that there are indications that the impacts will be significant and severe. Any decrease in the total supply of water, coupled with an expected increase in consumption due to the high population growth rates and the rise in the standards of living, will have drastic impacts. Water management is thus one of the most important adaptation actions.

Studies dealing with climate change and water resources in Egypt describe measures that could be undertaken in order to adapt to unexpected climate changes. These measures are applied to supply, as well as demand, and to quality as well as quantity.

### 3.5.1 Adaptation of Supply:

Egyptian authorities have prepared a number of scenarios capable of supplementing the water budget by additional quantities in order to cope with different circumstances. These scenarios include, but are not limited to the following:

One. Improvement of Rain Harvesting Techniques: Rain harvesting techniques helps in the promotion of incremental use of rain through a number of methods which include: the compaction of high ridges in order to enhance runoff to lower lands, the construction of cesterns and storage reservoirs at low evaluations, dyking, terracing, and land leveling. The most important objective of rain harvesting techniques is to make efficient use of the water by using as much as possible of the surface water, allowing as much as possible of this water to infilterate through the soil and replenish the groundwater reservoir to be used during periods of demand.

Two. Increased Abstraction of Groundwater: Under shortage of supply conditions, abstraction from deep groundwater reservoirs could provide a suitable supplement to supply. However, the location of the reservoir in relation to the consumption point should be taken into consideration, so as not to result in increased costs. In addition, abstraction from shallow aquifers should be dealt with carefully, since over pumping could lead to serious consequences with respect to increased salinity and possible pollution from other sources.

Three. Recycling of Water: Recent recycling plans include the reuse of about 7.0 bcm/year of land drainage water which goes unused to the Mediterranean Sea and the coastal lakes. A major problem of the reuse of land drainage water is that its quantity can be reduced considerably if strong measures towards rationalization of water are implemented.

Four. Desalination of Water: It is one of the most expensive methods of substituting fresh water, however the progress in the use of renewable energy might reduce the cost of desalination in the future. It is suitable for use in the coastal areas of Egypt where the Nile water supply is limited and where its use may be restricted to potable water supply for small sized communities.

Five. Transportation of Water: The use of pipelines, huge tankers and / or the so called water bags are some of the methods mentioned in the literature. However, the feasibility of water transport is not yet tested.

Six. Rationalization of Water Use: If climate change resulted in water shortages, then one of the most important scenarios would be the heavy application of water saving measures. In agriculture, which is the major consumer of water in Egypt, possible rationalization methods may include: replacement of surface irrigation methods by sprinkler and drip systems, application of pricing or cost sharing policies, and the improvement of delivery and control structures to reduce leakage and distribution losses.

### 3.5.2 Adaptation of Demand:

Demand water management requires minimizing the need for water and optimizing the economic return of its unit volume. Demand management covers potable water consumption, industrial requirements, water used in navigation and in hydro-electric power generation. In the later two cases, it is recommended that water used for these purposes should also be used simultaneously for other purposes. As for water used in agriculture, several proposed means for reducing demand include:

- The increase of water use efficiency by utilizing modern systems
- Land leveling
- Enhancing the contribution of shallow underground water abstraction
- Introduction of drought and salt tolerant crops that consume less quantities of irrigation water of low quality
- Raising short age varieties of different crops like wheat, maize, rice and cotton.
- Under severe water shortage conditions the whole cropping pattern can be changed in order to cope with the prevailing circumstances with respect to water availability. Cultivation of high water consuming crops, such as rice, should be limited to the smallest possible area depending on the amount of water available.

### 3.5.3. Adaptation of Water Quality:

As a result of the expected SLR under several climate change scenarios, sea water may intrude through the adjacent shallow groundwater aquifers and threaten the agricultural land in their vicinity due to the upward flux of saline seepage. An

important precaution that is recommended in these situations is to cultivate the largest possible area in the coastal belt with rice. The standing water layer needed for rice cultivation not only prevents saline water from intruding into the cultivated lands, but also pushes saline water out towards the sea. In addition, water ways should be maintained clean and free from pollution by preventing the disposal of contaminants into them.

### 3.6. Human Habitat and Settlements:

As a result of the SLR, there is likely to be a migration of at least two million people from the Delta coastal areas due to the inundation and loss of fertile land. This migration will have its impact on the human habitats and settlements. However, no separate studies have been carried out to examine this area in detail, and the resulting socio-economic impact of this migration in other areas of Egypt. Careful assessment is needed to determine the costs of resettlement, finding new jobs, new habitats, etc.

### 3.7. Human Health:

Climate change is expected to have both direct and indirect adverse impacts on human health. Although this statement is now accepted by most scientists, yet still comprehensive studies with detailed estimations and strong correlation between climate change and human health in Egypt in specific, are still lacking. Moreover, most public health assessments of climate control policies have focused on long term impacts of global change. Short-term public health impacts have generally not been considered in assessments of global climate change.

Direct impacts of climate change on human health are perceived to include physiological disorders, skin cancer, eye cataracts, damage to public health infrastructure, deaths and injuries, heat strokes and heat related phenomena, etc. Meanwhile, the indirect impacts are perceived to include factors like demographic dislocations, socio-economic disruptions, ecological system impacts, and air pollution impacts. To illustrate, many of the fossil fuel combustion processes that produce CO2 and other greenhouse gases also produce a host of air pollutants such as particulate matter (PM), sulphate, ozone, and other pollutants, all of which have short term adverse effects on public health. Extensive public health literature in several countries has shown that both mortality and morbidity are significantly associated with exposure to PM. For example, a study performed in the US predicts that by 2020, the avoidable number of annual deaths from PM exposure (without climate change control policy) would equal in magnitude deaths associated with immuno-deficiency diseases of all liver diseases in 1995.

# 4. POLICIES, PROGRAMMES AND MEASURES: STEPS TAKEN:

## 4.1. International Cooperation And Climate Change Activities:

The issue of climate change is quite new in the Arab Republic of Egypt. Despite the fact that Egypt's overall contribution to GHGs is relatively limited, the possible adverse impacts of climate change on the future SLR, Nile Delta inundation, and consequent social and economic effects, aggravates the problem.

Ever since the Rio Conference in 1992, and the recent signature of the Kyoto Protocol in March 1999, Egypt has realized the importance of international cooperation in dealing with the issue of climate change. It is no longer an option, but a necessity. Egypt realized that early on, and was one of the first Arab countries to take heed of the phenomenon. Over the past decade many steps have been taken to capitalize on international cooperation in the field.

### 4.1.1. Participation In International Conventions And Agreements:

The **United Nations Framework Convention on Climate Change (UNFCCC)** was signed by Egypt at the United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro in 1992. The Convention represented a global effort to mitigate the possible impacts of climate change. The primary objective of the Convention was to stabilize the concentration of Greenhouse Gases (GHG) believed to cause climate change, at a level that would prevent hazardous anthropogenic interference with the climate system. On December 5$^{th}$ 1994, Egypt ratified the United Nations Framework Convention on Climate Change (UNFCCC).

During the period 1995 – 1998, Egypt participated in the International Conference of Parties with its four sessions. Egypt participated in the first Conference of Parties **COP1** in Berlin, where the first review of the adequacy of commitments made by developed countries was conducted. In COP1, the parties decided that the commitments by developed countries, aiming at returning their emissions to 1990 levels by the year 2000, were inadequate to achieve the long term objective of the convention. In 1996, Egypt participated in the second Conference of Parties **COP2.** In December 1997, Egypt participated in the Third Conference of **Parties, (COP3)** held in Japan, when the Parties adopted the Kyoto Protocol.
In 1998**,** Egypt participated in the Fourth Conference of Parties, **COP4** held in Buenos Aires.

Egypt is also an active participant in both African and regional conferences and workshops related to climate change. For example, in August 1997, Egypt participated in the African Regional Workshop on National Communications to the UNFCCC in Dakar, Senegal. In October 1998, Egypt participated in the African Ministerial Conference on Environment, AMCEN, Special Consultation on the United Nations Framework Convention on Climate Change and its Kyoto Protocol and Related Multilateral Agreements, held in Nairobi. Moreover, Egypt participated in Climate Change Meetings in Tunisia and Canada. Her Excellency Egyptian Minister of State for Environmental Affairs and EEAA Chief Executive Officer participated in the **Ministerial Forum on the Clean Development Mechanism (CDM**) held in Ottawa, Canada in September 24 –26 1998. The Forum discussed key policy issues surrounding the Clean Development Mechanisms that require ministerial direction. Among those issues were:

- How to ensure that CDM projects will, on one hand, assist developing countries in achieving sustainable development and, on the other hand, will assist Annex I countries in meeting their emissions reductions commitments.
- What criteria or guidelines are needed to ensure that investments in emissions reduction projects in developing countries are additional to existing official development assistance?
- Will enhancement to sinks be included in CDMs?
- How many certified emission reduction credits can be applied against the domestic commitments of Annex I countries?
- How can the design of the CDM be conducive to encourage private sector investment?

In addition, Egyptian representatives from EEAA participated in several other conferences and workshops related to the issue of climate change.

### 4.1.2. Studies:

In 1993, Egypt participated in the **UNEP Greenhouse Gas Abatement Costing Studies.** The idea behind the national case studies covering the sources, abatement technologies, and costs of GHG, in both developed and developing countries, was based on the recognition that these types of studies were the first step in the right direction. They would provide detailed information on the GHG emissions and their sources in different countries, on the costs of decreasing these emissions, and they will also form the basis of integrated regional case studies. The Egyptian case study on the costs of abatement of GHGs is an example of positive international cooperation. First, it brought investigators from the North and the South together in close team work. Some expertise, tools and funds came from the North and a lot of data and experience came from the South. Second, the project included several

multinational multi-disciplinary workshops which created informal forums and opportunities for brain storming among experts of different backgrounds. Third, the coordination of the project and the studies was entrusted to UNEP collaborating center in Rio whose team has worked very effectively in putting the broad lines of the methodology and the details of the approach of the studies.

Starting 1995, two major programs have been launched by the Egyptian Environmental Affairs Agency, EEAA. The Support for National Action Plan – SNAP, a USCSP project, and the Building Capacity for Egypt Project, funded by GEF, whose aim was to respond to the United Nations Framework Convention on Climate Change, UNFCCC. Under the two programs sixteen studies have been executed to fill in the identified gaps. The studies covered the fields of GHG emissions inventory, mitigation and adaptation technology assessment, adaptation options, abatement costs, and other areas.

The titles of the studies that were carried out within the SNAP project are:

- **Vulnerability Assessment of Fresh Water Resources in Egypt to Climate Change:** The study extensively analyzed and quantified the amount of freshwater used in Egypt, and its different sources either surface or underground. It also further analyzed in detail the water demand for irrigation, municipal and domestic and industrial sectors. Based on such analysis, the impact of climate change is assessed for every source and its effect on both demand and supply.

- **Review of the Previous Framework of Egypt's Action Plan for Dealing with Climate Change:** The Framework of Egypt's Action Plan for Dealing with Climate Change was a first attempt at defining the structure of the framework national action plan. The main elements covered were monitoring climate change, actions for reducing GHG emissions, vulnerability and adaptation to climate change, and supporting activities.

- **Assessment of Strategy and Policy Measures for Adaptation to Climate Change in Egyptian Agriculture:** The purpose of the study was to investigate how to mitigate the potential effects of climate change on Egyptian agriculture through analysis and evaluation of adaptation strategies and determining the effective ones to reduce the adverse impacts and improve the positive impacts of the expected climate change on the agricultural sector. The potential impact of climate change on wheat, maize and cotton production in Egypt was evaluated by simulating crop production under different climatic scenarios in case of wheat and maize,

and by analyzing sensitivity to temperature in case of cotton in the three main agricultural regions of Egypt.

- **Adaptation Studies for Sea Level Rise:** This study carried out a detailed assessment of the vulnerability and expected socioeconomic losses over the Nile Delta Coast due to the impact of sea level rise. Impacts of SLR on the governorates of Alexandria and Port Said in particular are evaluated quantitatively, and results were summarized and discussed. Results indicate that there are very limited possibilities for vulnerable stakeholders to change jobs; the cost is the main barrier to implementation; the majority of stakeholders recommended protection actions; beach nourishment with limited hard structures is the best immediate option, while the ICZM approach is the best available strategic option.

- **$CO_2$ Projection for Energy Sector:** This study refined the earlier general assumptions, which were used to construct a baseline projection of future $CO_2$ emissions in Egypt. The report describes the main activities that have been undertaken to estimate future levels of $CO_2$ emissions from energy related activities and sources. It highlights difficulties encountered by the project team, and measures taken to overcome them. Finally, the report summarizes the results of the projections of the energy related $CO_2$ emissions in Egypt.

- **Technology Assessment Reports:** As part of the assessment of policies and measures to mitigate climate change, a set of seven efficiency technologies were selected for thorough evaluation. Such technologies, in addition to their economic and environmental attractiveness, have already been used or at least demonstrated in Egypt through the activities of the Organization for Energy Conservation and Planning (OECP), the Energy Conservation and Environment Project (ECEP), and the New and Renewable Energy Authority (NREA).

