Socialist Republic of Viet Nam

Ministry of Natural Resources and Environment

Viet Nam

Initial National Communication

Under the United Nations Framework Convention on Climate Change

Ha Noi - 2003

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PREFACE

Viet Nam signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it on 16 November 1994. In order to fulfill the commitment described in the articles 12.1, 12.5 of UNFCCC and following the guidelines "Preparation of the Initial National Communication" for Non-Annex I Parties that w

as approved at COP-2 dated 19 July 1996, the Goverment of Viet Nam assigned the Hydro-Meteorological Service, now adaps Ministry of Natural Resources and Environment of Viet Nam as a National Authority, to implement the project "Viet Nam: Preparation of the Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) - GF/2200-97-54" with the financial and technical support from the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP).

The Communication consists of 7 Chapters:

- Chapter 1: Describe the general features of geography, climate, and socio-economic conditions of Viet Nam in 1994.
- Chapter 2: National Greenhouse Gas Inventory in 1994, and estimated national greenhouse gas emissions to 2020.
- Chapter 3: Analyse the greenhouse gases mitigation options in energy, agriculture and forestry sectors.
- Chapter4: Assessment of the potential impacts of climate change on some major economic activities and response measures.
- Chapter 5: The system of climate observations and some results of climate change research in Viet Nam.
- Chapter 6: Describe the contents of education, training and raising public awareness on climate change.
- Chapter 7: The main orientation of mitigate greenhouse gases through economic development plan of energy, agriculture, forestry sectors.

GEOGRAPHICAL, CLIMATE, AND SOCIO-ECONOMIC CONDITIONS OF VIET NAM IN 1994

Viet Nam is located in the South East Asia. Its land area is 330,990 km^2 and the sea territories under sovereignty and jurisdiction is more than 1 million km^2. Viet Nam has a monsoon tropical climate with plentiful heat, high humidity, and is affected by many typhoons and tropical cyclones.

The agricultural land is 7.37 million hectares; gross output of food crops in paddy equivalent is 26.2 million tons. Agriculture, forestry and fishery contribute 28.7% to the GDP.

Forestland was about 19 million hectares (in 1994), in which only 9.3 million hectares had forest coverage of 28 -29 %.

The population of Viet Nam in 1994 was approximately 70.8 million with high growing rate, in average from 1.6 to 1.7%. Viet Nam is an agricultural country with 70 – 80% of the population living in rural areas.

Viet Nam industry is still not developed yet, the technologies in energy production and using are still obsolete and power consumption per one product unit is high. Commercial power supply level is low in comparison with other countries (only about 0.12TOE/person). However, the energy resources potentials are diversified and have not been explored enough.

The economy has had high growth rate since 1990-1999; GDP has increased by 2 times after 10 years. Average annual GDP growth rate was 8.2% during 1991 – 1995, in which agricultural output more than 4%, industry nearly 13% and services more than 9%. Domestic accumulation attained 18-20%.

GREENHOUSE GAS INVENTORY:

The National Greenhouse Gas (GHG) inventory of 1994 was carried out for the following main emitters: energy, industry processes, forestry and land use change, agriculture, and waste sector.

The methodology of inventory follows the guidance of IPCC version 1996, and complies with the guidelines for preparation of National Communications for Non-Annex I Parties.

Most of emission factors used in the inventory were the IPCC default emission factors of 1996. In addition, some emission factors of Thailand and India… were used and for reference. Particularly, the methane emission factor of the wet rice paddy with organic fertilizer was from the results of experiment in Viet Nam in the Methane Asia Campaign Programme, carried out during 1998-1999.

The total GHG emissions in 1994 were 103.8 million tons of CO_2 equivalent, and 1.4 tons CO2 equivalent per capita.

About GHG components, CO_2 contributed 40.6 million tons, i.e. 39.1%, 2.5 million tons of CH_4 – 50.6% and 34 thousand tons of N_2O – 10.1%.

GHG emissions from energy sector was 25.6 million tons of CO_2 equivalent, occupied 24.7% of total national emissions, forestry and land use change: 19.38 million tons of CO_2, occupied 18.7%, agriculture: 52.45 million tons of CO_2 equivalent, occupied 50.5%; industrial processes and wastes: 3.8 and 2.5 million tons of CO_2, occupied 3.7% and 2.4% respectively.

GHG inventory in 1994

Sector	Amount CO_2 equivalent (thousand tons) (CO_2+CH_4+N_2O)	(%)
1. Energy	25,637.09	24.7
2. Industrial processes	3,807.19	3.7
3. Agriculture	52,450.00	50.5
4. Forestry and land use change	19,380.00	18.7
5. Waste	2,565.02	2.4
Total emissions	103,839.30	100

Based on BAU scenario, estimated GHG emissions for 2010 is 140 million tons and for 2020 is 233 million tons of CO_2 equivalent.

GHG MITIGATION OPTIONS:

Based on the results of GHG inventory, GHG mitigation options in Viet Nam were developed for 3 following sectors:

- Energy
- Forestry and land use change
- Agriculture

In combination with former studies, in this communication 18 GHG mitigation options were developed and assessed, including 9 options for energy sector, 6 for forestry and land use change, 3 for agriculture.

❑ *Energy:*

The estimation of GHG mitigation options in energy was based on the model EFOM-EVN, which optimizes the energy flow to calculate the effectiveness of energy system when applying the energy saving measures to mitigate the GHG emissions in Viet Nam during the period 1994-2020. In this report, 9 GHG mitigation options were presented, including measures to increase the effectiveness of boilers in industrial production (2 options), transport sector (1 option), development of renewable energy sources such as geo-thermal, solar radiation and wind energy (3 options) and the effectiveness of energy use (3 options).

The potential of GHG mitigation of the above-mentioned 9 options is 283.8 million-ton CO_2. equivalent.

❑ *Forestry and land use change:*

The COMAP model was used in development and evaluation of GHG mitigation options in forestry

and land use change during 1994-2020.

The action plans of the existing program on plantation of 5 million ha forest and protection of the existing natural forest, to assure the forest planting activities, and forest protection with appropriate investment, were basic scenarios for development of mitigation options in forestry. Six options were developed and estimated as follows:

- Forest protection.
- Natural regeneration.
- Plantation of protection forest and special use forest.
- Plantation of short-term production forest.
- Plantation of long-term production forest.
- Planting scattered trees.

The total GHG emission mitigation potential of these 6 options is 3221.6 million tons of CO_2 equivalent, and it is the biggest mitigation potential among different sectors.

- ***Agriculture:***

Three GHG mitigation options in agriculture were developed based on the direction of agriculture development to 2020. These options are:

- Water management of rice field to reduce methane emission.
- Improvement of feed for animals.
- Build biogas stoves to replace traditional stoves in the rural areas.

The total GHG emission mitigation potential of these 3 options is 140.3 million tons of CO_2 equivalent.

- ***The evaluation results of the GHG mitigation options showed that:***

Among 9 options of energy sector, the improvement of the efficiency of coal boilers (E1), the development of geo-thermal power plants (E4) and solar energy (E5) and wind power require the costs of investment from US$3.65 to US$ 6.01 /ton of CO_2, while all the rest 6 options have negative costs (from - US$3.65 to - US$ 10.54/ton of CO_2).

The total GHG emission mitigation potential of these 18 options is 3,645.7 million tons of CO_2 equivalent for the period 1994-2020.

The option of natural forest protection has the biggest GHG emission mitigation potential (1,302.6 million tons of CO_2 equivalent).

The costs for reduction of 1 ton of CO_2 equivalent for all forestry options are under US$1, while for all agriculture options are from US$3.4 to US$13.1.

CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES:

The impacts of climate change on water resources, agriculture, forestry, energy, aquaculture and human health were assessed based on CSIRO scenario on climate change. According to this scenario, to the year 2070, the earth surface average temperature will increase from 1.5^{o}C to 2.5^{o}C; rainfall variation will be from -5% to 10%. In order to assess the impacts of climate change on coastal zones, the scenario of sea level rise of 1m by 2100 was used.

❑ *Water resources*

Climate change would have profound impacts on surface water resources: annual run-off varies from +4% to -19%, peak discharge, and evapotranspiration increase. Adaptation measures are mainly building, and upgrading of water resources constructions, exploitation and protection of water resources at the same time.

❑ *Agriculture*

Agriculture is a sector sensitive to climate change. The length of growing period would increase, annual sum of temperature and minimum temperature would increase and therefore, the boundary and length of growing period of tropical trees would increase. Drought, flood and evapotranspiration of the trees would also increase, adversely affecting the yield and productivity.

The adaptation measures to climate change in agriculture are mainly the development of suitable cropping patterns, development of appropriate farming techniques to climate change, enhancement of irrigation system for agriculture and producing new crop varieties that could stand against severe environment conditions.

❑ *Coastal zone*

The impacts of climate change, firstly sea level rise, would severely affect coastal zone: the inundated area in coastal zone would increase, millions of hectares of the Mekong Delta and Red River Delta would be inundated, hundred thousands of hectares of mangrove forests would be lost. The living and constructions of the coastal people would also become worsening. The adaptation strategy measures to climate change for coastal zone were designed as follows:

- Full protection.
- Adaptation.
- Withdrawal or avoidance.

❑ *Forestry*

Climate change would have seriously impacts on vegetation coverage and forest ecosystem. Sea level rise would make mangrove forest decreasing and adversely affect indigo forest and sulfated land forest. It is possible that there would be changes in boundary distribution of primary forest as well as secondary forest. That increase the gabfer of extinction of some animal and plants, leading to the loss of

precious gene resources. Furthermore, the increase of temperature and drought would lead to increasing danger of forest fire and spreading of plant pests and diseases.

Some adaptation measures included: enhancing afforestation and forest protection, firstly in watershed, regreening bare lands and hills, protecting and developing of mangrove forest, preventing forest fire, enhancing timber processing and limiting use wood as material, selecting and developing plant varieties suitable to natural conditions taking account climate change.

❑ *Energy and Transport*

The potential impacts of climate change on energy and transport sector mainly in energy production, consumption and supply, and infrastructure of transport, the decrease of efficiency and productivity, therefore increasing expenditure on new investment, maintenance, repair and upgrade of electric equipment and supply network.

The adaptation measures in energy and transportation sectors included: developing stratifies responding and adapting to the vagary of weather, demand site management of energy based on high efficiency of energy use, upgrading and reconstructing transport infrastructure in areas often threatened by sea level rise and flood.

❑ *Aqua-culture*

Aquaculture would be also affected by adverse impacts of climate change. The hydro-ecological system, sea product profit and fisheries… are subjected to direct impacts of climate change.