The titles of the studies that were carried out within the "Building Capacity for Egypt to Respond to the UNFCCC Communication Obligation" Project were:

- **Agricultural and Land Use Change, A Sector Profile:** The report discusses all elements of the agriculture and land use change in Egypt. The report highlights the fact that although the agricultural sector was heavily dominated by the government up to the 1970s, in the 1980s. As a result, drastic reforms of agricultural policies began to be introduced and the agriculture sector now stands at the forefront of other sectors of the national economy in initiating liberalization and privatization reforms.

- **Estimation of Emission Factor for Mobile Sources, Gasoline Motor Vehicles:** An inventory of national emissions of GHGs requires reliable estimates of emission factors for mobile sources, e.g. the road transportation sector. In Egypt, a pilot program for vehicle tune-up was implemented in 1995. The pre-tuning data was utilized to develop more compatible emission factors. The methodology developed employed the mass balance of the combustion chemical reactions to calculate Efs of CO and $CO_2$ in mass units (g/kg fuel). Efs of unburned hydrocarbons (HC) were estimated, considering the exhaust volume, (moles), HC concentration (ppm) and average molecular weight of hydrocarbons compounds, based on relevant detailed analysis of exhaust gases.

- **Solid Waste Management in Egypt, A Sector Profile**: According to this study, the main problems facing the solid waste management systems in Egypt are: lack of institutional support, insufficient funds, inadequate technical specifications for issuing licenses, insufficient law enforcement, lack of experience in solid waste collection, insufficient community participation, lack of solid waste landfills, and absence of a waste recycling policy.

- **Mitigation Options in the Agricultural Sector**: The report covers mitigation options for methane emissions from rice cultivation, mitigation options for methane and carbon dioxide emissions from livestock, and mitigation of $N_2O$ from soil.

- **Liquid Waste Management in Egypt, A Sector Profile**: This report provides a profile for wastewater management in Egypt, present and future (planned and suggested) projects. It includes both municipal and industrial liquid wastes, and it addresses each one of them as a separate issue. Among the recommendations proposed by the study are the need for capacity building in various areas related to compliance machinery, establishment of lines of command and communication between various entities pertinent to liquid waste management, and giving the highest priority to the maintenance of the newly developed primary and pretreatment systems.

- **Transportation, A Sector Profile:** The main objectives of this report are to present the amount of GHGs emitted from the transportation sector in Egypt taking into consideration the transport activities and the local specific energy consumption, to define and identify abatement policies and programs of transport-related GHGs, and to develop a recommendation

catalogue for needed actions in Egypt to reduce the GHGs generated from mobile sources in the target year 2015. For evaluation, the different scenarios are compared with a reference scenario which is based on the current transport policies and "business as usual" travel behaviour.

- **GHG Assessment of Scenario Development for the Energy Sector in Egypt:** The objective of this report is to estimate the future potential reduction in the levels of CO2 emissions from energy related activities/ sources including energy and transformation sectors (Petroleum and Electricity), industry, transport and small combustion sectors from the Business As Usual scenario, BAU, or base-line scenario. The Intergovernmental Panel on Climate Change, IPCC was the source for the emission factors used for estimating the GHG emission. The time horizon of the current study is covering the next four national five year plans till year 2017.

- **Underground Metro As A GHG Mitigation Option:** The report covers the underground transit system in the context of an integrated urban transport system and evaluates the potential impact of the metro in both Cairo and Alexandria.

### 4.1.3. Policies And Plans:

Within the framework of establishing the overall national policy for climate change, several parallel efforts were undertaken. These included the development of Egypt's Climate Change Action Plan, Egypt's National Communication on Climate Change, a National Energy Efficiency Strategy for Egypt, and the National Strategy for Solid Waste Management.

In 1995, Egypt started to develop the **National Climate Change Action Plan.** This plan aims to integrate climate change concerns into national planning processes and programs by enhancing policy dialogue, raising national awareness, and building national capacity to deal with climate change, and designing priority policies and measures to mitigate and adapt to possible impacts of climate change. Egypt started the development of the plan through its participation in the US Country Studies Program USCSP – Support for National Action Plan (SNAP). The project actually started in 1996. The main objectives of the project were the development of the plan, evaluating the priorities of GHGs abatement measures, and the mitigation policies relevant to the adverse impacts of the phenomenon; in addition to a definition of the national needs required for the implementation of this plan. Within the scope of the project, the following actions were undertaken:

- The preparation of a report about the GHGs emanating from the various sectors in Egypt, which have been calculated according to the methodology adopted by the International Governmental Committee for Climate Change;
- Developing policies and measures for GHGs abatement as part of the national program for the abatement of those emissions;
- Review of the "National Action Plan Framework" previously developed in July 1995;
- Assessment of the current technologies used for GHGs abatement, including economic, environmental, technical, and social impacts of applying a number of technologies in the industrial and electricity generation sectors;
- Preparation of a draft Climate Change Action Plan which includes: an inventory of GHGs in Egypt, proposed policies and measures for abatement of emissions and mitigation of adverse effects, plus an evaluation of economic and environmental impacts resulting from the implementation of those measures. The draft plan also includes a strategy for implementation in coordination with other national development plans.

In accordance with articles 4 and 12 of the Framework Convention on Climate Change (FCCC), which requests all parties to prepare National Communications on their implementation of the Convention, Egypt went into the lengthy process of preparing the **National Communication**. It was indeed a participatory process in which a large number of national research centers and experts participated. First, EEAA, the national focal point for climate change, identified a group of experts to constitute the technical committee for the preparation of the National Communication. Second, a training workshop was held on how to prepare the National Communication Report according to the Framework Convention. Third, consultants were selected. Fourth, several drafts were prepared and discussed by external specialized readers. Fifth, the final draft was discussed by the National Committee on Climate Change in its meeting held in May 1999.

In October 1998, the Organization for Energy Planning (OEP) signed a protocol with eight public and private entities to engage in developing a **National Energy Efficiency Strategy for Egypt**. The GOE thus announced the beginning of an on-going effort to ultimately establish an enabling framework to improve energy use in various sectors of the economy, thus reducing pollution and greenhouse gases. On February 1999, all participating agencies met as the Energy Efficiency Council and agreed to meet quarterly to provide direction and guidance for a team of experts assigned by each agency to discuss, develop and implement an action plan that will be coordinated by OEP. The development of the strategy is a major objective under the

USAID's new Environmental Policy Program and a vital component of Egypt's Climate Change Action Plan.

Moreover, Egypt is in the process of developing a **National Strategy for Solid Waste Management** with the overall aim of providing proper waste collection and waste reception and disposal services nationwide, and at the same time, contributing to the overall purposes of Egypt's climate change policies and plans through controlling GHGs emanating from solid waste management activities. Among the technical programs included under the strategy, for example, is the waste reception facilities program which entails the establishment of both sanitary landfills and managed dumpsites. The landfills will be owned and prepared by the municipalities and operated by private companies and/or individuals to produce compost and recyclable materials.

The pronounced national objectives of the plan include: increased waste collection service coverage, increased waste reception facilities, increased waste recycling in both rural and urban Egypt, covering Egypt with an administrative network at a local, regional and central level, and cooperating with local, regional, and national NGOs and the private sector in the planning, implementation, monitoring and evaluation of solid waste management plans.

### 4.1.4. Projects:

On the 9$^{th}$ of October 1996, the Egyptian Cabinet of Ministers agreed in principal to the establishment of the first **Integrated Solar Thermal / Natural Gas Power Plant** at Kuraymat. The solar thermal power project is included in the Fourth National Five Year Plan (1997-2000), and it is tentatively agreed that this project should be undertaken with private sector participation. The New and Renewable Energy Agency (NREA) has prepared a program for implementing a serial number of solar thermal power plants. The program aims at studying and implementing the first "ISCCS" project of (100-150) MW capacity from the year 1997 with a target to start project operation by the year 2001 followed by the second project of almost similar capacity to be operative before the year 2005. It is planned that the solar contribution reaches from (15%-20%) for the first plant and rises gradually for farther plants to be constructed. Moreover, the targets, by the year 2017, the satisfaction not only of local needs, but also the beginning exportation of solar generated electricity to Europe.

In January 1997, GEF approved the **Energy Efficiency Improvement and Greenhouse (GHG) Reduction Project.** The project aims at achieving an absolute reduction in GHG Emissions through adapting policies of demand-side management and energy conservation activities and creating an enabling environment for

utilization of energy efficiency equipment and techniques.

Among the important projects which started implementation in 1998 is the **Integrated System for Zero or Reduced Emission Fuel Cell Bus Operation in Cairo Project.** The project addresses energy efficiency and energy conservation issues in Egypt. Fuel cell technology converts the energy carried by hydrogen gas directly into electricity without the need for moving parts or a combustion process. By eliminating the intermediate step of combustion, fuel cells would eliminate vehicle air pollution and secure a leap in energy efficiency over the internal combustion engine. The overall objective of the project is to contribute to the long term reduction of the cost of an integrated and optimized fuel cell based system. This system is to be applied in the Cairo public ground transport sector. Expected duration of the feasibility study of the project is from October 1998 to April 1999.

Currently, in 1999, two projects related to climate change have been submitted by EEAA to the Canadian Egyptian Environmental Cooperation Program. The first project is titled**: Climate Change Early Action Technology Measures: Retrofitting Two Stroke Engines.** The objective of this project is to reduce emissions from motorcycles equipped with two stroke engines through a phased program of retrofitting. The proposed program includes a number of phases starting with Greater Cairo, and the retrofitting of about 150,000 motorcycles. The retrofitting technique shall be determined based on technical, economical and environmental feasibility analysis. The project would include two phases: technical, economical and feasibility investigation, and the implementation of a feasible approach for retrofitting.

The second project is titled: **Climate Change Early Action Technology Measures: Methane Recovery from Landfill.** The goal of this project is to recover methane generated from sanitary landfills as a mitigation option for reducing GHG emissions in Egypt. The recovered methane could be used as: fuel for internal combustion engines, alternative vehicular fuel, or fuel for leachate treatment systems. The project activities would include two phases: project feasibility study phase, and an implementation phase that would include site preparation, construction, operation, monitoring and evaluation.

Another project in the pipeline is that titled**: "Reduction of Methane Emissions to the Atmosphere through Commercial Utilization of Landfill Methane in Egypt",** for which a concept paper has recently been submitted by EEAA to the Global Environment Facility. The project is being developed to promote the energy and economic benefits of commercial landfill methane recovery commensurate with solid waste management in Egypt. The major objective of this project is to develop an initial successful demonstration of commercial landfill methane recovery from an

exiting disposal site in the greater Cairo area. Site engineering and gas extraction would permit exploitation of the landfill gas to replace fossil fuel in an existing industrial boiler. This project, in itself, will provide tangible benefits to the greater Cairo area and, moreover, will provide a model for future projects. Importantly, this project would also provide in-country technical training and outreach activities centering on landfill methane recovery from controlled waste management as part of a national strategy to deal with increasing quantities of solid waste. Landfill methane recovery projects for direct boiler use can be economically implemented using readily available technology at relatively modest cost. As a result of this initial project, it is anticipated that the planning, engineering, and construction of commercial landfill methane recovery facilities can function efficiently.

Also in the pipeline, is the World Bank /Swiss Government Program of National CDM Strategy Studies. The program aims at promoting a better understanding and practical implementation of flexible mechanisms on GHG emission reduction trading, and analyzes and proposes enabling conditions in host countries to benefit from international co-operation in the climate change areas.

# 5. POSSIBLE MITIGATION OPTIONS:

## 5.1. Introduction:

A number of mitigation options have been assessed for Egypt through the SNAP and GEF building capacity projects. These studies cover mitigation policies and measures in the following sectors: energy, transport, agriculture, livestock, and waste. Mitigation actions aim basically at reducing two gas emissions namely, Carbon Dioxide, $CO_2$ , and Methane, $CH_4$ . Mitigation actions to reduce $CO_2$ mainly cover the energy and industrial processing sectors, while those for $CH_4$ mainly cover the agriculture/livestock and waste sectors.

## 5.2. Energy:

### 5.2.1. An Overview Of Options:

Several studies on the likely effects of climate change on the energy sector in Egypt point out to the possibility of reducing greenhouse gas emissions by:

- **Improving energy efficiency**: This reduces demand for energy and hence the amount of $CO_2$ generated during energy production. This can also improve economic performance, reduce other pollutant emissions and increase energy security.
- **Using cleaner energy sources and technologies**: This reduces $CO_2$ emissions

For instance**,** the UNEP/VTT/EEAA Study on greenhouse abatement costing established an inventory of GHGs emissions in Egypt using 1990 as a baseline. A base scenario of GHGs emissions until the year 2020 was developed. Moreover, two abatement scenarios with 25% and 50% $CO_2$ reduction by the year 2020 were assessed and their costs were estimated. Fifty-seven abatement measures were selected to achieve the targeted reductions. The results of that study have shown that Egypt has considerable potential for no-regret GHG abatement measures.

Among these mitigation measures were a fuel switch to natural gas, energy conservation and the use of renewable energy. This is due to the fact that such measures reduce GHGs emissions without any negative impact on the Egyptian economy.

The SNAP Study On GHG Mitigation And Adaptation Technology Assessment took a step further by identifying a set of seven energy efficiency technologies that have

been used in Egypt. The set included the following technologies:

-Fuel Substitution of oil with natural gas in the industrial sector;
-Combined heat and power production, co-generation;
-Combustion control;
-Waste heat recovery;
-Efficient lighting systems;
-Use of renewable energy in electricity production;
-Steam condensate recovery.

This set has been thoroughly evaluated in terms of costs, effectiveness and socioeconomic impact. Table (5.1 ) summarizes the assessment of these technologies according to energy saving, capital investment, cost of saved carbon (CSC) and annual average saved $CO_2$.

**Table (5.1 ) Energy Savings, Capital Investments and Cost of Saved Carbon for the Assessed Technology Options.**

| Assessed technology | Options | Options Given No. | Ann. Energy Savings T.O.E | Capital Costs 1000$ | C.S.C. $/Ton CO2 | Total Saved CO2 1000Tons |
|---|---|---|---|---|---|---|
| Fuel Substitution of Oil with Natural-Gas | 20%Gas Oil to NG | 1 | 152,000 | 45,500 | -103 | 1,520 |
| Fuel Substitution of Oil with Natural-Gas | 20%Fuel Oil to NG | 2 | 320,000 | 18,756 | -14 | 3,472 |
| Combined Heat and Power Production | Back Pressure Steam Turbine | 3 | 589,325 | 71,500 | -52 | 1,505 |
| Combined Heat and Power Production | Extraction Steam Turbine | 4 | (*) | (*) | -41 | 0 |
| Combined Heat and Power Production | Gas Turbine | 5 | 533,410 | 464,750 | -12 | 1,657 |
| Combined Heat and Power Production | Diesel Engine | 6 | 21,320 | 12,000 | 0 | 79 |
| Combined Heat and Power Production | Gas Engine | 7 | 40,850 | 18,582 | -11 | 169 |
| Combustion Control | Fuel-Air Ratio Control Program | 8 | 493,660 | 111,366 | -22.57 | 1,512 |
| Combustion Control | Pressure Modulating Control Program | 9 | 133,473 | 3,273 | -24.566 | 409 |
| Combustion Control | Gas Analyzer, Tune-Up | 10 | 273,663 | 2,025 | -18.07 | 835 |
| Waste Heat Recovery | Regenerative Burners | 11 | 30,205 | 8,576 | -24.58 | 91 |
| Waste Heat Recovery | Metallic Recuprator | 12 | 18,460 | 1,256 | -12.72 | 59 |
| Waste Heat Recovery | Economizers | 13 | 4,920 | 2,600 | 9.02 | 16 |
| Waste Heat Recovery | Water Treatment | 14 | 226,920 | 29,600 | -24.76 | 726 |
| Waste Heat Recovery | Boiler F.W.Preheating System | 15 | 94,280 | 30,000 | -3.13 | 301 |
| Waste Heat Recovery | Boiler Air Preheaters | 16 | 26,380 | 5,000 | -4.54 | 84 |
| Waste Heat Recovery | Preheating Sys. for Feeding Materials | 17 | 200 | 30 | -9.589 | 1 |
| Waste Heat Recovery | Waste Heat Boilers | 18 | 9,875 | 2,000 | -8.365 | 31 |
| WHR Under Natural Gas, Scenario | Regenerative Burners | 19 | 30,205 | 8,576 | 6.295 | 71 |
| WHR Under Natural Gas, Scenario | Metallic Recuprator | 20 | 18,460 | 1,256 | -16.11 | 43 |
| WHR Under Natural Gas, Scenario | Economizers | 21 | 4,920 | 2,600 | 14.87 | 12 |
| WHR Under Natural Gas, Scenario | Water Treatment | 22 | 226,920 | 29,600 | -29.79 | 533 |
| WHR Under Natural Gas, Scenario | Boiler F.W. Preheating System | 23 | 94,280 | 30,000 | -3.13 | 222 |
| WHR Under Natural Gas, Scenario | Boiler Air Preheaters | 24 | 26,380 | 5,000 | -4.858 | 62 |
| WHR Under Natural Gas, Scenario | Preheating Sys. for Feeding Materials | 25 | 200 | 30 | -10.33 | 0 |
| WHR Under Natural Gas, Scenario | Waste Heat Boilers | 26 | 9,875 | 2,000 | -8.623 | 23 |
| Efficient Lighting Systems | 1 Million Lamps | 27 | 155,000 | 19 | -28.89 | 407 |
| Efficient Lighting Systems | 5 Million Lamps | 28 | 775,000 | 93 | -28.93 | 2,033 |
| Efficient Lighting Systems | 10 Million Lamps | 29 | 1,528,000 | 185 | -28.45 | 4,011 |
| Efficient Lighting Systems | 20 Million Lamps | 30 | 2,990,000 | 366 | -27.992 | 7,849 |
| Efficient Lighting Systems | 40 Million Lamps | 31 | 5,980,000 | 732 | -27.991 | 15,698 |
| Efficient Lighting Systems | 80 Million Lamps | 32 | 11,527,000 | 1,447 | -27.03 | 30,259 |
| Efficient Lighting Systems | 100 Million Lamps | 33 | 14,408,000 | 1,809 | -27.029 | 37,823 |
| Efficient Lighting Systems | 160 Million Lamps | 34 | 20,945,000 | 2,800 | -24.6 | 54,983 |
| Efficient Lighting Systems | 190 Million Lamps | 35 | 25,720,000 | 3,367 | -25.387 | 67,518 |
| Use of Renewable Energy in Electricity Pro. | 60 MW Wind Farm ( 20 Units ) | 36 | 1,123,660 | 1,270,807 | -35 | 3,287 |
| Use of Renewable Energy in Electricity Pro. | 60 MW Wind Farm ( 10 Units ) | 37 | 561,830 | 635,403 | -35 | 1,644 |
| High Steam Condensate Recovery | Foodstuff | 38 | 25,401 | 4,290 | -33 | 81 |
| High Steam Condensate Recovery | Chemical | 39 | 15,870 | 4,683 | -25 | 47 |
| High Steam Condensate Recovery | Textile | 40 | 14,762 | 5,273 | -18 | 47 |
| High Steam Condensate Recovery | Petroleum | 41 | 6,459 | 2,770 | -10 | 21 |
| High Steam Condensate Recovery | Metallurgical | 42 | 2,308 | 439 | -30 | 7 |
| High Steam Condensate Recovery | Commercial | 43 | 4,120 | 894 | -23 | 13 |
| Medium Steam Condensate Recovery | Foodstuff | 44 | 11,290 | 1,144 | -38 | 36 |
| Medium Steam Condensate Recovery | Chemical | 45 | 9,919 | 1,756 | -35 | 30 |
| Medium Steam Condensate Recovery | Textile | 46 | 8,119 | 1,740 | -29 | 26 |
| Medium Steam Condensate Recovery | Petroleum | 47 | 3,327 | 856 | -24 | 11 |
| Medium Steam Condensate Recovery | Metallurgical | 48 | 1,385 | 158 | -36 | 4 |
| Medium Steam Condensate Recovery | Commercial | 49 | 2,884 | 375 | -30 | 9 |
| Low Steam Condensate Recovery | Foodstuff | 50 | 5,645 | 381 | -41 | 18 |
| Low Steam Condensate Recovery | Chemical | 51 | 5,951 | 702 | -40 | 18 |
| Low Steam Condensate Recovery | Textile | 52 | 4,798 | 686 | -35 | 15 |
| Low Steam Condensate Recovery | Petroleum | 53 | 1,957 | 336 | -31 | 6 |
| Low Steam Condensate Recovery | Metallurgical | 54 | 923 | 70 | -39 | 3 |
| Low Steam Condensate Recovery | Commercial | 55 | 412 | 36 | -33 | 1 |

Source : Support for National Action Plan Stand alone technology assessment reports, OECP 1997

(*) : The share of extraction steam turbine will be deducded from the back pressure steam turbine or gas turbine

The evaluation of the socio-economic impact of the assessed technologies are represented in table (5.2 )

**Table (5.2): Evaluation of Social and Cultural Impacts of Assessed Technologies**

| No | Criteria | F.S.O.N.G. | C.H.P. | C.C | W.H.R | E.L.S | U.R.E.E.P | S.C.R |
|---|---|---|---|---|---|---|---|---|
| 1 | Job O opportunities | 8 | 8 | 9 | 2 | 5 | 10 | 2 |
| 2 | Enhancement Employee's Cleverness | 7 | 7 | 8 | 9 | 5 | 10 | 2 |
| 3 | The Comply With Current Legislation | 8 | 5 | 7 | 10 | 9 | 10 | 10 |
| 4 | The Replacement of Local Communities | 3 | 9 | 9 | 10 | 9 | 10 | 10 |
| 5 | Change in Cultural Behavior | 2 | 8 | 8 | 5 | 8 | 10 | 10 |
| 6 | Improve Management Commitment to Energy Savings | 2 | 10 | 10 | 4 | 9 | 10 | 2 |
| 7 | Management Acceptance for Energy Saving Incentive | 2 | 6 | 8 | 3 | 8 | 10 | 3 |
| 8 | Labor Reaction Towards Safety and Social Aspects | 7 | 7 | 8 | 10 | 8 | 10 | 5 |
| 9 | Possibility of Using Revenues in social Services | 2 | 10 | 10 | 3 | 10 | 10 | 1 |
| 10 | Society Acceptance to Invest in the Technology | 7 | 7 | 7 | 5 | 8 | 8 | 7 |
| | Total | 48 | 77 | 85 | 61 | 79 | 98 | 53 |

**Source**: SNAP, Stand Alone Technology Assessment Reports, OECP, 1997.

The technology assessment was followed by another study “Assessment of Scenario Development for the Energy Sector In Egypt”, aimed at estimating the future potential reduction in the level of $CO_2$ emissions from energy- related activities /sources for the next four National Plans till the year 2017.

Based on the base line scenario for energy and $CO_2$ emissions, the study tried to identify and assess a number of measures /technology for mitigating $CO_2$ emissions. These selected measures and technologies were classified into the following scenarios:

- Fuel substitution Scenario, FSS
- Use of Renewable Energy in Electricity Production Scenario, RES
- Energy Efficiency Scenario, EES

The energy saving for the three scenarios, fuel substitution, renewable energy and energy efficiency were found to reach about 7.81, 45 and 2.92 PJ in Year 2000/1 and about 19.64, 117.4 and 70.68 PJ in 2016/17 respectively. The corresponding $CO_2$ reduction is expected to reach about 2.345 and 2.055 million tons in 2000/1 and about 5.863 and 4.28 million tons in 2016/17 respectively.

The projected $CO_2$ reduction resulting from the implementation of the three scenarios are presented in Figure (5.1 ). While the cumulative $CO_2$ emissions of the three scenarios and Business As Usual, BAU, scenario is presented in Figure ( 5.2) . The expected capital investment needed for each scenario is the summation of the capital investments needed for implementing the selected options within each scenario. The total investments needed for implementing the selected scenario is presented in table (5.3 ). About 3,277 million US $ are needed for the renewable energy scenario which represents about 76% of the total investment of the three scenarios.