The main adaptation measures are changes in farming structure in aquaculture areas, protection of coastal aquaculture areas...

❑ *Human health*

Climate change would has direct negative impacts on human health: the danger of diseases suffering would increase, the human capabilities to resist diseases would decrease…the resources of disease carriers and spreading would rise such as fever, hemorrhages…

Adaptation measures for community in the condition of climate change are improving the people's living standard, developing a national Programme on control and inspection of public health, establishing areas with green, clean and beautiful microclimate…

CLIMATE AND WEATHER OBSERVATION AND MONITORING SYSTEM

Climate and weather observation and monitoring system in Viet Nam has been set up since the end of 19th century. After more than 100 years of establishment and development, at present, the meteorological station network in Viet Nam consists of 166 meteorological surface stations, 902 rain-gauge stations and some other specialized stations. The Hydro-Meteorological Service of Viet Nam (HMS) now is Ministry of Natural Resourches and Environment is responsible for their management and development.

The data collected from the Hydrometeorological station network are processed, archived and studied to monitor the changes and tendencies of climate characteristics, especially temperature and rainfall. The research into climate change in Viet Nam based on the last 50 years of observation has come to the following conclusions on climate change and tendency:

- ❏ Monthly mean temperature has increased in the past decades with the rate from 0.07 to 0.15^{o}C per decade.
- ❏ There are big variations without clear tendencies in rainfall.
- ❏ Sea level rises from 2.5 to 3.0cm per decade.
- ❏ The trajectory of typhoons was moving southward and typhoon season was shifting to later months of the year.

EDUCATION, TRAINING AND ENHANCEMENT OF PUBLIC AWARENESS

Viet Nam pays attention to the enhancement of public awareness on environment in general and climate change in particular. In 1993, the Environment Law was adopted by General Assembly. In 1994, the Government of Viet Nam issued “Guidelines for implementation of Environment Law”. The national environment protection strategy for the period of 2001-2010 was also formulated.

Since the Government of Viet Nam signed and ratified the United Nations Framework Convention on Climate Change and signed the Kyoto Protocol, many activities on climate change have been implemented. In 1994, Viet Nam Climate Change Country Team (VNCCCT) was established with the task to strengthen the public awareness on climate change and its impacts on socio-economy and environment. VNCCCT was also responsible for formulating "Country Programme to implement the United Nations Framework Convention on Climate Change". Viet Nam has developed and implemented many projects on climate change with the cooperation from international organizations and other countries. These projects help to raise the public awareness on climate change and give good ground and manpower for implementing future climate change project.

Moreover, the national mass media also contribute to enhance the public awareness through their programs, newspaper articles, as well as videotapes and movies… on climate change. Viet Nam has organized many workshops, seminars, meetings,… for policy makers, managers and local authority.

Viet Nam is planning to conduct education on environmental broadly within schools and universities. There are Natural Resources and Environment Faculties in Universities conducting education and training courses on climate change.

GREENHOUSE GAS MITIGATION ORIENTATION IN SOCIO-ECONOMIC SECTORS: ENERGY, AGRICULTURE, FORESTRY

In energy sector:

- Efficient use of energy.
- Effective and rational use of power resources, development and maximal utilization of

hydropower and gas.

- Development of new and renewable energy.
- Determination of environment standards, evaluation of environmental benefits and costs for energy projects.

In agriculture:

- Development and application of sustainable agricultural farming techniques to enhance the agricultural production and to mitigate GHG emissions.
- Improvement of irrigation-drainage management in rice fields.
- Strengthening the capacities of agriculture research institutions.
- Researching on improving the crop and animal varieties.

In forestry and land use change:

- To promote the implementation of the programme to plant 5 million hectares of forest effectively.
- To conserve and restore the existing forest, to minimize the exploitation of natural forest.
- To stabilize the area structure of forests, including 12 million hectares of natural forest and 3.5 million hectares of planted forest.
- Forest fire prevention and preparedness.
- To raise the living standard of the people in mountainous areas, in combination with the realization of all social policies at the same time: allocating of land and forest to local households, settlement of living and cultivation areas, poverty alleviation…

INTRODUCTION

The Government of Viet Nam signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it on 16 November 1994. As a Party to the Convention, Viet Nam has participated in many activities to implement the Convention. The First National Communication is one of those activities.

On the basis of Decision 10/CP2 of the Second Conference of the Parties (COP2) for Non-Annex I Parties, the project "Viet Nam: Preparation of the Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) - GF/2200-97-54" is implemented with the financial and technical supports from GEF and UNEP (Articles 12.4 and 12.7 of UNFCCC). The main objectives of the project are to prepare the Initial National Communication of Viet Nam on climate change to submit to the Convention Secretariat, (Article 12.5 of UNFCCC).

The Communication was 7 Chapters. Chapter 1 describes the general features of geographical, climate and socio-economic conditions of Viet Nam in 1994. On its basis, Chapter 2 gives the results achieved in the National Greenhouse Gas Inventory in 1994, and projected GHG emissions to 2020. The methodology of inventory follows the guidance of IPCC version 1996. Most of emission factors used in the inventory were the IPCC default emission factors. On the basis of GHG inventory, the GHG mitigation options were analyzed and presented in Chapter 3. One of the contents of the Communication was the evaluation of potential impacts of climate change and adaptation measures for major economic sectors, some ecosystems and human health. These were analyzed and presented in Chapter 4. Chapter 5 described the climate observation and monitoring system and results of research into climate change and tendency in Viet Nam. Chapter 6 focused on general content of education, training and strengthening of public awareness on climate change and the organization of these activities in Viet Nam. In Chapter 7 there were proposals on GHG mitigation orientations in the development strategies of major economic sectors: energy, forestry, agriculture…Moreover, a list of projects on climate change were also presented in this Communication.

The Communication not only includes the results of activities in project GF/2200-97-54, but also makes use of the achievements of former researches on climate change in the project "Asia Least-costs Greenhouse Gas Abatement Strategy", "Economics of Greenhouse Gas Limitations" etc.

During the preparation of this Communication, experts on energy, industry, agriculture, forestry, transport, construction, aqua-product, education and training, planning, development strategy…have had valuable contributions in the research, collection, processing of data, analysis, evaluation… following the guidelines of UNFCCCs secretariat.

Bach Ho oil exploitation

Rice harvest

CHAPTER 1

VIET NAM'S GEOGRAPHY, CLIMATE AND SOCIO-ECONOMY IN 1994

Rice field and Sugar palm trees in AnGiang

1.1. GEOGRAPHY

Viet Nam is located in South East Asia, stretching, from 8°27 to 23°23N and from 102°08 to 109°30E. The land area occupies 330,992 km^2. Viet Nam has 1,400 km of borderline to the North with China, 2067 km with Laos and Cambodia to the West. The coastal line of 3,260 km covers the East and the South. The sea water territory under sovereignty and jurisdiction is about 1 mil km^2, 3 tunes of land territory. Apart from 2 offshore archipelagoes Hoang Sa (Da Nang province) and Truong Sa (Khanh Hoa Province), Viet Nam also has a system of coast 3000 big and small islands with total area of more than 1600 km^2.

Three of fourth Viet Nam territory is covered by mountains and hills with the elevation mostly from 100 to 1000 m. The plains concentrate in the down streams of two big rivers, the Red River and Mekong River. The river network in Viet Nam is rather dense with 2360 rivers. The average density is 0.6 km/km^2.

Based on topography[1], Viet Nam is divided into 7 regions:

- Northern upland region;
- Red River Delta;
- Northern Central Coast;
- South Central Coast;
- Central Highland;
- Northern East of the South;
- Mekong Delta

1.2. CLIMATE

Viet Nam possesses a monsoon tropical climate with plentiful heat and humidity but due to the lengthy territory stretching on many latitudes and diversified topography, the differentiation of climate among the regions is rather clear.

Annual mean temperature in different regions ranges from 18 to 29°C. Monthly mean of the coldest month is about 13 – 20°C in the northern mountainous part and from 20 to 28°C in the Southern parts. Temperature of the summer varies from 25 to 30°C.

Viet Nam is located in the area affected by typhoon and tropical cyclones in the North West Pacific Ocean. In average, annually, there are 4-5 typhoons/tropical cyclones affecting Viet Nam.

Annual rainfalls are very different in different regions, ranging from 600mm to 5,000mm. About 80-90% of rainfall concentrates in rainy season, the number of rainy days in the year is also very different between the regions and ranges from 60 to 200. In several regions, floods and inundation occur during rainy season but in dry season, drought is often recorded. As the rainfall distribution is not even during the year.

[1] *Sources:* Viet Nam Statistical Yearbook 1994

Red river Delta

1.3. FOREST LAND AND AGRICULTURE LAND USE

Before 1943, Viet Nam had a forest coverage exceeding 43%. After two wars against the French and the American, the forest cover has decreased rapidly. There is always the threatening of forest reduction due to the stress of population growth, unreasonable exploitation and use of land. In 1994, the forestland remained only 28%-29%. Owing to active forest protection and reforestation measures, forest coverage rate has increased in recent years.

Table 1.1: Land use per capita in 1994

Nº	Region	Average land use per capita (m^2/person)					
		Natural land	Agricultural land	Forest-land	Special useland	Land tenure	Fallow land
1	Northern mountainous and midland region	8321	970	1645	184	154	5359
2	Red River Delta	895	506	40	133	62	154
3	North Central Coast	5262	689	1935	171	71	2396
4	South Central Coast	5978	720	2460	191	73	2534
5	Central Highland	18736	2098	10894	297	177	5270
6	North East South	2635	1077	574	159	110	715
7	Mekong River Delta	2496	1675	192	104	104	421
	Total	4565	1016	1367	155	99	1928

Sources: Viet Nam Statistical Yearbook 2000

Total agricultural land in 1994 is about 7.37Mha (about 22%), 4 Mha of which under rice cultivation. Total paddy equivalent production in 1994 was 26.2 million tons. Agriculture, forestry and aquaculture products occupy 27.4% of GDP. The main sectors in Viet Nam agricultural production are cultivation and husbandry. Farming and food processing technologies are still low. Crop yields and effectiveness of husbandry are not high. Agricultural production depends much on nature. However, Viet Nam agriculture has had remarkable progress since 1990. The growth rate of 1991-2000 is at about 4.2%, assures enough food/foodstuff for domestic consumption and a portion for export. Other agricultural products such as tea, coffee, rubber, have significant contribution to the growth of Viet Nam export.

1.4. POPULATION AND GDP GROWTH RATE

In 1990s, Viet Nam had rather high population growth rate from 1.6 to 1.7%, in 1994, it was 1.69% in the successful family planning implementation, the growth rate of 2000 is 1.4%.