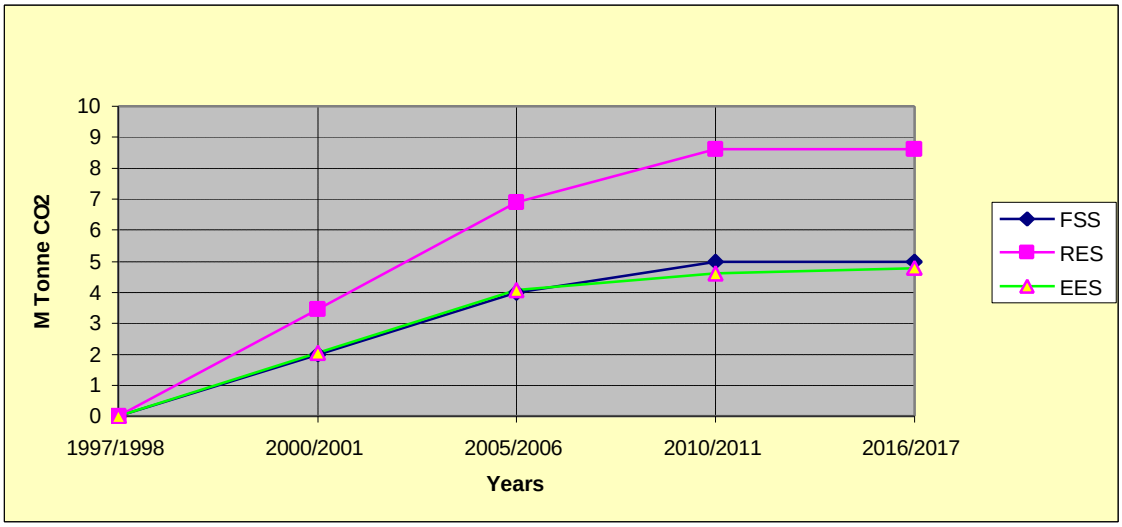


**Figure: ( 5.1) Expected $CO_2$ Reduction for the Three Scenarios**

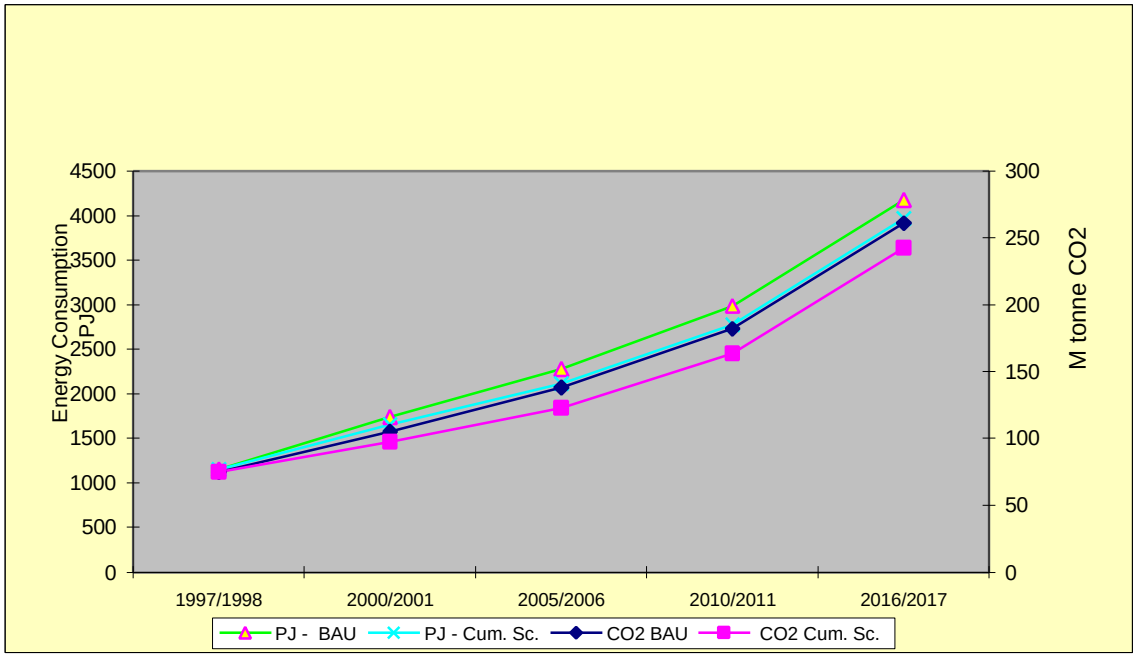


**Figure: (5.2 ) $CO_2$ Emissions for BAU and CUMUL**

**Table(5.3)Total Investments for the Assessed Scenarios**

| Capital Investment US 1000$ | Scenario |
|---|---|
| 96,390 | Fuel Substitution Scenario |
| 3,277,250 | Use of Renewable Energy Scenario |
| 926,222 | Energy Efficiency Scenario |
| 4,299,862 | Cumulative Scenario |

**Source**: EEAA. Building Capacity for Egypt to Respond to UNFCCC Communication Obligations,1998.

The environmental, economic and social impacts of the mitigation options are summarized in table (5.4).

**Table (5.4) Summary of The Impacts of Mitigation Options**

| Criteria | 1-Fuel Substitution Scenario (FSS) | 2-Renewable Energy Scenario (RES) | 3-Energy Efficiency Scenario (EES) |
|---|---|---|---|
| **1-GHG Saving** | | | |
| *CO2 (Mt) | 78 | 134 | 72 |
| *CH4 (tonne) | 40 | 402 | 215 |
| *N2o | 4.2 | 5.3 | 2.8 |
| **2-Life-cycle-cost (US$/t CO2equiv.)** | | | |
| *Capital investment (US$/ t CO2equiv.) | 12.9 | 77.3 | 15.9 |
| *Net costs (US$/ t CO2equiv.) | -103 to -14 | -35 | -11 |
| **3-Indirect impacts** | | | |
| *Jobs created | Medium | High | High |
| *Reduced imports | High | Low | Low |
| **4-Equity considerations, impact on:** | | | |
| *Low-income jobs | Medium | High | Low |
| *Low-income monthly expenditure | Medium | Low | High |
| **5-National Environmental Impacts (net change):** | | | |
| *Sulfur oxides SOX (Mt) | +6 | -74 | -42 |
| *Particulates (Mt) | -0.6 | -3.6 | -2.1 |
| | Uncertain | Positive | Positive |
| **6-Potential impact of implementation policy** | Low | High | Medium |
| **7-Sustainability of option** | Low | High | High |
| **8-Consistency with national development goals** | Medium | High | High |
| **9-Uncertainty of data** | | | |
| *Technology performance and test | Low | Low | Low |
| *Costs of implementation programs | Low | Medium | Low |

**Source:** EEAA.Building Capacity for Egypt to Respond to UNFCCC Communication Obiligatios,1998.

Based on the above mentioned studies in Egypt's National Action Plan, the following mitigation actions were identified:

### 5.2.1. Energy Supply Mitigation Actions:

There are four recommended mitigation actions:

- Efficient production and transmission of energy: This includes increasing the efficiency of existing power stations through proper housekeeping measures and systems controls, improving the efficiency of gas turbine power stations, improving the transmission and distribution losses through voltage upgrading, reconductoring, and power factor correction, upgrading of crude heat exchangers in oil refining industry, preheating of boiler make-up water in the power sector, and tuning up of boilers for proper operation by adjusting the air fuel ratio.

- Maximizing the use of natural gas, as far as local supplies permit. Actions include promoting natural gas exploration and development through increased incentives for foreign companies; expanding the infrastructure of gas production facilities and transmission and distribution systems to promote fuel switching to natural gas; and fuel switching to natural gas in power generation and refineries.

- In the petroleum industry, reusing the flared gas, as far as it is technically and economically feasible.

- Promoting renewable energy in electricity generation using wind and solar energy: These renewable energy sources may be either used directly, or to complement traditional electric energy production. In that regard, it is possible to increase the dependence on PV systems to supply power for advertising business and remote areas, promote the implementation of mini-hydro projects, as well as pumped storage, and increasing the role of renewable energy sources as power generation candidates, especially the wind option.

### 5.2.2. Energy Demand Mitigation Actions:

In the **industry** sector, energy conservation is recommended in industrial processes with the aim of reducing $CO_2$ emissions. Measures and policies under this sector include the following:

- Energy efficiency improvement: through tuning up of industrial boilers

and furnaces, improving steam production and management through the use of economizers and other waste heat recovery systems, maximizing the use of waste heat recovery system, improving energy management systems and improving motor drive systems through the use of high efficiency motors, pumps, fans compressors and drive controls;

- Database and performance monitoring through collecting data on industrial energy consumption and energy intensity indicators to help monitoring performance;
- Promoting fuel switching to natural gas in the industrial sector;
- Promoting the use of solar hot water applications in the industrial processes;
- Supporting and encouraging energy conservation efforts through free industrial energy auditing, and free consultation services;
- Promoting energy efficiency and environment protection.

In the **electric energy** sector, energy conservation is recommended through:

- the use of steam production management techniques, thermal insulation, condensate recovery, waste heat recovery, use of high efficiency motors, and efficient burners;
- the establishment of energy efficiency standards and labeling for all generic and industrial equipment such as motors, pumps, fans, compressors, boilers, heaters, etc. Such standards have to be reflected in local production and import regulations.

In the **residential and commercial** sector, small conservation measures can be encouraged since they can build up to a significant amount in the long run. Among the proposed measures are the following:

- Energy efficiency improvement: This includes the improvement of housekeeping measures, such as regular maintenance, turning off unnecessary lighting and turning down idle office equipment. It also includes improving the efficiency of existing and new equipment through automated or manual controls for lighting and air conditioning;
- Update and integrate the data base related to consumption patterns, equipment stock of household appliances based on data collected by several agencies;
- Adopting information programs to promote energy conservation in homes and commercial buildings through mass media communicatins, booklets listing the most efficient devices, and handbooks of low energy passive architecture for building designers;
- Set up a mechanism for enforcing the standard and labeling regulations covering imported and locally produced materials;

- Launch a study to find out why solar heaters and compact fluorescent lamps CFL are not as widely used as expected, and propose ways and means to promote these applications on a national scale;
- The building code has to be revised to ensure the proper insulation of walls and roofs, and the proper design of windows and the use of energy intensive materials in the building industry. Moreover, further research is required to promote the use of locally manufactured and / or cheaply imported materials having overall impact on heat insulation. A study is required to define ways and means to develop an incentive program to encourage the use of such materials especially in public and commercial buildings.

In the context of improving overall energy efficiency, on the national level, over the life cycle of different fuels from the exploration stage to final usage, an Energy Efficiency Council, EEC, was formed in October 1998. The aim of the council is to reduce GHG emissions from the energy sector. Currently, the Council is working on the development of a National Energy Strategy. The National Energy Strategy will identify, design, set the time frame and supervise the implementation of the needed actions to achieve the council objective. The committee within the Council which is responsible for this endeavor comprises representatives from the following organizations and ministries:

- Organization for Energy Planning, OEP
- Egyptian Environmental Affairs Agency, EEAA
- Egyptian General Petroleum Corporation, EGPA
- Ministry of Transportation, MOT
- New and Renewable Energy Authority, NREA
- Egyptian Electricity Authority, EEA
- Federation of Egyptian Industries, FEI
- Egyptian Energy Services Business Association
- Ministry of Public Works and Water Resources
- General Organization for Industrialization, GOFI
- Egyptian General Organization for Standardization and Quality Control, EOS.

## 5.3. Transport Sector:

Mitigation in this sector is based on the efficient use of energy as well as demand management. Measures include the following:

- Energy efficiency through improvement of vehicle maintenance and tuning up of automobile motors;

- Intensifying the awareness campaign for using natural gas in commercial vehicles, in addition to increasing the number of gas charging and refueling stations in Cairo and Alexandria areas, as well as in other governorates;

- Re-introduce the electrified railways, i.e. using electric energy and electric motors for mass transport within the city and between cities;

- Intensifying the use of environmentally sound river transport with the aim of reducing the overall fuel consumption and consequently GHG emissions;

- Extending metro lines to newly developed cities: $10^{th}$ of Ramadan, $6^{th}$ of October, $15^{th}$ of May, New Cairo, Obbour, Badr, and Qattamiya, and eventually to Alexandria;

- Encouraging private sector participation in financing and management of the new metro lines;

- The Underground Transport System as a Mitigation Option for GHG Emissions: Trams and metros emit far fewer emissions per passenger-km. In Cairo, one of the outstanding observations of travel behaviour, since the operation of the first line of the rapid transit network (El Marg/ Helwan), is the continuous increase in the number of passengers using the metro. As for Alexandria, a study estimates the potential impact of the proposed rapid transit in Alexandria in the year 2017 on the amount of GHG emissions as reducing GHG emissions by 40% $CO_2$, 59% $CH_4$ and 39% $N_2O$. Accordingly, the more underground metro lines are established, the greater the positive impact on the reduction of GHG emissions.

## 5.4. Agriculture And Livestock:

The mitigation measures discussed here deal mainly with mitigation options of methane emissions from rice cultivation, mitigation options of methane and carbon dioxide emission from livestock and mitigation options of $CO_2$ in agriculture.

### 5.4.1. Mitigation Options Of Methane Emissions From Rice Cultivation:

Methane emissions are considered one of the main sources influencing the predicted global warming phenomenon. Global estimates of methane emissions from paddy fields account for 5-30% of total methane emissions. The flooded rice soils are a major source of methane. Moreover, studies indicate that rice plants have a large capacity for methane transport and that they play a primary role in methane flux from paddy fields.

There are several ways of reducing methane emission from rice fields. In Egypt, the most promising ones are either through reduced cultivated area, or through improved management practices of rice cultivation.

**Reduce cultivated area:**

In Egypt, the annual cultivated paddy rice area is in the average of about 1.5 million feddans. This rice area represents 10.7% of the total cultivated area. By reducing this amount by half, to 750,00 feddans, total methane emissions is expected to decrease from 0.0857 Tg. to only 0.0321 Tg, or it will be only 37.5% of the present value of methane emissions.

However, the economic and social effects of the reduction in the total acreage of rice should be carefully calculated. Rice is a favored food to farmers, and they prefer to cultivate such a high cash crop. Moreover, no special technique is required for post harvesting storage and its marketing is easier than other summer crops.

**Improved Management Practices of Rice Cultivation:**

**Short duration varieties:** Generally, methane emissions are proportional to the number of days the crop is flooded. By switching from long duration varieties to short duration varieties of rice cultivars, the number of flooded days will decrease. For example, Giza 171 and Giza 172 are two old traditional rice varieties that are commonly cultivated. The growing season for these varieties is about 160 days as compared to about 130 days for the new short duration varieties such as Giza 177, Giza 178.

Studies pointed out that methane production ceased with field drainage prior to harvest. Normally, the paddy soil should be dry for a month before harvesting, i.e. one fourth of the growing season of the short duration varieties. Thus, by converting to short duration varieties, methane emissions will be decreased.

Here again, the social and economic impacts of the different rice cultivars should be carefully considered. Rice is one of the main food staples in Egypt. Moreover, Egyptians may be accustomed to specific qualities of the rice crop, and other new types may not be easily marketable.

**Water Management:** One potential way to reduce methane emissions from paddy soils is through lengthening irrigation intervals, changing the irrigation schedule and intermittent watering. Suitable management of irrigation water and its scheduling could lead to reduced rates of methane emissions without decreasing the rice yield.

**Fertilizer Management:** The use of nitrogen fertilizers leads to an increase in the amount of methane emissions from paddy rice fields. Studies indicate that by switching the N-fertilizer from urea to $(NH_4)_2 SO_4$, a substantial reduction in methane emissions can be achieved, up to 55%. The main problem with this option is that farmers need to be convinced of switching from one fertilizer to another.

**Soil Temperature:** In general, methane emissions decrease in plantings that receive less solar radiation. Studies point out that in general, methane emissions decreased with later plantings that received less solar radiation. Accordingly, the effect of soil temperature on methane emissions might be controlled via the determination of the timing of planting of paddy rice in Egypt.

### 5.4.2. Mitigation Options Of Methane And Carbon Dioxide Emission From Livestock:

- Dairy and non dairy cattle account for the larger part of methane emissions due to anaerobic conditions. Thus, by altering fermentation patterns, i.e. altering the composition of diets and/or adding chemical compounds, this shall directly result in a reduction of methane emissions. However any action in this area has to be integrated in the current MOA program in a way that it must not adversely affect the ultimate goal of the declared program for increasing meat and milk production.
- Further detailed implementation studies and field trials under local conditions are required to determine the best way to achieve both goals, i.e. the main one which is the increase in the meat and milk production in addition to reduction in methane emissions from livestock manure. Acceptance of the results of these studies by small-scale experimental breeders and farmers is necessary and should be carefully assessed on the field, in order to give convincing solutions.

### 5.4.3. Mitigation Options Of $CO_2$ In Agriculture:

Agriculture activities per se, do not pollute the environment. The pollution is a result of the human interference with nature to maximize the benefit of agricultural activities. Mitigation options include the following:

**Making the most of the natural sink of $CO_2$**: Forests and high biomass producing crops are important sinks for carbon dioxide; for example one hectar of sugar cane is a permanent sink on average for some 80 tons of this greenhouse gas.

**Increased production of biogas:** This is an efficient means of utilizing dung and plant wastes compared to burning which emits large amounts of $CO_2$, or compared to composting and then using as fertilizers which produces a good compost but still emits a small amount of $CO_2$.

## 5.5. Waste Sector:

Actions under this sector are concentrated in two areas: municipal solid waste disposal system and waste water treatment (industrial, domestic and commercial).
In fact, EEAA formulated a National Action Plan for safe handling of solid waste in March 1997. The implementation of the plan will cost L.E. 3.755 billion, in a ten year frame. The plan encourages public participation in solid waste management. Moreover, three studies concentrate on solid and liquid waste management were carried out under the "Building Capacity Program". Two of these studies covered the sector profile for Egypt's solid and liquid waste. These recommendations were:

**First: For the Solid Waste Sector:**

- Establishing a specialized administrative mechanism for solid waste management in each governorate and city;
- Recruiting specialized experts for the choice of locations and the design of sanitary landfills;
- Enhancing the participation of NGOs by training their local staff and providing necessary funding for public awareness of hygeinc aspects of waste disposal;
- Providing financial and technical assistance to private sector companies who are interested in waste collection and waste recycling;

- Launching a study to determine the most appropriate and acceptable durable multiple use materials for packing, wrapping and filling in. Plastics for packing should only be of the bio-degradable type.

**Second: For the Liquid Waste Sector:**

The studies recommend the following for the liquid waste sector:

- Maintenance of the newly developed primary and pretreatment systems should be given the highest priority;

- Lines of command and communications should be established and clarified between various entities pertinent to liquid waste management systems;

- There is a strong need to have a clearer, more realistic, and more accurate industrial map of Egypt;

- Special attention should be drawn to the industrial cities, e.g. $10^{th}$ of Ramadan, October $6^{th}$ , and Bourg El-Arab, for further development of the institutional and enforcement capabilities of their local authorities in order to avert the dangers of contaminating the underground waters and corroding the sewage networks.

## 5.6. Carbon Dioxide Sink Actions:

The aim of these actions is to increase the country's CO2 absorptive capacity through planting trees wherever possible. This includes:

- Planting and maintaining suitable types of trees along the sides and the middle islands of all main inter-city roads;
- Planting and maintaining suitable types of trees along the Nile as well as all water canals and drains;
- Developing man-made forests comprised of wood trees irrigated by treated sewage water. In that regard the Ministry of Agriculture has already undertaken extensive efforts and planted several forests as follows:
  - Qena Forest: It is located near the sanitary drainage station in the Salahia region in Qena with a targeted area of 500 feddans, is 3 years old, and is irrigated using an advanced surface irrigation system. The forest has different types of trees such as Khiya, Morus, Jatropha, Casuarina and Eucalyptus.
  - Luxor Forest: It is located near the sanitary drainage station in Luxor,

with a total area of 200 feddans, is 5 years old, and is irrigated using an advanced surface irrigation system.

- Idfu Forest: It is located near the sanitary drainage station in Idfu, Aswan governorate, with a targeted area of 300 feddans, is 1 year old and is irrigated using an advanced surface irrigation system. The trees planted include Eucalyptus, Acasia Saligna, Khiya, Morus and Jatropha.
- The New Valley Forest: It is located near the sanitary drainage station near the Kharga city, with a targeted area of 300 feddans, is 5 years old, and is irrigated using an advanced surface irrigation system. The trees planted include Eucalyptus, Casuarina, Khiya and Terminalia.
- Sarabioum Forest: It is located near the sanitary drainage station in Sarabioum, Ismailiya governorate, with a targeted area of 500 feddans, is 1 and a half years old and is irrigated using drip irrigation. It has different types of trees such as Cupressus, Eucalyptus and Casuarina.
- Sinai Torr Forest: It is located near the sanitary drainage station in the city of Torr in South Sinai governorate, with a targeted area of 200 feddans, is 3 years old, and is irrigated using a combination of both drip irrigation and advanced surface irrigation systems. The types of trees include Casoarina, Eucalyptus and Morus.
- Sadat Forest: It is located near the sanitary drainage station in Sadat city with a targeted area of 200 feddans, is one year old, and is irrigated using the drip irrigation system. The trees planted include Cupressus, Eucalyptus, Casuarina and Acasia Saligna..

Table ( 5.5 )shows climate change priority sectors for mitigation and adaptation measures.

**Table ( 5.5) Climate Change Priority Sectors for Mitigation & Adaptation Measures**

| Priority sector | Measures |
|---|---|
| **MITIGATION** | |
| **Energy**: Industry | Waste heat recovery<br>Co-generation<br>Combustion control<br>Switching to natural gas<br>Using condensate recovery systems<br>Efficiency standards |
| **Energy:** Commercial/ residential | Efficient lighting systems<br>Co-generation<br>Building codes<br>Switching to natural gas<br>Appliance efficiency standards |
| **Energy:** Electricity generation | Wind power<br>Switching to natural gas combined cycle<br>Solar thermal<br>Power purchase agreements |
| **Energy:** Transportation | Compressed natural gas<br>Improved public transportation<br>Inner and inter-city electrified metro |
| **Waste management:** Solid waste | Composting<br>In vessel digestion<br>Landfilling |
| **Agriculture** | Reduction of Rice cultivated area<br>Improved management of rice cultivation<br>Improved nutrition on small farm<br>Widespread use of small on-farm digestors<br>Planting of shelter belts on the northern coast |
| **ADAPTATION** | |
| **Coastal resources: Short term**<br>**Long term** | Beach nourishment & hard structures<br>Integrated coastal zone management |
| **Agriculture** | New cultivars<br>Less water consuming crops<br>Change cropping patterns |
| **Fresh water resources** | Water management program |

Source: EEAA. Facing Global Challenge: Egypt and Climate Change. Building Capacity to Respond to UNFCCC Communication Obligations. Nov.1998.(presented to Ministry o f State for Environment affairs).

# 6. PUBLIC AWARENESS, EDUCATION AND TRAINING

## 6.1. Background:

Capacity building in the area of climate change, including training, education and awareness, is a crucial pre-requisite for any serious effort in that regard. During 1996, Egypt initiated the Project titled: Building Capacity for Egypt to Respond to the UNFCCC. It is a joint cooperation project implemented by the Organization of Energy Conservation and Planning (OECP), the Egyptian Environmental Affairs Agency (EEAA), and the United Nations Development Program / Global Environment Facility (UNDP/GEF). Three project objectives are indicated in the project document. These are: to strengthen Egypt's capacity to comply with the requirements of the UNFCCC, to institutionalize the national communication to comply with the UNFCCC, and to contribute to the emergence of Egyptian approaches and responses to the UNFCCC. Among the expected project outputs in EEAA are the following:

- the development of an institutional structure to address climate change issues and comply with the UNFCCC;
- broadening the terms of reference of the established technical working group (TWG) to ensure full sectoral coverage;
- the preparation of country reports on the assessment of policy opportunities and priority areas for intervention focusing specifically on the non-energy sectors,
- filling of specific gaps for a number of non-energy activities in the established inventories of GHG sources and sinks in Egypt;
- the assessment of experiences from the past, ongoing and proposed climate change initiatives and impacts study in Egypt;
- increased technical capacity in climate change related issues;
- the development of a strengthened national mechanism that can provide full support for climate change related activities.

The project was approved by GEF in July 1996, and the project implementation is proceeding. To date the following activities have been accomplished:

- Several workshops have been held to promote the issue of climate change among different sectors in society, such as media personnel . An example for one such workshop was that held in Ismailiya in November 1996 under the title of : "Climate Change and Media". The workshop covered climate change and its potential impacts on different sectors in Egypt. It also discussed the Climate Change National Action Plan and emphasized the role of mass media in raising public awareness and fostering policy dialogue on the climate change issue.

- Specialists have been trained in the various governmental sectors, such as health, agriculture, electricity generation, and industry sectors, the treatment of wastes emanating from each sector and the relation of the sectors to the issue of climate change.
- Project team members and technical working group members have been trained though participation in various international seminars and workshops.
- Drawing competitions in the fields of climate change and the environment in general have helped to raise awareness among Egyptian children.
- The Climate Change quarterly bulletin covers international and national events related to the issue of climate change, and the bulletin is distributed to specialists and stake holders.
- Regional cooperation helps to build indigenous capacities in the field of climate change: Egyptian experts participated in building Arab capacities in Jordan and in Lebanon.

The following are the recommended actions to enhance capacity building efforts in the field of climate change:

## 6.2. Public Awareness:

Despite the increasing public awareness regarding environmental issues in general, the issue of climate change is still relatively dormant. Since the early eighties, steps have been taken to spread public awareness regarding environmental issues. There are now weekly environmental pages in several national daily newspapers such as Al-Ahram, Al Gomhoria, and Al-Akhbar. In addition, there are several specialized T.V. and radio programs address environmental problems and community participation. However, much still needs to be done, specially in the area of Climate Change. The Egyptian National Action Plan for Climate Change identified the following recommended actions and needs:

- Strengthening EEAA public relations and publicity office with media experts specialized in mass communication.
- Organization of national campaigns for public awareness on climate change for different sectors, i.e. agriculture, water resources, coastal zones and other threatened sectors.
- Writing and producing specialized radio and TV programs addressing climate change issues - the programs should be simple and friendly and should target audience belonging to various sectors of society.
- Upgrading the ongoing climate change newsletter produced by EEAA.

- Organizing periodic seminars and gatherings for media personnel to brief them on what is new, and what messages EEAA wants to convey to the public.
- Close coordination and cooperation with NGOs working in the field of the environment so that they become a cornerstone of EEAA's PR and publicity department.
- Establishing links and holding continuous discussions with members of the legislative branch, the People's Assembly and the Shura Council, the Specialized National Committees and the top officials in the Executive branch; one possible way to do this is to organize periodic workshops or conferences to which members of the above groups could be invited.
- Cooperating with international organizations, networks and other national focal points for the purpose of exchanging information, material and promotional items. In that regard, an internet web site was established having the following address: http://www.idsc.gov.eg/ccinfo.