Table 1.2. Population and GDP

Factor \ Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population (million persons)	66.0	67.2	68.4	69.6	70.8	72.0	73.2	74.3	75.5	76.6
Growth rate GDP (%)	5.1	5.8	8.7	8.1	8.8	9.5	9.3	8.2	5.8	4.8

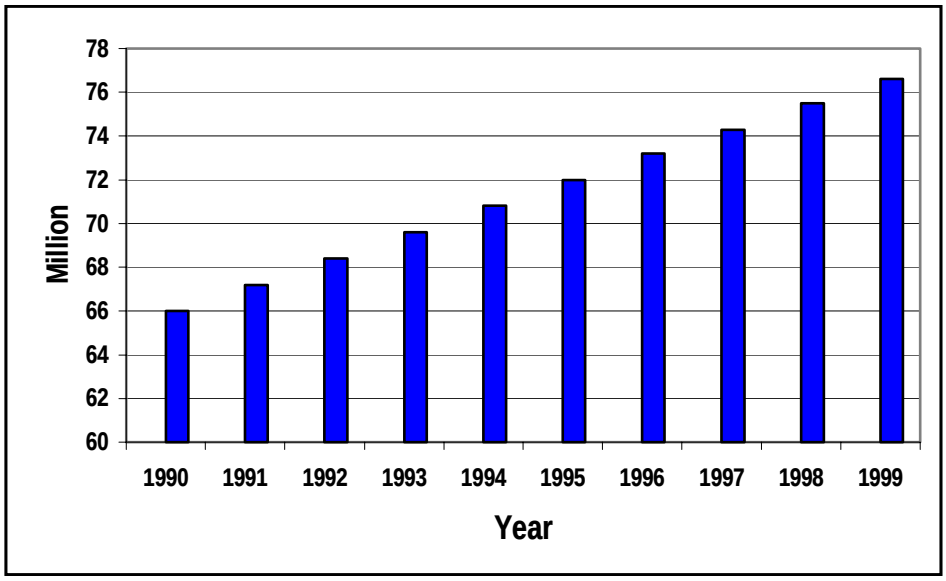
Sources: Viet Nam Statistical Yearbook 2000

Table 1.3: Population structure of different regions (1994)

No	Region	Population structure		Urbanization rate (%)
		Urban (1000 persons)	Rural (1000 person)	
1	Northern mountainous and midland region	1,559.1	8,724.6	15.2
2	Red River Delta	2,596.5	13,339.5	16.3
3	North Central Coast	1,007.0	8,455.9	10.6
4	South Central Coast	1,424.8	4,691.1	23.3
5	Central Highland	742.5	2,465.0	23.1
6	North East of the South	4,741.3	5,725.9	45.2
7	Mekong River Delta	2,381.4	12,996.9	15.5
	Whole country: 70,824.5	**14,425.6**	**56,398.9**	**20.4**

Sources: Viet Nam Statistical Yearbook 2000

Fig. 1.1: Population of Viet Nam, 1990-1999



1.5 INDUSTRY, ENERGY AND ELECTRICITY

During recent years, industry has had the annual growth rate from 10 to 15% (table 1.4). However, Viet Nam industry is still not developed, with obsolete industrial equipment and high-energy consumption per unit of product.

Viet Nam has diverse energy resources, but their potentials are not really abundant and not yet explored. Table 1.5. presents potential and deposits of different energies.

- The total theoretical hydropower potential is about 70,000MW of output capacity and 308 billion kWh of yield. Technical potential is 17,566MW of output capacity and 72billion kWh of yield. Taking into account the economic and environmental factors, the hydropower potential that could be exploited till 2020 is 10,595MW and output is 51.8 billionkWh.
- In uranium, through preliminary exploration (level P1+P2) the kind of price below US$260/kg has the total deposit of about 106.6 thousand tons U308. Uranium potential is rather rich but quality of ore is low.
- Geothermal potential of Viet Nam is not high, with about 300 widely distributed sources and theoretical potential of about 472MW, which could be exploited till 2020 of about 200 MW, and output is 1.2 billion kWh.
- Solar energy potential is rather rich. Average sunshine duration is 1700-2500 hours/year and radiation intensity is about 100-175Kcal/cm^2/year.

- Potential of wind energy is not high, mainly in islands and coastal areas.
- Potential of small and micro hydropower is rather rich in remote areas, its total capacity can attain 2,000 MW, and output can reach 2 billion Kwh.
- Biogas gas potential is not high, and its theoretical potential (in 1994) is about 0.44 TOE/year (924.6 million m^3/year). In reality, only 10-15% of it was exploited.
- Biomass exploited in Viet Nam is rather big, occupies up to 60% of total energy consumption in Viet Nam, mainly for fuel in rural areas.

Table 1.4: Industrial production value in recent years (prices to compare 1989 and 1994)

Year	Total (Billion Viet Nam Dong)	Development index compared to previous year (%)
Prices to compare **1989**		
1990	14 011.1	103.1
1991	15 471.1	110.4
1992	18 116.9	117.1
1993	20 412.0	112.7
1994	23 214.2	113.7
1995	26 584.1	114.5
Prices to compare **1994**		
1995	103 374.7	114.5
1996	118 096.6	114.2
1997	134 419.7	113.8
1998	151223.3	112.5
1999	168749.4	111.6
2000	195321.4	115.7

Sources: Viet Nam Statistical Yearbook 2000

Table 1.5 Energy resources

Kind of energy	Unit	Total deposit (Explored)	Potential	Exploited	Unexploited
Oil	Million m^3	611.9	2329.8	59.5	2270.3
Gas	Million m^3	643.2	1640.4	14	1626.4
Anthracite	Million tons	3,600	6,600	344	6,256
Lignite	Million tons	318.6	3,000-5,000	6.0	

Sources: Project KHCN-09

Table 1.6: Production of various commercial energy types

Forms of energy	1990	1994	1995	1999
Electricity production (Billion Kwh)	8.69	12.28	14.64	23.56
Commercial electricity (Billion Kwh)	6.18	9.28	11.19	19.54
Coal – MTg	4.64	6.37	8.16	9.39
Oil – MTg	2.70	7.07	7.67	15.20
Gas – Billion m^3	-	-	0.18	0.90

Sources: General Department of Statistics and Ministry of Planning and Investment

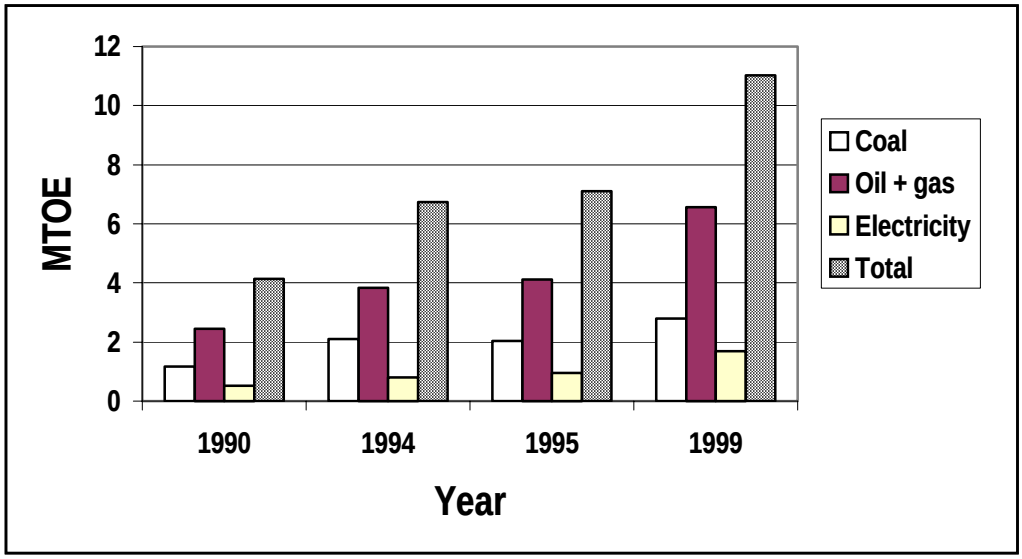
Total energy consumption in 1994 was 6.74 MTOE (table 1.7), in which oil occupied 57.0%, coal 31.1% and electricity 11.9%.

Table 1.7: Total energy consumption during the period 1990-1999 (MTOE)

	1990	1994	1995	1999
Coal	1.16	2.10	2.03	2.79
Oil + gas	2.45	3.84	4.12	6.56
Electricity	0.53	0.80	0.96	1.68
Total	4.14	6.74	7.11	11.03

Sources: Project KHCN-09 (2001)

Figure 1.2: Total energy consumption during 1990-1999



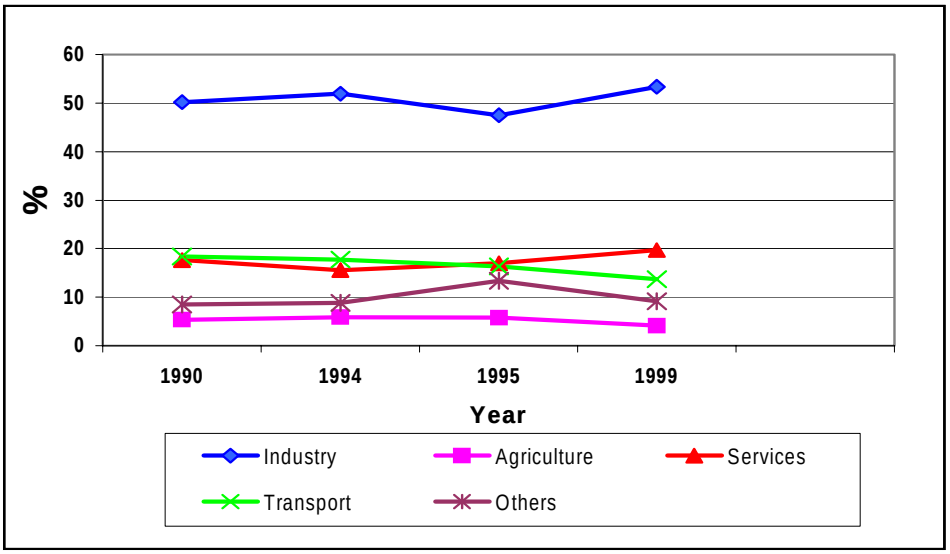
Sources: Project KHCN-09

Table 1.8: Energy consumption of various economic sectors (%)

	1990	1994	1995	1999
Industry	50.2	51.9	47.5	53.4
Agriculture	5.3	5.9	5.8	4.1
Services	17.6	15.6	17.0	19.7
Transport	18.4	17.8	16.3	13.7
Others	8.5	8.8	13.4	9.1
Total	**100**	**100**	**100**	**100**

Sources: Project KHCN-09

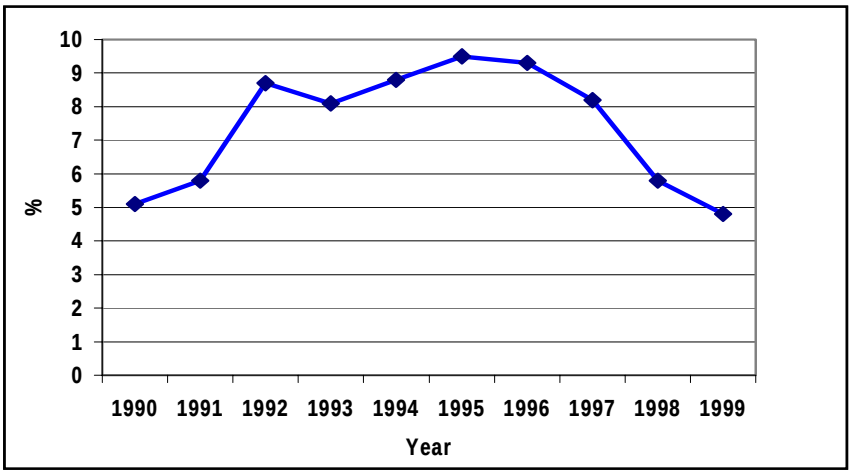
Figure 1.3: Energy consumption by sectors



1.6 ECONOMY

Economic potential has increased significantly. After 10 years, GDP increased by 2 times. GDP per capita increased by 5.32% per year. In this condition, the standard of living has been improved.