## 6.3. Education:

Introducing environmental studies into the traditional educational agenda at schools and universities has gained a lot of attention in recent years. The subject of environment education enables students to understand environment, its various phenomena and problems and to learn different means of managing it. It is very significant as it can raise students' awareness with their environment, hence, change their behavior towards it and empower them to participate more effectively in resolving environmental problems.

Recognizing the importance of environment education, the Egyptian Environmental Affairs Agency (EEAA), in coordination with the Ministries of Education and Higher Education, made a serious attempt to integrate Environmental Science at all education levels. The efforts made in that respect followed two approaches:

- Approach I: Integrating environmental issues within the existing National Curriculums;
- Approach II: Establishing independent specialized degrees, diplomas or courses in the field of Environmental Science.

The realization of the above mentioned approaches were manifested in serious steps undertaken at the Basic and Higher Education levels as follows:

**Basic Education**: Efforts at that level covered Primary, Preparatory and secondary grades and sought to integrate environmental issues within the existing national

curriculums. In Primary and Preparatory grades environmental issues were integrated in the existing National Curriculums of Science and Geography. As for the Secondary Education level, a new section on environmental science was added to the National Science Curriculum.

**Higher Education:** Efforts at this level followed the two above mentioned approaches and extended to both the undergraduate and postgraduate studies. These included:

- Undergraduate studies: The main focus here was integrating environmental science in the National Curriculum and this was evident, for example, at the Engineering School in Alexandria University. Another successful example was carried out at the Faculty of Economics and Political Science (FEPS) which established a Minor in Environmental Management that addressed several issues as climate change and its impact on Egypt. In addition, the American University in Cairo has an Environmental Engineering Program within the engineering department, and offers a minor in environmental sciences.

- Postgraduate studies: Several concrete projects were directed towards developing independent degrees. These include, among others:
    - The faculty of Economics and Political Science (FEPS) at Cairo University established, in-cooperation with EEAA, the Environment Management Diploma which was introduced as a new field study for the first time in 1995. The diploma included several courses as Environment Economics, Environment Legislation, Environment Management, Global Environmental Management that focus on global environmental problems, including Climate Change.
    - The American University in Cairo, within the Public Administration division in the Management Department provides graduate students with the opportunity for a concentration in Environmental Management. This comprises two courses: Environmental Policies and Urban Environmental Management. In addition, a Professional Environmental Engineering Diploma is provided through the Engineering department.
    - A UNESCO chair professor on energy and environment is being established at Alexandria University.
    - A post-graduate diploma program in energy conservation and management is being instituted at Alexandria University.

In addition, most universities have research centers that work on environmental problems and provide policy makers with recommendations through workshops, seminars and published papers.

The efforts realized in the field of environment education require further development in scope and scale. More attention should be directed towards supporting existing curriculums with more comprehensive environmental studies, emphasizing interactive teaching methods and fieldwork and generalizing the core subjects in all universities.

Egypt's Climate Change Action Plan recommended the following:

- At the basic education level, efforts should be undertaken to discuss with the Curriculum Development Center of the Ministry of Education how climate change issues could be incorporated in the appropriate regular curriculums. Meanwhile, it is possible to prepare occasional day programs during school hours targeting pupils of primary, preparatory and secondary schools.

- At the higher education level, EEAA can prepare a series of demonstration lectures explaining various aspects of the phenomenon, Egypt's vulnerability areas, and the main necessary mitigation measures, etc. Moreover, support and assistance should be provided to universities and faculties which have started a diploma or masters degree program on environmental aspects with possibilities for establishing international or regional cooperation links with other universities and organizing programs for exchange of experts and professors.

## 6.4. Training:

In addition to the existing training programs and projects, previously mentioned, the following recommendations were identified in Egypt's Climate Change Action Plan:

- Extending the program launched and executed under the "SNAP" and "Building Capacity" projects with the aim of creating and sustaining an indigenous critical mass of experts in all branches of physics, chemistry, biology, meteorology, and engineering, etc, as related to climate change;
- Establishing multidisciplinary educational and training institutions with interest in climate change;
- Placing special emphasis on training of trainers programs, since their training is expected to have high multiplier effects. This includes preparation of teaching staff for climate change issues at the university level;
- Providing on the job training to young researchers in the study program under

the present action plan.

# 7. RESEARCH GAPS & NEEDS

Despite the efforts and projects which have taken place in Egypt in the field of Climate Change, there are still a lot of research gaps and needs that ought to be covered in the near future. Climate research needs to address three main issues:

- The science of climate;
- The likely impacts of climate changes;
- The policy mitigation and adaptation measures to be implemented.

Consequently, research gaps may be classified into the following main areas:

## 7.1.Research Related to the Science of Climate:

There is a need to upgrade Egypt's capacity to better understand climate change and the exact nature of its impact through a dedicated programme of scientific research aiming at the development of a regional Climate Change model.

### 7.1.1. Remote Sensing Sector:

The National Authority for Remote Sensing and Space Sciences (NARSS) identified the following needs in the area of climate change:

- Up to date hardware and software;
- Capacity building in the field of modeling and prediction;
- Development of a common database on climate patterns.

### 7.1.2. The Meteorological Sector:

The Egyptian Meteorological Authority identified the following areas of research as its priorities:

- Global Climate Observing System;
- Global Terrestrial Observing System;
- Global Oceanographic Observing System.

Moreover, the Egyptian Meteorological Authority needs capacity building that involves staff training on the use of satellites monitoring equipment, and networking with national and international universities, and the World Meteorological Organization ( WMO).

## 7.2. Research Related to the Likely Impacts of Climate Change:

Although several studies had been conducted to assess the negative impact of Climate Change, there is a great need for further understanding of its likely impacts on specific sectors in Egypt.

### 7.2.1. Integrated Research:

Most of Climate Change assessment studies were unidimensional and sectoral, hence there is a great need for integrated research that assesses the average climate change impact on the coastal zone, on water resources and human health.

### 7.2.2. Impact of Climate Change on Water Resources:

Both the Environment and Climate Change Research Institute (ECRI), and the National Water Research Center (NWRC) pointed to the following issues as research priorities:

- Identification and assessment of various hydrologic, physical, Environmental, economical and social elements that are sensitive to climate change in the Nile basin and evaluate their variation over time;
- Simulating the impacts of climate change scenarios on the Nile River flow;
- Assessing quantitatively the water-related resource impacts in the water supply Nile basin;
- Identification of potential adjustments and adaptation measures to climate change.

Among the technological needs identified by the National Water Research Center at the Ministry of Public Works and Water Resources were the following:

- Development of regional climate models for the Nile basin;
- Link climate change models to hydrological models;
- Establish a local and regional climate and environmental network to enable data collection, monitoring and assessing climate changes and likely impacts within Egypt and in the Upper Nile basin countries;
- Establish database for the data of the climatological data including rainfall, temperature, evaporation, and the evaporative demand of crops;
- Examining regional circulation models for potential use;
- Study and assess sea water intrusion and the change of water quality in the shallow aquifers in the coastal areas;
- Encourage academic and on the job training of the subject and provide the necessary professional assistance through technical, local and foreign consultants, short courses, seminars and workshops.

### 7.2.3. Impact of Climate Change on Coral Reefs:

Significant attention needs to be given to the monitoring of coral reef ecosystems, research on the projected and realized impacts of global climate change, and measures

to curtail greenhouse gas emissions.

## 7.3. Policy Oriented Research:

This part deals with research gaps and needs related to policy mitigation and adaptation measures.

### 7.3.1. GHG Emissions:

- The analysis of GHG emissions was limited to $CO_2$, $CH_4$, and $N_2O$. Thus, the other GHG gases such as Nox, CO, NMVOCs, HFCs, PFCs, and SF6 need to be considered.
- In the petroleum sector, a comprehensive study for measuring and monitoring $CH_4$ emissions from exploitation, transmission, and distribution is needed.
- Mitigation modeling of GHGs emissions in the agriculture sector is needed, especially the estimation of carbon fraction in Egyptian rice fields

### 7.3.2. The Energy Sector:

- In the power sector, a prominent role was given to renewable energy resources particularly wind energy, where more than 16 TWh need to be produced by the year 2020.This would necessitate a comprehensive pre-feasibility study to investigate whether these ambitious plans were realistic and could be implemented under the industrial capacities in Egypt.
- A feasibility study on nuclear power as a long term energy option for Egypt is needed.

In addition, the following areas of research were identified in the Egyptian Climate Change Action Plan:

- Research projects for energy efficient buildings and buildings that use renewable energy technologies
- Research on the potential role of the international electricity trades in $CO_2$ reductions.
- Research to improve automobile and freight transportation fuel efficiency.
- Research on alternative transportation fuels, e.g. hydrogen and natural gas driven vehicles.
- Research on electric and solar cars.
- Research on traffic management and practices.
- Research and demonstration projects on the production of energy from sewage and solid wastes.

### 7.3.3. The Agriculture Sector:

A comprehensive study is needed to investigate the technical, economic, social and environmental aspect of turning millions of hectares in the Eastern or Western Desert into green areas suitable for planting crops and trees. Moreover, the effect of the "New Valley Project" on Egypt's agricultural sector is needed.

Other perceived research needs include the following areas:

- Scheduling irrigation of maize crop using pan evaporation
- Application of sprinkler and drip irrigation systems to conserve water in the old lands.
- Adaptation to climate change in Egyptian agriculture
- Application of intermittent irrigation and mechanization in rice cultivation to mitigate GHG emissions.

### 7.3.4. Solid waste sector:

As solid waste was found to be an important source of methane, whether dumped in landfills or open dumps, it could be used in bio-gas plants for the production of power and useful compost. A feasibility study is urgently needed to select a few sites for these plants and estimate their social, environmental, and economic benefits.

### 7.3.5. Water Resource Sector :

In order to develop adaptation and mitigation measures for the resource system, the NWRC suggest the following proposals:

- **Climatic Change Impacts on Water Resources Vulnerability Assessment:** The main objective of this proposal is to establish and to strengthen technology transfer and human resources development on climate change issues. Activities of the project include establishment of specialized computer centers, water quality monitoring labs and equipment, and libraries, in addition to organization of workshops and both long term and short term training on state of the art technology and approaches related to climate change and water resources vulnerability assessment.
- **Technology Transfer of Monitoring and Evaluating the Global Sea Level Rise to the Coastal Research Institute**: The main objective of the proposed project is to upgrade the capabilities of the Coastal Research Institute through technology transfer to meet the challenges imposed by the global rise in sea level. In this respect, advanced instrumentation for recording the phenomenon is essential, as well as, up-to-date techniques for estimating the long-term relative and absolute sea level changes and also predicting their impacts on the entire region.

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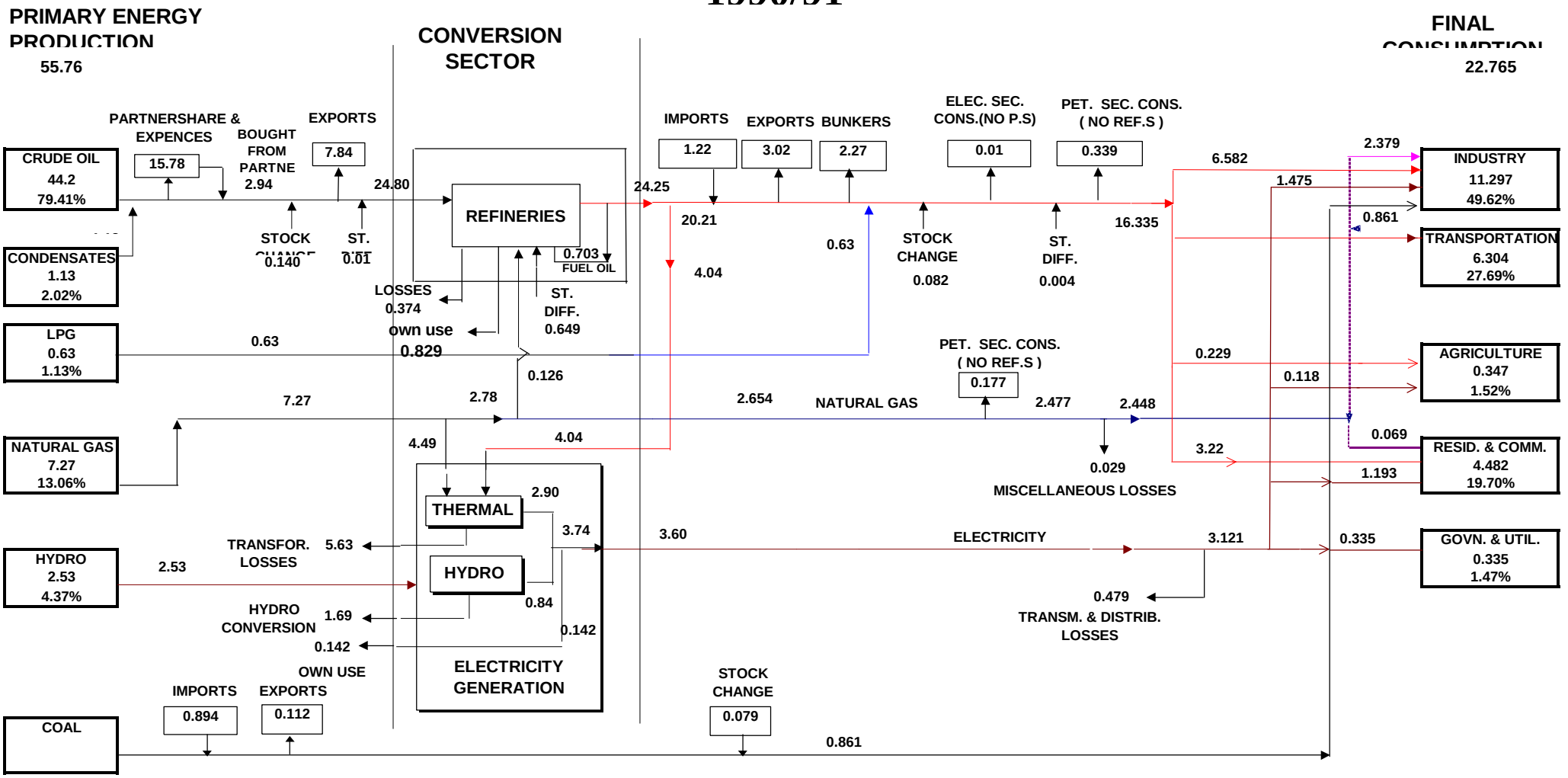
# Appendix

# ENERGY BALANCE IN EGYPT
# 1990/91




HYDROPOWER IS CALCULATED AS 1 KWH THERMAL GENERATION REQUIRES 260 GRAM OF OIL EQUIVALENT

**UNITS : MILLION TOE**

## STANDARD DATA TABLE 1

## Energy : 1A Fuel Combustion Activities (Sheet 1 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption<br>(PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Liquid fuel | 814.74 | 60,309 | 11.11 | 10.88 | | | | 74.0223 | 0.0136 | 0.01133 | | | |
| Natural Gas | 256.194 | 14,372 | 0.08 | 0.53 | | | | 56.1001 | 0.0003 | 0.0021 | | | |
| Total | 1,070.93 | 74,681 | 11.19 | 11.41 | | | | 69.735 | 0.0104 | 0.0106 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A Fuel Combustion Activities (Sheet 2 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| **Energy & Transformation** | | | | | | | | | | | | | |
| Liquid Fuel | 181.07 | 13,967 | 0.02 | 0.56 | | | | 77.1361 | 0.0001 | 0.0031 | | | |
| Gas/Diesel Oil | 12.175 | 901.68 | 0 | 0.04 | | | | 74.06 | 0 | 0.0033 | | | |
| Residual Fuel Oil | 168.554 | 13,040.35 | 0.02 | 0.52 | | | | 77.366 | 0.0001 | 0.0031 | | | |
| Lubricants | 0.34 | 25.01 | 0 | 0 | | | | 73.3431 | 0 | 0 | | | |
| Natural Gas | 198.81 | 11,153 | 0.06 | 0.41 | | | | 56.1001 | 0.0003 | 0.0021 | | | |
| Total | 379.88 | 25,120.41 | 0.08 | 0.97 | | | | 66.1269 | 0.0002 | 0.0026 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A1a Fuel Combustion Activities (Sheet 4 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| Energy & Transformation | | | | | | | | | | | | | |
| Electricity & Heat Prod. | | | | | | | | | | | | | |
| Liquid fuel | 167.32 | 12,931.50 | 0.02 | 0.51 | | | | 77.2862 | 0.0001 | 0.003 | | | |
| Gas/Diesel Oil | 3.769 | 279.13 | 0 | 0.01 | | | | 74.0594 | 0 | 0.0027 | | | |
| Residual Fuel Oil | 163.33 | 12,636.19 | 0.02 | 0.5 | | | | 77.366 | 0.0001 | 0.0031 | | | |
| Lubricants | 0.221 | 16.21 | 0 | 0 | | | | 73.3484 | 0 | 0 | | | |
| Natural Gas | 186.24 | 10,448 | 0.06 | 0.38 | | | | 56.1001 | 0.0003 | 0.002 | | | |
| Total | 353.56 | 23,379 | 0.08 | 0.89 | | | | 66.1263 | 0.0002 | 0.0025 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A1b Fuel Combustion Activities (Sheet 5) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| Energy & Transformation | | | | | | | | | | | | | |
| Petroleum Refining | | | | | | | | | | | | | |
| Liquid fuel | 13.75 | 1035.5 | 0 | 0.05 | | | | 75.3098 | 0 | 0.0036 | | | |
| Gas/Diesel Oil | 8.4 | 622.55 | 0 | 0.03 | | | | 74.0602 | 0 | 0.0036 | | | |
| Residual Fuel Oil | 5.22 | 404.16 | 0 | 0.02 | | | | 77.366 | 0 | 0.0038 | | | |
| Lubricants | 0.12 | 8.8 | 0 | 0 | | | | 73.3333 | 0 | 0 | | | |
| Natural Gas | 12.57 | 705.29 | 0 | 0.03 | | | | 56.1001 | 0 | 0.0024 | | | |
| Total | 26.32 | 1,740.80 | 0 | 0.08 | | | | 66.1348 | 0 | 0.003 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A2 Fuel Combustion Activities (Sheet 7 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| **Industry** | | | | | | | | | | | | | |
| Liquid Fuel | 239.43 | 18,283.92 | 0.03 | 0.75 | | | | 72.1635 | 0.0003 | 0.0031 | | | |
| LPG | 1.513 | 95.41 | 0 | 0 | | | | 63.0601 | 0 | 0 | | | |
| Other Kerosene | 0.313 | 22.49 | 0 | 0 | | | | 71.853 | 0 | 0 | | | |
| Gas/Diesel Oil | 57.96 | 4,292.89 | 0.01 | 0.18 | | | | 74.06 | 0.0002 | 0.0031 | | | |
| Residual Fuel Oil | 173.66 | 13,434.34 | 0.02 | 0.53 | | | | 77.36 | 0.0001 | 0.0031 | | | |
| Lubricants | 1.664 | 122 | 0 | 0.01 | | | | 73.3173 | 0 | 0.006 | | | |
| Other Oil Products | 4.32 | 316.79 | 0 | 0.03 | | | | 73.331 | 0 | 0.0069 | | | |
| Natural Gas | 54.527 | 3,058 | 0.02 | 0.11 | | | | 56.1001 | 0.0004 | 0.002 | | | |
| Total | 293.96 | 21,343 | 0.05 | 0.86 | | | | 64,132 | 0.00035 | 0.00259 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A3 Fuel Combustion Activities (Sheet 8) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| **Transport** | | | | | | | | | | | | | |
| Liquid Fuel | 252.132 | 18,189.67 | 10.63 | 8.87 | | | | 73.2 | 0.0193 | 0.01585 | | | |
| Gasoline | 95.782 | 6,637.69 | 9.65 | 2.17 | | | | 69.3 | 0.1007 | 0.0227 | | | |
| Jet Kerosene | 20.137 | 1,446.90 | 0 | 0.06 | | | | 71.8528 | 0 | 0.003 | | | |
| Gas/Diesel Oil | 125.48 | 9,293.27 | 0.93 | 6.59 | | | | 74.06 | 0.0074 | 0.0525 | | | |
| Residual Fuel Oil | 6.189 | 478.82 | 0.05 | 0.02 | | | | 77.3663 | 0.0081 | 0.0032 | | | |
| Lubricants | 3.195 | 234.29 | 0 | 0.02 | | | | 73.3302 | 0 | 0.0063 | | | |
| Other Oil Products | 1.346 | 98.7 | 0 | 0.01 | | | | 73.3284 | 0 | 0.0074 | | | |
| Total | 252.132 | 18,189.67 | 10.63 | 8.87 | | | | 73.2 | 0.0193 | 0.0158 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A Fuel Combustion Activities (Sheet 10 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| **Small Combustion** | | | | | | | | | | | | | |
| Liquid Fuel | 142.1 | 9,868 | 0.43 | 0.7 | | | | 69.446 | 0.003 | 0.0049 | | | |
| LPG | 39.21 | 2,473.15 | 0.12 | 0.12 | | | | 63.06 | 0.0031 | 0.0031 | | | |
| Other Kerosene | 101.35 | 7,282.87 | 0.31 | 0.31 | | | | 71.8529 | 0.0031 | 0.0031 | | | |
| Gas/Disel Oil | 0.763 | 56.51 | 0 | 0.13 | | | | 74.0629 | 0 | 0.1704 | | | |
| Lubricants | 0.763 | 55.95 | 0 | 0 | | | | 73.32 | 0 | 0 | | | |
| Natural Gas | 2.855 | 160.17 | 0 | 0.7 | | | | 56.1016 | 0 | 0.0035 | | | |
| Total | 144.958 | 10,028 | 0.43 | 0.71 | | | | 69.1831 | 0.003 | 0.0049 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A 4a Fuel Combustion Activities (Sheet 11 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| Small Combustion | | | | | | | | | | | | | |
| Commercial | | | | | | | | | | | | | |
| Liquid fuel | 5.487 | 346 | 0.02 | 0.29 | | | | 63.06 | 0.0036 | 0.052 | | | |
| LPG | 5.487 | 346 | 0.02 | 0.02 | | | | 63.06 | 0.0036 | 0.0036 | | | |
| Total | 5.487 | 346 | 0.02 | 0.29 | | | | 63.06 | 0.0036 | 0.0529 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A4b Fuel Combustion Activities (Sheet 12 ) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| Small Combustion | | | | | | | | | | | | | |
| Residential | | | | | | | | | | | | | |
| Liquid fuel | 127.97 | 8,898.78 | 0.39 | 0.39 | | | | 69.5353 | 0.003 | 0.003 | | | |
| LPG | 33.73 | 2,127.14 | 0.1 | 0.1 | | | | 63.06 | 0.003 | 0.003 | | | |
| Other Kerosene | 94.24 | 6,771.64 | 0.29 | 0.29 | | | | 71.853 | 0.0031 | 0.0031 | | | |
| Natural Gas | 2.85 | 160.17 | 0 | 0.01 | | | | 56.1016 | 0 | 0.0035 | | | |

## STANDARD DATA TABLE 1

## Energy : 1A 4c Fuel Combustion Activities (Sheet 13) - detailed technology based calculation

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | Emissions Estimates | | | | | | AGGREGATE EMISSION FACTORS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector Specific Data by fuel | A<br>Consumption (PJ) | B<br>Quantities Emitted<br>(Gg of Full Mass of Pollutant) | | | | | | C<br>Emission Factor<br>(t Pollutant/ TJ)<br>C=B/A | | | | | |
| | | CO2 | CH4 | N2O | NOx | CO | NMVOC | CO2 | CH4 | N2O | NOx | CO | NMVOC |
| 1 A Fuel Combustion Activities | | | | | | | | | | | | | |
| Small Combustion | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | | | | | |
| Liquid fuel | 8.641 | 623.69 | 0.02 | 0.02 | | | | 72.178 | 0.0023 | 0.0023 | | | |
| Other Kerosene | 7.115 | 511.23 | 0.02 | 0.02 | | | | 71.8524 | 0.0028 | 0.0028 | | | |
| Gas/Diesel Oil | 0.763 | 56.51 | 0 | 0 | | | | 74.0629 | 0 | 0 | | | |
| Lubricants | 0.763 | 55.95 | 0 | 0 | | | | 73.329 | 0 | 0 | | | |
| Total | 8.641 | 623.69 | 0.02 | 0.02 | | | | 72.178 | 0.0023 | 0.0023 | | | |

# STANDARD DATA TABLE 1

## Energy : 1B2 Fugitive Emissions from Fuels (Oil and Natural Gas)

| SOURCE AND SINK CATEGORIES | ACTIVITY DATA | EMISSION ESTIMATES | | | AGGREGATE EMISSION FACTORS | | |
|---|---|---|---|---|---|---|---|
| | Fuel Quantity (PJ) | CH4 (Gg) | CO2 (Gg) | NMVOC (Gg) | CH4 Kg/GJ | CO2 Kg/GJ | NMVOC Kg/GJ |
| 1 B2 a Oil | | | | | | | |
| i Exploration (no. of wells drilled) | 15 | 0.04 | | | 2650 | | |
| ii Production of Crude Oil | 1851 | 4.91 | | | 2650 | | |
| iii Transport of Crude Oil (Qnty. loaded on tankers) | | | | | | | |
| iv Refining/ Storage (Qnty. refined) | 1038 | 0 | | | 745 | | |
| v Distribution of Oil Products (Qnty. consumed) | 953 | 0.77 | | | 745 | | |
| vi Other | | | | | | | |
| 1 B 2 b Natural Gas | | | | | | | |
| i Production/Processing (Qnty. produced) | 304.4 | 21.61 | | | 71000 | | |
| ii Transmission/Distribution (Qnty. consumed) | 303.16 | 35.77 | | | 118000 | | |
| iii Other Leakage (Qnty. consumed) | 303.16 | 26.45 | | | 87000 | | |
| 1B2 c Venting and Flaring | | | | | | | |
| i Oil (Qnty. produced) | 1851 | 3.7 | | | 2000 | | |
| ii Natural Gas (Qnty. produced) | 304 | 58.37 | | | 192000 | | |
| iii Combined (Qnty. produced) | | | | | | | |