Figure 1.4: Annual GDP growth rate (%)



According to statistics, the contributions of various sectors into general economic growth are as follows: industry 28%, agro-forestry 20%, services 15% etc.

During 4 years 1996-1999, although there were many difficulties, the total investment implementation was about USD 29 billion (1995 prices), equaled 70% of estimation for the five year plan 1996-2000, in which:

- State budget capital 21%
- State credit capital 15%
- State enterprises capital 16%
- Inhabitant and private sector capital 24%
- Foreign direct investment capital 24%

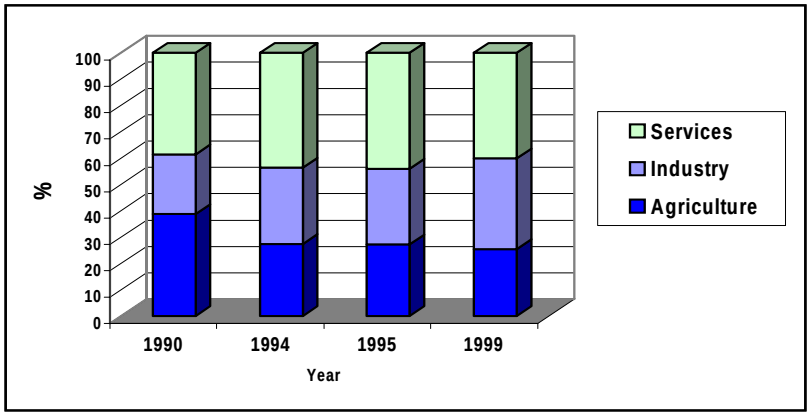
Table 1.9: Gross Domestic Products divided by economic sectors (1994 price)

Unit: billion VND

Year	Total	Agriculture, Forestry and aqua-product	Industry and construction	Services
1990	131968	42003	33221	56744
1991	139634	42917	35783	60934
1992	151782	45869	40359	65554
1993	164043	47373	45454	71216
1994	178534	48968	51540	78026
1995	195567	51319	58550	85698
1996	213833	53577	67016	93240
1997	231264	55895	75474	99895
1998	244596	57866	81764	104966
1999	256272	60895	88047	107330
2000	273666	63717	96913	113036

Sources: Viet Nam Statistical Yearbook 2000

Figure 1.5: GDP structure



The factors reflected national circumstances in 1994 were presented in the table 1.10

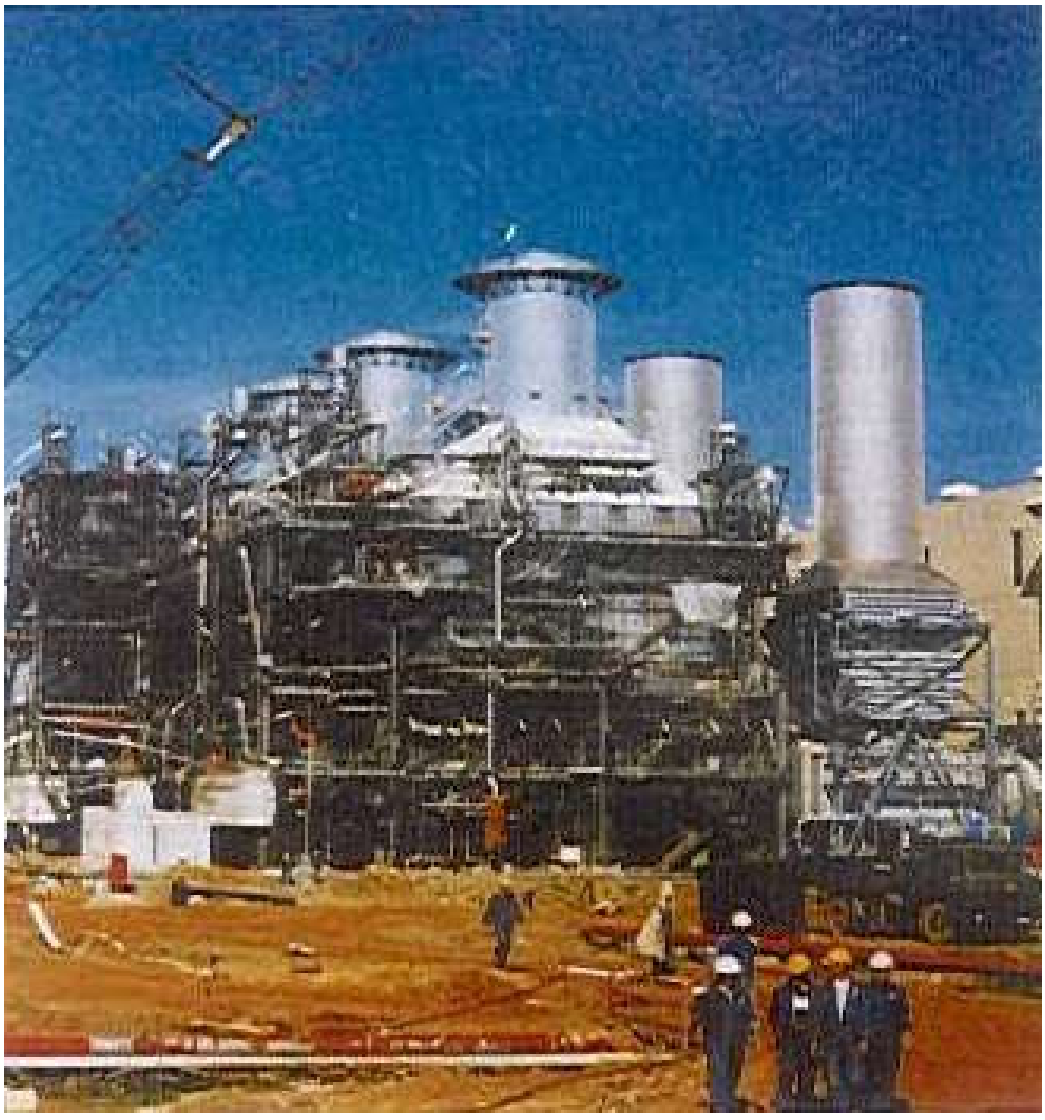
Table 1.10: National circumstances in 1994

No	Factors	1994
1	Population (million persons)	70.8
2	Area (km^2)	330,992
3	GDP (at current price; Billion Viet Nam Dong)	178,534
4	GDP (1994; Billion US dollars; foreign exchange rate 1 US$ = 11.111 Viet Nam Dong)	1.629
5	Average GDP per capita (1994, US$)	239
6	GDP value added of main national economic sectors (%) : ▪ Industrial sector (%) ▪ Services sector (%) ▪ Agriculture, Forestry, Fishery (%)	 28.9 43.7 27.4
7	Agricultural land (Mha)	7.37
8	Proportion of urban to rural population (%)	25.6
9	Cattle heads: ▪ Buffalo (thousand heads) ▪ Cattle (thousand heads) ▪ Pig (thousand heads) ▪ Horse (thousand heads) ▪ Goat, sheep (thousand heads) ▪ Domestic poultry (Million heads)	 2,977.3 3,466.8 15,587.7 131.1 427.9 137.8
10	Forest land (M ha)	9.30
11	Average life-span (year): ▪ Male ▪ Female	 68 72

Sources: Statistical year book 1995, 2000

CHAPTER 2

NATIONAL GREENHOUSE GAS INVENTORY IN 1994



Bac Giang Nitrogenous fertilizer factory

National GHG inventory in 1994 was carried out for the main GHGs such as CO_2, CH_4, and N2O… and for the main sources of emissions:

- ***Energy:***

In energy sector, GHGs are emitted from combustion of fuel and fugitive emission from fossil fuel production. The data on energy exploitation and consumption were collected and processed from various reports of General Statistical Office, Institute of Energy, VinaCoal Company, Electricity of Viet Nam, Ministry of Planning and Investment and Ministry of Science, Technology and Environment.

- ***Industrial processes:***

GHG emissions from these processes are related to chemical and physical transforms of materials. There are few of these processes in Viet Nam. GHGs emitted are CO_2, CH_4, N_2O and others. The data used for GHG emission calculation were from reports of industrial sector and Viet Nam Statistical Yearbook.

- ***Forestry and land use change:***

Forest is at the same time GHG emission source and sink. Those activities such as land use change and forest exploitation are CO_2 emission sources. While, the activities of forest protection, natural forest regeneration and reforestation will protect, maintain and expand carbon sinks.

The data of GHG Inventory in this sector were collected from Institute of Forest Inventory and Planning, Forest Science Institute, Agricultural Economic Institute and Viet Nam Statistical Yearbook.

- ***Agriculture:***

Agriculture is the largest GHG emission source. Its main GHGs are methane (CH_4), N_2O, follows by carbon monoxide (CO) and oxide nitrogen (NO_x). The main sources are rice paddy, livestock, field burning of agriculture residue, savanna burning, agricultural soil… Data were collected from the Institute of Water Resources Research, National Institute for Planning and Projection, National Statistic Yearbook.