## STANDARD DATA TABLE 2 : INDUSTRIAL SECTOR

| Source and Sink Categories | Activity Data | Emissions | | | Aggregate Emission Factors | | |
|---|---|---|---|---|---|---|---|
| **Sectors** | A<br>Production Quantity (Gg) | B<br>Full Mass of Pollutant (Gg) | | | C<br>Tonne of Pollutant per tonne of product (t Pollutant \ t)<br>C=B/A | | |
| | | CO2 | CH4 | N2O | CO2 | CH4 | N2O |
| **A Iron and Steel** (1) | 2611.3 | 1041.91 | | | 0.399 * | | |
| **B Non-Ferrous Metals** | | | | | | | |
| Aluminum production (2) | 177.7 | 390.94 | | | 2.2 * | | |
| **C Inorganic Chemicals** | | | | | | | |
| Ammonia Production (3) | 66 | 143.682 | 1.452 | | 2.177 * | 0.022 * | |
| Nitric Acid production | 5.833 | | | 0.032 | | | 0.0055 |
| **D Organic Chemicals** | | | | | | | |
| Adipic Acid production | NP | | | | | | 0.3 |
| **E Non-Metallic Mineral Products** | | | | | | | |
| Cement production (4) | 15782 | 7867.3 | | | 0.4985 | | |
| Lime production | 71.23 | 55.9 | | | 0.785 | | |
| **F Others** (5) | | | | | | | |
| Carbon Black | NP | | | | | 0.011 | |
| Methanol | 9.16 | | 0.018316 | | | 0.002 | |
| Coke production | 1210.3 | | 0.61 | | | 0.0005 | |
| Sinter production | 2000 | | 1 | | | 0.0005 | |
| Pig iron production | 1000 | | 0.9 | | | 0.0009 | |
| **Total** | | 9499.8 | 3.98 | 0.032 | | | |

**Sources:**

(1) Production quantities : The General Organization for Indus
Emission Factors: Procedure of calculations "attache

(2) Production quantities : The General Organization for Indus
Emission Factors: Procedure of calculations "attached in a case stuc

(3) Production quantities : The General Organization for Indus
Emission Factors: Procedure of calculations "attached in a case stuc
E.F. for N2O from IPCC guidelines, 199

(4) Production quantities : UNEP GHG Abatement Costing Studies, Case Study on Egypt, 1993. & The General Organizatio
E.F. for cement from IPCC guidelines, 199
E.F. for cement from U.S. Environmental Protection Agency, U.S. GHG Emissions & Sinks, Sep. 19

(5) Production quantities : The General Organization for Indus
E.F. from IPCC guidelines, 199

**STANDARD DATA TABLE 4**
**Agriculture: 4A & B**

## Enteric Fermentation & Manure Management

| Source and Sink Categories | Activity Data | Emission Estimates | | Aggregate Emission Factor | |
|---|---|---|---|---|---|
| | A | B | | | |
| | Number of Animals | Enteric Fermentation | Manure Management | Enteric Fermentation | Manure Management |
| | 1000 | Gg CH4 | | kg CH4 per head per year C=(B/A)X 1000 | |
| 1-Cattle | 2993 | 101.26 | 4.36 | | |
| a-Dairy | 1327 | 49.39 | 2.74 | 36 | 2 |
| b-Non-Dairy Cattle | 1612 | 51.87 | 1.62 | 32 | 1 |
| 2-Buffalo | 2729 | 153.56 | 13.96 | 55 | 5 |
| 3-Sheep | 4147 | 20.74 | 0.87 | 5 | 0.21 |
| 4-Goats | 4446 | 22.23 | .98 | 5 | 0.22 |
| 5-Camels and Llamas | 197 | 9.06 | 0.5 | 46 | 2.56 |
| 6-Horses | 10 | 0.18 | 0.02 | 18 | 2.18 |
| 7-Mules/Asses | 1624 | 16.24 | 1.93 | 10 | 1.19 |
| 8-Swine | 102 | 0.1 | 0.61 | 1 | 6 |
| 9-Poultry | 42 | 0 | 0 | NE | 0.02 |
| 10-Other | | | | | |

*Number of animals is calculated as an average value of the years 1989,1990,1991.

**STANDARD DATA TABLE 4**
**Agriculture: 4C Rice Cultivation-Flooded Rice Fields**

| Source and Sink Categories | Activity Data | | Emission Estimates | Aggregate Emission Factor |
|---|---|---|---|---|
| | A<br>Area Cultivated<br>In Megahectar<br>(Mha) | B<br>Megahectar<br>Days of<br>Cultivation<br>Mha-days | C<br>Methane<br>Gg CH4 | D<br>CH4 Average<br>Emission Factor<br>Kg CH4 per ha-day |
| | | | | D=C/B |
| 1-Continuously Flooded | 0.43 | 51.6 | 189 | 3.68 |
| 2-Intermittently Flooded | No | No | No | No |
| 3-Other | No | No | No | No |

**STANDARD DATA TABLE 4**
**Agriculture: 4D Agriculture Soils**

| Source and Sink Categories | Activity Data | | | Emission Estimates | | | Removal Estimates | Aggregate Emission Factor(s) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A Amount of Nitrogen Applied in Fertilizer And Manure (Tn) | B Area Cultivated (ha) | C Amount Of Biological Fixation Of Nitrogen | Emissions of N2o,co2,ch4 (Gg) | | | G Removals of CO2 (Gg CO2) | H (tn2o/Tn) (t CO2/ha) (tCH4/ ha) | | |
| | | | | D | E | F | | 1000D/A | 000E/B | 1000F/B |
| | | | | N2O | CO2 | CH4 | | N2O | Co2 | Ch4 |
| All Crops | 939,480 | 5,122,304 | 159,000 | 21.14 | 0 | 0 | | 0.0225 | 0 | 0 |

**STANDARD DATA TABLE 4**
**Agriculture: 4F Agriculture Soils**

| Source Categories | Activity Data | | Emission Estimates | | | | | Aggregate Emission Factor(s) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop Type | A Annual Burning Of crop Residues (Gg dm) | B Carbon Fraction (t/t dm) | C Full Mass of Pollutant (Gg) | | | | | D Pollutant per tonne of Dry Matter (Kg/t dm) | | | | |
| | | | | | | | | D=(C/A)X1000 | | | | |
| | | | CH4 | N2O | NOX | CO | CO2 | CH4 | N2O | NOX | CO | CO2 |
| 1-Wheat | 45.06 | 0.4853 | 0.146 | 0.003 | - | - | IE | 0.003 | 0 | - | - | IE |
| 2-Barley | 1.54 | 0.4567 | 0.005 | 0 | - | - | IE | 0.003 | 0 | - | - | IE |
| 3-Chickpea | 0.1 | 0.4226 | 0.003 | 0 | - | - | IE | 0.003 | 0 | - | - | IE |
| 4-Bean | 2.87 | 0.4226 | 0.008 | 0.001 | - | - | IE | 0.003 | 0 | - | - | IE |
| 5-Lupines | 4.09 | 0.4226 | 0.012 | 0.001 | - | - | IE | 0.003 | 0 | - | - | IE |
| 6-Cotton | 571.88 | 0.4709 | 1.795 | 0.059 | - | - | IE | 0.003 | 0 | - | - | IE |
| 7-Maize | 1,013.07 | 0.47 | 3.174 | 0.105 | - | - | IE | 0.003 | 0 | - | - | IE |
| 8-Peanut | 8.99 | 0.4226 | 0.025 | 0.002 | - | - | IE | 0.003 | 0 | - | - | IE |
| 9-Sorghum | 133.43 | 0.4709 | 0.419 | 0.014 | - | - | IE | 0.003 | 0 | - | - | IE |
| 10-Rice | 439.8 | 0.4144 | 1.215 | 0.028 | - | - | IE | 0.003 | 0 | - | - | IE |
| 11-Sesame | 12.64 | 0.4226 | 0.035 | 0.003 | - | - | IE | 0.003 | 0 | - | - | IE |

# STANDARD DATA TABLE 5

## Land Use Change & Forestry: 5A (Sheet 1) Changes in Forest and Other Woody Biomass Stoks - Annual Growth Increment

| SOURCE AND SINK CATEGORY | | | ACTIVITY DATA | UPTAKE ESTIMATES | AGGREGATE UPTAKE FACTOR |
|---|---|---|---|---|---|
| Sector Specific Data (units) Land Type | | | Area of Forest/Biomass Stocks (Kha) | Total Carbon Uptake Increment (Gg C) | Carbon Uptake Factor (t C/ha) |
| Tropical Forests | Plantations (specify type) | | | | C=B/A |
| | | | No | No | No |
| | | | | No | No |
| | | | | | |
| | Other Managed Forests | Moist | No | No | No |
| | | Seasonal | No | No | No |
| | | Dry | No | No | No |
| | Other | | No | No | No |
| Temperate Forests | Plantations (specify type) | | No | No | No |
| | | | | | |
| | Commercial | Deciduous | No | No | No |
| | | Evergreen | No | No | No |
| | Other | | No | No | No |
| Boreal Forests | | | No | No | No |
| Other Ecosystem Type | | | No | No | No |
| Non-Forest Trees (specify type) | | | Number of Trees (1000) | Annual Carbon Uptake (Gg C) | Carbon Uptake Factor (t C/tree) C=B/A |
| | | | 60,000 | 2,700 | 22.2 |
| | | | | | |
| | | | | | |

## STANDARD DATA TABLE 5

**Land Use Change & Forestry:**

**5A (Sheet 3) Changes in forest and Other Woody Biomass Stocks - Net**
**CO2 Emissions/Removals**

| SOURCE AND SINK CATEGORIES | A<br>EMISSION/ UPTAKE<br>C (Gg) | B<br>EMISSIONS/REMOVALS<br>CO2(Gg) |
|---|---|---|
| | | B = Ax(44/12) |
| Total Annual Growth Increment | 2,700 | 9,900 |
| Total Annual Harvest | | |
| NET EMISSIONS (+) OR REMOVALS(-) | | |

## STANDARD DATA TABLE 6
## WASTE: 6 A SOLID WASTE DISPOSAL ON LAND, 6 C WASTE INCINERATION, 6 D OTHER WASTE

| SOURCE/SINK CATEGORIES | ACTIVITY DATA Gg | EMISSION ESTIMATES Gg | | | AGGRIGATE EMISSION FACTORS Kg/ t | | | CH4 RECOVERED Gg |
|---|---|---|---|---|---|---|---|---|
| DISPOSAL METHOD | A | B1 CO2 | C CH4 | D N2O | H1 CO2 | I CH4 | J | |
| | ANNUAL DOC | | | | 1000B/A | 1000C/A | | |
| | LANDFILLED (Gg) | | | | | | | |
| A1 LANDFILLS | 137.7 | | 70.68 | | | 513.2898 | | 0 |
| A2 OPEN DUMPS | 342.7 | | 193.59 | | | 564.8964 | | 0 |
| | QUANTITY OF WASTE TREATED (Gg) | CO2 | CH4 | N2O | CO2 1000B/A | CH4 1000C/A | N2O 1000D/A | |
| C WASTE INCINERATION | | | | | | | | |
| D OTHER WASTE | | | | | | | | |

**Standard Data Table 6**
**Waste; 6B Wastewater Treatment**

| **Source and Sink Categories** | **Activity Data** | | **Emission Estimates** | | | **Aggregate Emission Factor(s)** | | | **$CH_4$ Recovered** |
|---|---|---|---|---|---|---|---|---|---|
| **Wastewater Type** | A Annual Bod | B Quantity of Bod Anaerobically Treated (Gg Bod5) | C Total Methane Released Gg | D Carbon Dioxide Gg | E Nitrous Oxide Gg | F Methane | G Carbon Dioxide | H Nitrous Oxide | I Quantity $CH_4$ |
| | | | | | | ($GgCH_4$/Gg BOD5) F=C/B | ($GgCO_2$/Gg BOD5) G=D/B | ($GgN_2O$/Gg BOD5) H=E/B | (Gg) |
| **B1 Industrial Wastewater** | 298.2 | 23.84 | 5.25 | | | 0.22 | | | 0 |
| **B2 Domestic &Commercial Wastewater** | 837.76 | 67.02 | 1.34 | | | 0.02 | | | 0 |
| **B3 Other** | | | | | | | | | |