- ***Wastes:***

The inventory of GHG emission in this sector is based on statistical data of 1994, data of project "Waste processing" in Quang Ninh province financed by Denmark (1996) and report on waste of Ho Chi Minh City (1998).

The inventory was carried out following IPCC methodology, revived version 1996, some emission factors were referred to Thailand and India study. The emission factor of CH_4 in particular, for wet rice paddy with organic fertilizer, was obtained from the experiment Program of ADB – Methane Asia Campaign 1998-1999.

2.1 GHG INVENTORY IN ENERGY SECTOR

GHGs emission from energy sector are emissions from burning of fossil fuel (coal, oil and gases...), fugitive emissions from mining, transportation of coal, oil and gases and biomass burning (fire-wood, agricultural residues…). The consumption of biomass is calculated in average per capita for urban and rural areas. The estimated annual firewood consumption rates per capita in urban and rural areas are 100 Kg and 390 Kg respectively. The estimated total firewood consumption in 1994 is 23.77 million tons.

According to IPCC methodology, GHGs emissions in energy sector depend on characteristics and amount of fuel. CO_2 emission amount is defined mainly by carbon content in a certain fuel.

2.1.1 GHG emissions from fuel combustion:

In 1994 Viet Nam produced 6.2 million tons of coal, 7.1 million tons of oil (table 2.1). All crude oil is exported. Coal is partly exported, partly goes to meet domestic needs.

Firewood remains an important fuel source in the Viet Nam energy structure. It occupies 56% total domestic fuel consumption.

Table 2.1- Energy production and consumption in 1994 (not including hydropower)

Kind of Fuel	Produced (1000 tons)	Imported (1000 tons)	Exported (1000 tons)	Reserved (1000 tons)	Consumed (1000 tons)	Consumed (TJ)
Crude oil	7074		6949	125		
Petrol		1052			1052	45369
Aviation kerosene		193			193	8323
Kerosene		285			285	12291
DO		2193			2193	93657
FO		822			822	34073
LPG		13			13	588
Other oils		176				
Coal	6197		2068		4129	96813
Fossil fuel		0				291114
Biomass	23771	0			23771	380096

Sources: Project KHCN 09

The estimated emissions from fuel combustion is presented in table 2.2

Table 2.2: GHG emissions from combustion of fuel types in 1994

Unit: thousand tons

Fuel type	CO_2	CH_4	N_20	$N0_x$	CO	NMVOC	SO_2
Petrol	3233.4						1.450
Aviation kerosene	609.2						0.058
Kerosene	907.4						0.079
DO	6967.6						3.947
FO	2530.3						1.480
∑ liquid fuel	14247.9	1.142	0.130	73.167	172.671	33.429	7.014
Coal	7293.5	5.339	0.106	17.552	56.678	5.879	6.606
LPG	38.6						0.023
∑ Fossil fuel	21580.0	6.481	0.236	90.719	229.3547	39.309	13.634
Biomass	*40837.79**	114.029	1.520	38.010	1900.482	228.058	285.197
Total emission	21580.0**	120.509	1.756	128.729	2129.836	267.367	298.831

* *Used for estimating other gases, apart from CO_2*
** *CO_2 from biomass is not included*

GHG emissions by fuel combustion in 1994 were estimated at 21 million tons of CO2, more than 120 thousand tons of CH_4 and nearly 2 thousand tons of N_2O. CO_2 are mainly emitted by coal and oil combustion. Meanwhile CH_4 and N_2O are mainly from biomass burning. The total GHG emissions by fuel combustion are 24.655 mill. tons of CO_2 equivalent. (table 2.4).

Table 2.3. Greenhouse gas emissions by energy consuming sectors in 1994

Unit: thousand tons

Sector	CO_2	CH_4	N_2O	NO_x	CO	NMCOV	SO_2
Energy Industry	4115.07	0.109	0.045	11.759	0.836	0.246	2.979
Industry and Construction	7671.17	0.433	0.081	22.061	5.199	0.931	5.359
Transport	3634.43	0.465	0.043	35.822	158.724	30.342	1.365
Services/Commercial	1974.69	0.242	0.022	2.421	19.198	1.964	1.118
Household	1806.04	118.777	1.545	40.011	1931.933	231.216	286.69
Agriculture, Forestry and Fishery	887.73	0.098	0.007	14.537	12.355	2.446	0.511
Others	90.87	0.385	0.013	2.155	1.590	0.222	0.812
Total emission	**21580.0**	**120.509**	**1.756**	**128.763**	**2129.836**	**267.367**	**298.84**

Table 2.4: GHG emissions from energy consuming (CO2 equivalent)

	GHG emission *(Gg)* *(thousand tons)*	**GWP**	**CO_2 equip.***(Gg)* *(thousand tons)*	**%**
CO_2	21,580.00	1	21,580.000	84.11
CH_4	120.509	21	2,530.689	10.26
N_2O	1.756	310	544.360	5.63
Total			**24,655.049**	**100**

2.1.2 GHG Fugitive Emissions

In Viet Nam, GHGs fugitive emission is mainly generated by coal, oil, and gas exploitation and transportation.

❑ *Fugitive Emission of Methane (CH4) from coal mining*

In coal mining, CH_4 fugitive emission is, generated by underground and surface mining, and coalfields.

Total commercial coal in 1994 was 6,197 thousand tons, mainly Anthracite, about half of which was from 10 open coalmines. The rest was from underground coal cellars or coal wells.

Using methane emission coefficient from coal mining of India (table 2.5) and Conversion coefficient (from volume to weight unit in the conditions of 20^{o}C and 1 atmosphere) as 0.67 Gg $CH_4/10^6m^3$, methane fugitive emission from coal exploitation in 1994 was 39.749 thousand tons (table 2.6)

Table 2.5: Emission coefficients in coal exploitation (m^3/tone)

Exploitation type	Underground		Open-cast mine	
Methodology	IPCC	India	IPCC	India
Mining	10-25	18	0.3 – 2.0	1.15
After exploitation	0.9 – 4.0		0 – 0.2	

Table 2.6: Estimated CH_4 from coal mining

Exploitation type	Exploited coal (million tons)	Emission coefficient	Conversion coefficient	Methane emission *(thousand tons)*
Underground mining	3.098	18.00	0.67	37.362
Surface mining	3.098	1.15	0.67	2.387
Total				**39.749**

- ***CH_4 Fugitive Emission from oil exploitation***

Oil exploitation in Viet Nam has been started since 1986. During the period 1986 - 1995, crude oil production was 35 million tons. In 1994, 7.1 million tons of oil was exploited.

Methane fugitive emission from oil exploitation in 1994 is 7.015 thousand tons.

- ***Fugitive methane emission from fuel exploitation***

The total CH4 emission from coal underground and surface mining, oil and gas exploitation and gas burning in 1994 is 46.764 thousand tons (table 2.7).

Table 2.7: Total fugitive methane emission from coal and oil exploitation in Viet Nam

Unit: thousand tons

Exploitation type	CH_4
Underground coal mining	37.362
Surface coal mining	2.387
Oil exploitation	0.748
Gas exploitation +gas burning	4.565
Leaking	1.702
Total	**46.764**

2.1.3 GHG emission from energy sector activities

The total GHG emission from energy sector activities in Viet Nam in 1994 was 25.637 million tons CO_2 equivalent (table 2.8 and 2.9)

Table 2.8: Greenhouse gas emission from energy sector in 1994

Unit: thousand tons

Sector	CO_2	CH_4	N_2O	NO_x	CO	NMCOV	SO_2
Electricity generation	4115.07	0.109	0.045	11.759	0.836	0.246	2.979
Industry and Construction	7671.17	0.433	0.081	22.061	5.199	0.931	5.359
Transport	3634.43	0.465	0.043	35.822	158.724	30.342	1.365
Services/Commercial	1974.69	0.242	0.022	2.421	19.198	1.964	1.118
Household	1806.04	118.777	1.545	40.011	1931.933	231.216	286.69
Agriculture, Forestry and Fishery	887.73	0.098	0.007	14.537	12.355	2.446	0.511
Others	1486.5	0.385	0.013	2.155	1.590	0.222	0.812
Total emission from energy consumption	21580.0	120.509	1.756	128.766	2129.836	267.367	298.84
Fugitive emission from fuel exploitation		46.764					
Total	**21580.0**	**167.273**	**1.756**	**128.766**	**2129.836**	**267.367**	**298.84**

Table 2.9: GHG emissions from energy sector in CO_2 equivalent

	GHG Emission *(thousand tons)*	**GWP**	**CO_2 equi** *(thousand tons)*	**%**
CO_2	21,580.000	1	21,580.000	84.17
CH_4	167.273	21	3,512.733	13.70
N_2O	1.756	310	544.360	2.13
Total			**25,637.09**	**100**

The biggest GHGs emission comes from industrial and construction activities, then from residential, energy production and transport as shown in table 2.10 and fig. 2.1, 2.2.

Table 2.10: CO_2 equivalent emissions by sources

Emission source	CO_2 equivalent *(thousand tons)*	%
Industry and Construction	7705.37	30.1
Household	4779.31	18.6
Electricity Generation	4131.31	16.1
Transport	3657.52	14.3
Services/Commercial	1986.59	7.7
Others	1502.99	5.9
Fuel exploitation	982.04	3.8
Agriculture, Forestry and Fishery	891.96	3.5
Total	**25637.09**	**100**

Figure 2.1: GHG emissions and fugitive (CO_2, CH_4, N_2O) from energy sector by sources

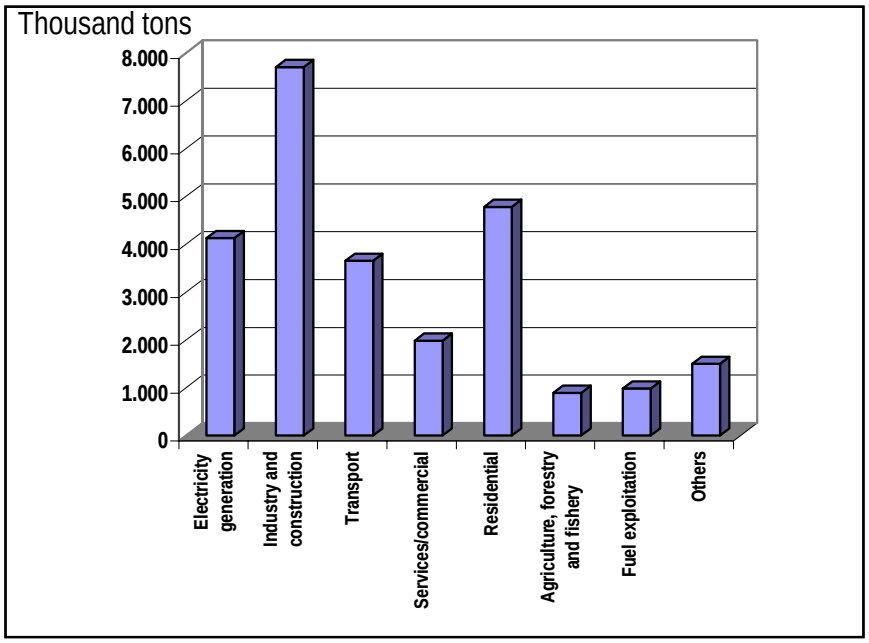
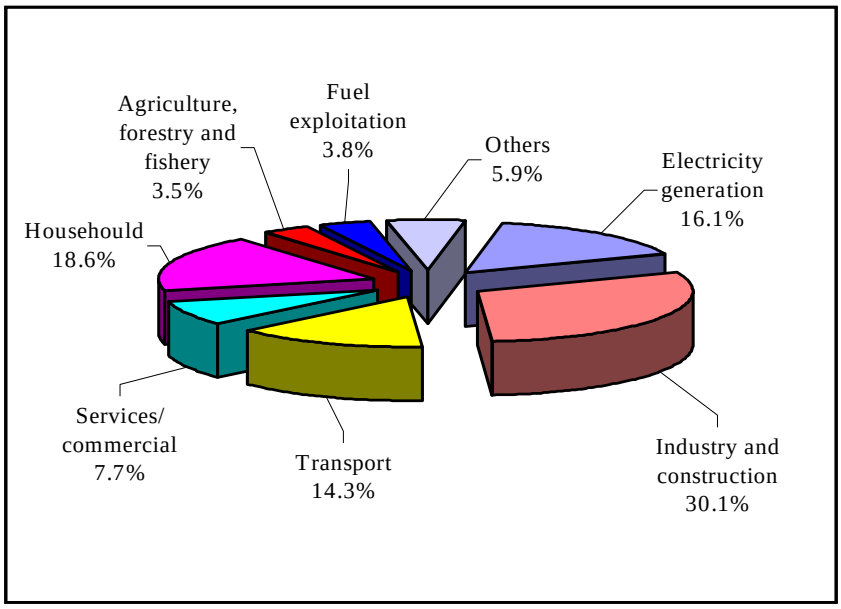


Fig. 2.2: Proportions of CO2 equivalent emissions from energy sector by sources (%)



2.2 GHG EMISSIONS FROM INDUSTRIAL PROCESSES

GHGs emissions from various types of industrial processes are non-energy use related emissions. These emissions are related to physical and chemical transforms of materials, in which GHGs such as CO_2, CH_4, N_2O and other gases are released.

The methodology for estimation of emission from various industrial processes is based on the amount of gases emitted from a product unit (emission coefficient) and amount of used material.

2.2.1 Industrial processes

Industrial processes and industrial products manufactured or used in Viet Nam in 1994 relating to the emissions of following GHGs: CO_2, CH_4, NO_x, NMVOC, CO and SO_2 were presented in table 2.11.

Table 2.11: Industrial processes and GHG in Viet Nam in 1994.

Industrial processes	Greenhouse gases					
	CO_2	***CH_4***	***NO_x***	***NMVOC***	***CO***	***SO_2***
Cement production	x					x
Lime manufacturing	x					x
Use of hydrated lime	x					
Soda production and consumption	x					
Steel manufacture	x	x	x	X	x	x
Paper and pulp production			x	X	x	x
Beverage				X		
Food processing industries				X		

2.2.2 GHG emissions from industrial processes

GHGs inventory in industrial processes of 1994 is presented in the table 2.12.

Total CO_2 emission was 3.807 million tons, mainly from construction material manufacturing (cement production occupied about 2.7 million tons, lime baking more than 650thousand tons) and steel rolling (about 500 thousand tons).

SO_2 emission was about 1.6 million tons, mainly from cement production.

Other GHGs emission were insignificant.

Table 2.12: GHG emissions from industrial processes in 1994

Unit: Thousand tons

Industrial type	CO_2	NO_x	CO	SO_2	NMVOC
Cement	2677.24			1611.18	
Lime baking	651.99				
Soda production	0.52				
Soda consumption	2.24				
Steel rolling	475.2	0.011		0.012	0.008
Paper and paper production		0.230	0.861	1.076	0.569
Beverage					0.136
Food processing					4.075
Total	***3807.19***	***0.241***	***0.861***	***1612.27***	***4.788***

2.3 GHG EMISSIONS FROM FORESTRY AND LAND USE CHANGE

Estimation of CO_2 emission and sequestration in this sector was focussed on the following:

- Change in forest area and woody biomass stocks in natural and planting forests
- Forestry and grassland conversion, forest exploitation
- Forest natural renovation in abandoned farmland

2.3.1 Estimation of GHG emissions/up takes

❑ *CO_2 sequestration by forest biomass growth*

In 1994, Viet Nam had 8.252 Mha of natural forest, 1.049 Mha of planting forest and 9.778 Mha classified as forestland without forest. Table 2.13 presents the data on area, type of forest and their biomass growth.

Table 2.13: Area of forest and forest land 1994

Forest type	Area (1000ha)	Annual growth rate tdm/ha/year
Forest	9302.2	
1. Natural forest	8252.0	
A/ Woody	6787.0	
❑ Evergreen	5181.3	
Copsewood	600.0	0.05
Temperate	3100.0	4.0
Young	1481.3	3.5
❑ Deciduous	935.0	3.5
❑ Pinus spp mixed	226.2	4.0
❑ Mangrove	34.7	3.6
❑ Melaluica cajuputa	13.6	3.0
B/Bamboo, mixed	1464.8	3.0
C/ Special use forest	0.7	1.0
2. Plantations	1049.7	
Eucalyptus spp	350	6.75
Acacia	200	8.45
Pinus spp	200	4.5
Other species	270	4.0
Bamboo	29.7	3.0
3. Savanna	9778.6	
Grass, bushes	6205.0	1.0
Tree stands	2817.6	1.5
Rocky	756.3	0.05

Source: Forest Inventory and Planning Institute, 1995

The total planting trees in 1994 were 350 million. Annual woody logs are 2823m^3 and peel wood is 30.44 mill ster.

CO_2 being sequestered by forest in 1994 is 39.272 million tons.

- ***CO_2 emissions from forest and grassland conversion***

In 1994, there were 338,000ha of land use change, in which 40,600ha under evergreen forest.

GHGs emissions from these activities were estimated as below:

- CO_2: 56.72 million tons
- CH_4: 0.18 million tons
- N_2O: 0.00124 million tons
- CO: 1.57 million tons
- NO_x: 0.0447 million tons

- ***CO_2 sequestration by natural regeneration in abandoned farmland***

The natural regeneration of forest in abandoned farmland or degraded forest for the period of about 20 years is 820,000 ha.

Estimated CO_2 absorbed amount is: 11.05 million tons

- ***CO_2 emission in inventory year by soil from previous land use change and management:***

The data on classification of soil groups are as follows:

Group of active mineral clay:	3,503,024ha
Group of non-active mineral clay:	20,245,806ha
Group of volcano soil:	171,402ha
Group of sand soil:	533,434ha
Group of wet soil:	6,914,347ha
Group of peat soil:	250,733ha

The amount of lime used for reform of soil for planting trees in the inventory year: 27,815tons.

Estimated CO_2 emission amount is: 8.824 million tons

2.3.2 GHGs emission/sequestration balance in this sector:

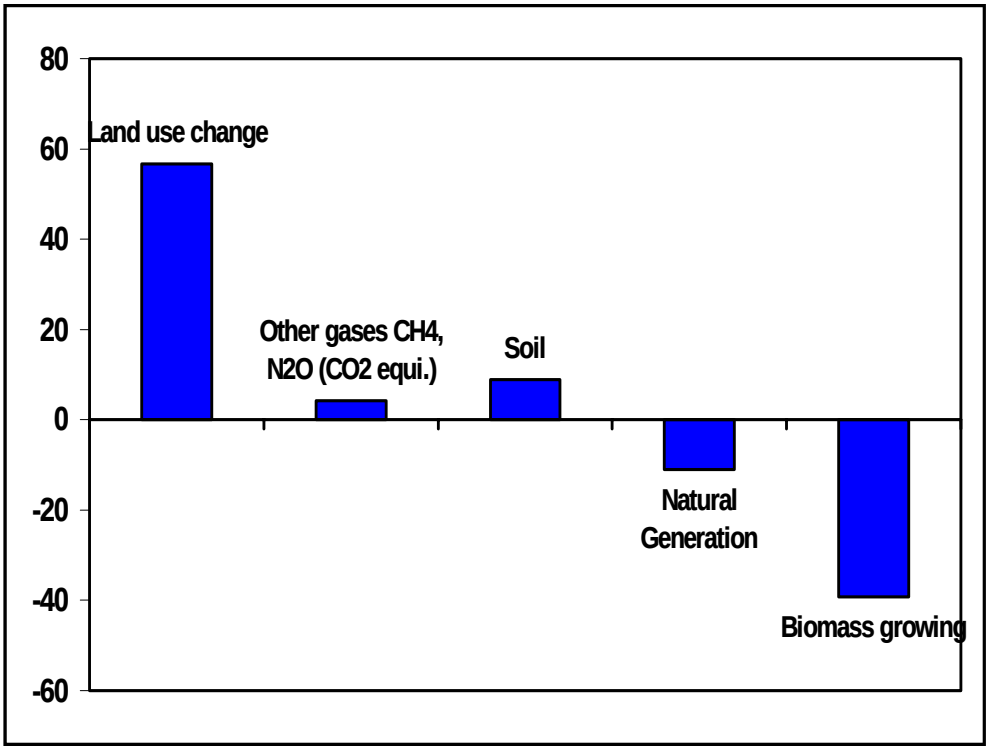
Greenhouse gases (in CO_2 equivalent) emitted into the atmosphere by forestry and land use change in 1994 are summarized in table 2.14 and figure 2.3.

Table 2.14: GHG inventory in forestry and land use change in 1994

Unit: Million tons CO_2

Emission/absorption type	Emission (+)/absorption (-)
CO_2 absorption by biomass growth	- 39.27
CO_2 emission due to land use change	+ 56.72
CH_4, N_2O Emissions (estimated in CO_2 equivalent)	+ 4.16
CO_2 absorption by natural regeneration	-11.05
CO_2 emission from soil	+8.82
Total:	**+19.38**

Fig. 2.3: GHG emission and sink from forest and land use change



2.4. GHG EMISSIONS FROM AGRICULTURAL SECTOR

2.4.1 Livestock

Table 2.15 presents domestic livestock population in 1994

Table 2.15: Domestic livestock population in 1994 and projected for the coming years

(Unit: million heads)

N°	Livestock type	1994	2010	2020
1	Dairy cattle	0.018	0.044	0.060
2	Non-dairy cattle	3.449	5.776	7.440
3	Buffalo	2.977	3.605	4.463
4	Goat & Sheep	0.428	0.65	0.60
5	Horse	0.131	0.18	0.40
6	Domestic poultry	137.779	274.0	330.0
7	Swine	15.588	25.04	37.80

Sources: Institute for Agricultural Planning and Projection, 1998

Methane emission from livestock sector is 465.565thousand tons, 336.585 thousand tons of which is from enteric fermentation and 128.980 thousand tons from manure management.

2.4.2 Rice cultivation

Results of IPCC studies showed that methane emission from rice paddy is dependent on water management, fertilization regime, soil characteristics, and agricultural practices…

The areas with different water management regimes are presented in table 2.16 (data from Institute of Water Resources Research)

Table 2.16: Rice cultivated area with different water management regimes in 1994.

Water management regime	North Viet Nam	South Viet Nam	Total
Constantly flooded irrigation	1.957	2.353	4.310
Intermittently flooded irrigation	0.224	1.049	1.273
Rainfed	0.326	0.690	1.016
Total	**2.507**	**4.092**	**6.599**

Source: Water Resources Science Institute

The total rice cultivated area in 1994 was 6.599 Mha, more than 60% of which under constantly flooded irrigation, the rest is not constantly irrigated and mostly relies on rainfall

The emission factors in rice paddy with organic and inorganic fertilizers, using for CH_4 estimation in North Viet Nam were calculated from local methane measurement experiment in 1998-1999. The factors are presented in table 2.17 below.

Table 2.17: Values of SIF of rice paddy with organic and inorganic fertilizers in North Viet Nam

Water management regime	Constantly flooded irrigation	Intermittently flooded irrigation	Rainfed
SIF (g/m^2)	37.5	18.8	30.0

In the South of Viet Nam, by agricultural cultivation habit, mostly inorganic (chemical) fertilizers are used. The emission factor used was default of IPCC Guideline for GHG Inventories, 1996.

Total methane emission from wetland rice field is 1559.7 Gg, among which, 873.8 thousand tons in the North of Viet Nam and 685.9 thousand tons in the South.

2.4.3 Prescribed burning of savanna

The main emission source in this sub-sector is savanna prescribed burning due to slash and burn farming practices of the mountainous ethnic minorities. There are two kinds of savanna in Viet Nam: shrub savanna (20,000 ha) and grass savanna (260,000 ha). The biomass densities of the shrub savanna is 50 tons dm/ha/year, and of grass savanna is 35 tons dm/ha. Forest Inventory and Planning Institute provided these data.

Total emissions in this sub-sector are 15.91 thousand tons CH_4, 417.5 thousand tons CO, 0.20 thousand tons N_2O and 7.11 thousand tons NO_x.

2.4.4 Field burning of agricultural residues

The main field crop residues burning sources are rice and sugarcane residues in the South

The emissions in this sub-sector are as follows: 51.72 thousand tons CH_4, 1086.07 thousand tons CO, 1.19 thousand tons N_2O and 43.17 thousand tons NO_x.

2.4.5 Agricultural soil

N_2O emission from agricultural soil relates to the microbial processes of nitrification and denitrification in the soil. There are 3 types of emission from this sub-sector:

a/ Direct emission from:

- Synthetic fertilizers;
- Nitrogen from animal waste;
- Nitrogen input in N-fixing crops;
- Nitrogen input from crop residues.
- Nitrous oxide emissions from cultivation of histosols

b/ Direct emission of N_2O from grazing animal

c/ Indirect N_2O emission from nitrogen used in agriculture.

The estimated GHGs emissions from this sub-sector are as follows:

Total emission is 26.02 thousand tons N_2O, including:

- N_2O emitted directly from soils: 16.63 thousand tons;
- N_2O emitted directly from animals: 0.004 thousand tons;
- Indirect N_2O emission: 9.39 thousand tons.

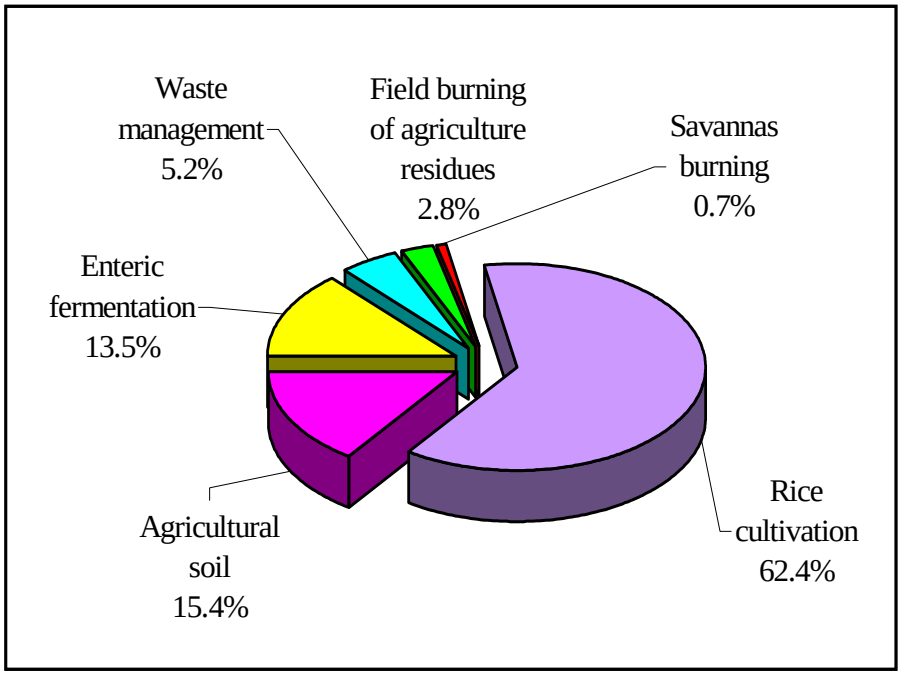
2.4.6 Results

The results of the GHGs inventory in agricultural sector are described in the following table 2.18.

Table 2.18: GHG emissions from agricultural sector in 1994.

Sub sector	CH_4 (*thousand tons*)	N_2O (*thousand tons*)	CO (*thousand tons*)	NOx (*thousand tons*)	Total CO_2 (*million tons*)	%
Rice cultivation	1559.7				32.75	62.4
Livestock						
- Enteric fermentation manure	336.6	0.001			7.07	13.5
- Manure management	129.0				2.71	5.2
Agricultural soil		26.0			8.06	15.4
Prescribed burning of savannas	15.9	0.2	417.5	7.1	0.40	0.7
Field burning of agriculture residues	51.7	1.2	1086.1	43.2	1.46	2.8
Total	**2092.9**	**27.4**	**1503.6**	**50.3**	**52.45**	**100**

Fig. 2.4 GHG emission from agriculture sector



2.5 GHG EMISSIONS FROM WASTE SECTOR

GHGs emissions from municipal solid waste (MSW) were estimated based on the following indexes:

- Waste disposed to landfill;
- The proportion of decomposable organic carbon and the proportion of actually decomposed organic

carbon.

- The proportion of methane in landfill waste.

CH_4 emission from domestic wastewater is estimated based on Biochemical Oxygen Demand (BOD); methane emission from industrial wastewater is estimated based on Chemical Oxygen Demand (COD).

2.5.1 Municipal Solid Waste (MSW)

In Viet Nam, only in provincial and district towns, waste is collected and processed. In 1994, the population in urban areas was 14,425,600, in which 10,238,000 lived in four big cities (Ha Noi, Ho Chi Minh City, Hai Phong, and Da Nang) and 3,901,300 in small cities, provincial and district towns.

Table 2.19: MSW generation rate

Location	MSW rate (kg/person/day)	Fraction of collected MSW	Fraction of MSW in land fill
Big city	0.665	90%	80%
Town	0.330	40%	20%

Sources: Waste Project of Ho Chi Minh City, 1998

In average, for Viet Nam, DOC composition equals to 8.1% MSW.

Estimated methane emission from waste is 66.3 Gg, mainly from big cities. (table 2.20)

Table 2.20: Methane emission from waste in urban areas in Viet Nam 1994

Unit: thousand tons

Area	**Methane emission**
4 big cities: (Ha Noi, Ho Chi Minh city, Hai Phong and Da Nang)	65.485
The rest urban areas	0.813
Total:	**66.298**

2.5.2 Domestic, commercial and industry waste water

❑ *Methane emission from domestic and commercial wastewater*

The basis for methane emission estimation is bio-chemical oxygen demand (BOD) for decomposition of organic material in wastewater. At present, there is not available BOD data of domestic wastewater in Viet Nam. In this report, BOD of wastewater in Thailand was used for estimation (table 2.21).

Table 2.21: BOD values of wastewater in Thailand, 1995

Area	BOD_5 kg/person/day	BOD_5 kg/1000 person/year
Bangkok	0.024	0.00854
Others	0.014	0.00690

The proportion of wastewater anaerobically treated and methane emission coefficient are 5% and 75% respectively.

Methane emission from domestic wastewater treatment in Viet Nam is 1.027 thousand tons in 1994.

❑ *Estimation of methane emission from industrial wastewater*

Total production and wastewater components of some industries in 1994 are presented in table 2.22 and 2.23:

Table 2.22: Production of some industries in Viet Nam in 1994

No	Industry	Total production in 1994
1	Beer	282 000 000 litter = 282 000 tons
2	Wine	45 800 000 litter = 45 800 tons
3	Milk	157 500 000 cans = 47 250 tons (1can = 0.3kg)
4	Sugar	463 000 tons
5	Seafood processing	722 055 tons (in 1995)
6	Vegetable oil	30 900 tons
7	Paper industry	153 700 tons
8	Rubber industry	20 182 000 bicycle tires 49 000 sets of car tires

Source: Statistical Yearbook 2000

BOD and COD of wastewater for various industries are as follows:

Table 2.23: COD and BOD values of waste water of some industries in Viet Nam

No	Industry	COD content (kg/m^3)	BOD content (kg/m^3)
1	Beer	3.81	2.60
2	Wine	0.44	0.253
3	Milk	0.764	0.19
4	Sugar	1.68	0.733
5	Seafood processing	1.177	0.905
6	Vegetable oil		2.873
7	Paper industry	0.4783	0.173
8	Rubber industry	0.074	0.073

Source: Survey data of Ministry of Industry

Wastewater volume per product unit is average value for whole sector based on the data collected from some enterprises in each industrial area (table 2.24).

Table 2.24: Volume of wastewater per unit of product of some industries in Viet Nam

No	Industrial sectors	Volume of waste water per unit of product	By IPCC
1	Beer	10.79 m^3/ ton	
2	Wine	43.42 m^3/ ton	
3	Milk	7.38 m^3/ ton	2.8 m^3/ ton
4	Sugar	6.075 m^3/ ton	
5	Seafood processing	20.73 m^3/ ton	
6	Vegetable oil	14.11 m^3/ ton	1.6 m^3/ ton
7	Paper industry	209.7 m^3/ ton	97 m^3/ ton
8	Rubber industry	0.072 m^3/1 bicycle tire 0.12 m^3/1 motor bicycle tire 0.61 m^3/1 car tire set	

Source: Survey data of Ministry of Industry

Estimation of total methane emission from industrial wastewater processing in 1994 is 0.79 thousand tons .

- ***Human emission***

Population: The population of Viet Nam in 1994 was approximately 70.8 million. N_2O emission from human in 1994 is 3.66 thousand tons .

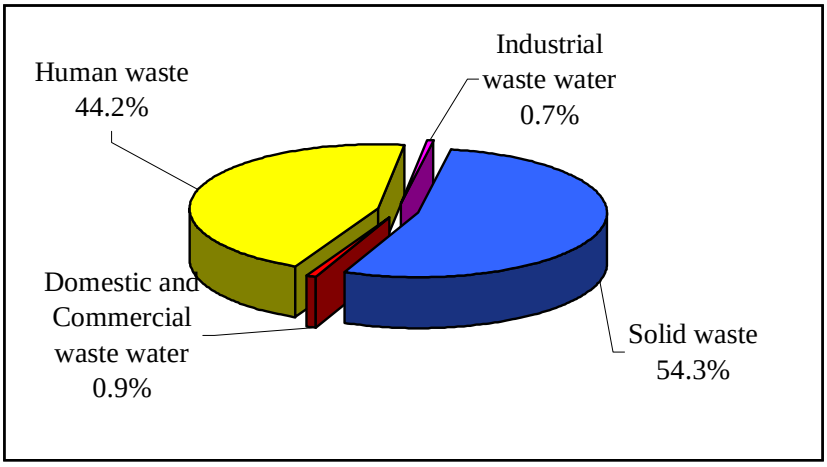
2.5.3 GHG emission from waste sector in Viet Nam in 1994

Estimated GHGs emission from various waste sources in 1994 is 68.63 thousand tons CH_4 and 3.66 thousand tons N_2O, equal to 2575.8 thousand tons CO2 equivalent (table 2.25, figure 2.5).

Table 2.25: Emission (CO_2 equivalent) from waste sources in Viet Nam, 1994

Emission source	CH_4 Emission (thousand tons)	N2O emission (thousand tons)	Global warming effect	CO_2 Equivalent (thousand tons)
Solid waste	66.298		21	1392.258
Domestic and commercial waste water	1.027		21	21.567
Industrial waste water	0.79		21	16.59
Emission from human	3.66	3.66	310	1134.6
Total	68.115	3.66		***2565.015***

Figure 2.5: GHG emission proportion from waste sector



2.6 SUMMARY OF NATIONAL GHG INVENTORY IN 1994

Summary of National GHG Inventory in Viet Nam is presented in table 2.26 and fig. 2.6

Table 2.26: Results of GHG inventory in 1994

Emission sector	Emissions in CO_2 equivalent (thousand tons)	(%)
1. Energy	25,637.09	24.7
2. Industrial processes	3,807.19	3.7
3. Agriculture	52,450.00	50.5
4. Forestry and land use change	19,380.00	18.7
5. Waste	2,565.02	2.4
Total emission	**103, 839.30**	**100**

Figure 2.6. GHG inventory in 1994

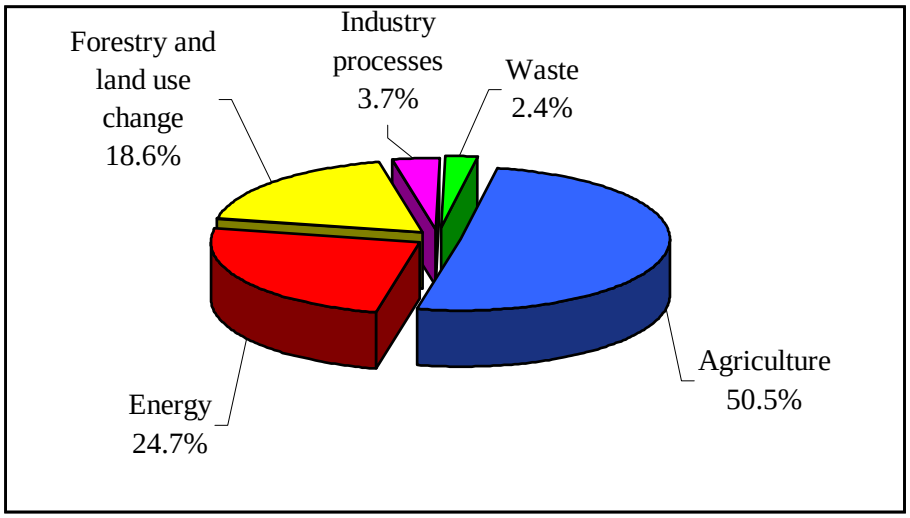


Table 2.27: GHG inventory of some sectors ASIAN countries, 1994

Unit: thousand tons

Country	Energy	Industry	Forestry and land use change	Waste	Total
Cambodia	1,270	50	45,200	0	46,520
Malaysia	84,400	5,000	7,600	300	97,300
Philippines	47,300	10,600	65,500	0	123,400
Singapore	26,600	0	0	200	26,800
Thailand	125,500	16,000	99,600	0	241,000
Viet Nam	25 ,637	3,807	19,380	2,565	51,389

2.7 GHG EMISSION PROJECTION

In the future, the major emission sectors would be energy, agriculture, forestry and land use change. Based on economic development scenario of medium level, done before Asian financial crisis in 1997, GHGs emissions of major sectors in Viet Nam were estimated at more than 140 million tons in 2010 and 233 million tons in 2020. From 1994 to 2020, GHGs emissions would drop from 19.38 million tons down to -28.4 million tons in forestry, increase from 52.45 million tons up to 64.7 million tons in agriculture, and rocket up from 25.63 million tons to 196.98 million tons in energy (table 2.28). Thus, in the future, energy would be the main emission source (figure 2.7).

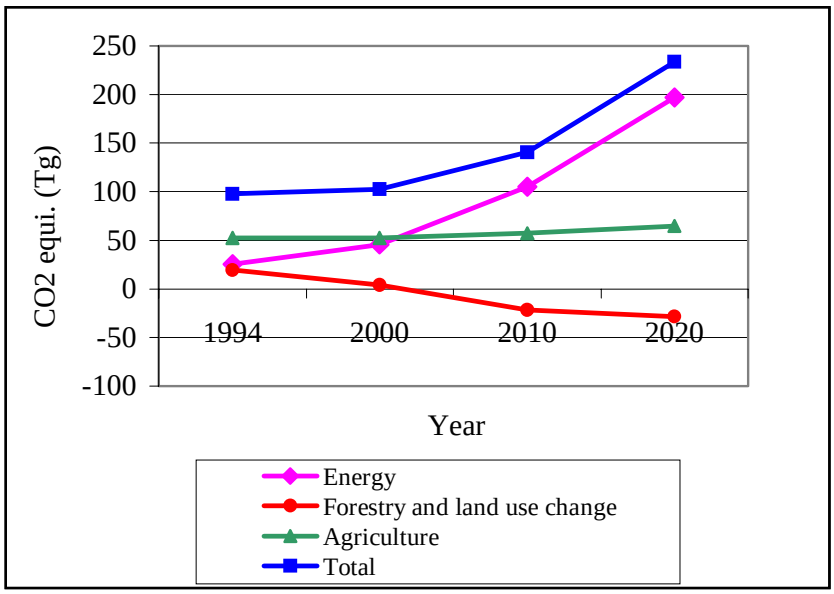
Table 2.28: Estimated GHG emissions to 2020, baseline scenario

Unit: million tons CO_2

Year	1994	2000	2010	2020
Energy	25.64	45.92	105.17	196.98
Forestry and land use change	19.38	4.20	-21.70	-28.40
Agriculture	52.45	52.50	57.20	64.70
Total	**97.47***	**102.62**	**140.67**	**233.28**

Source: ALGAS, 1997. (*) Not including emissions from industrial processes and waste, which occupied about 6.2% (6.4 million tons) in 1994.

Figure 2.7: GHG emission projection to 2020



Source: Project ALGAS. 1997

CHAPTER 3

Greenhouse gas mitigation options

Hoa Binh hydropower plan

3.1. GENERAL

The 1994 National Greenhouse Gas (GHG) Inventory shows that GHGs emissions in Viet Nam are about 103.8 Tg CO_2 equivalent, in which the main GHGs emission sources are agriculture, energy and forest – land use change. Waste management and industrial processes are insignificant emission sources.

In view of this, GHGs mitigation options in Viet Nam concentrate in 3 following sectors:

- ❏ Energy
- ❏ Forest and land use change
- ❏ Agriculture

3.2. GHG MITIGATION OPTIONS IN ENERGY SECTOR

The most important actions to mitigate GHGs emissions during the period 1994-2020 are economic and effective use of energy and use of renewable energy.

The Energy Flow Optimization Model (EFOM-EVN) was used to estimate the costs of GHGs mitigation as well as the among of GHGs reduced.

3.2.1 Energy demand projection:

In this report, the model MEDEE-S was used for projection of the energy demand. The structure for energy demand assessment of the MEDEE-S is based on the division of the energy consumption system into synchronous modules. The energy consumption system in Viet Nam is divided into 5 sectors:

- Industry
- Agriculture
- Transport
- Household
- Commercial and services

The projection was given to various periods from 1996 to 2020, based on the scenario of medium economic growth developed by the Institute of Strategy and Development, Ministry of Planning and Investment (table 3.1).

Table 3.1: Projection of GDP growth by sectors during the period 1996-2020

Unit: %

	1996-2000	2001-2010	2011-2020
GDP	8.0	7.8	6.5
In which:			
• Industry and construction	12.5	10.0	8.0
• Agriculture	4.2	4.2	3.0
• Services	7.6	7.3	7.1

Sources: Institute of Strategy and Development, Ministry of Planning and Investment, 1999

The outputs of MEDEE-S shows that the demand on commercial energy is increasing during the period 1994-2000 from 6,641.50 KTOE in 1994 to 12,420.40 KTOE in 2000; 19,626.30 KTOE in 2005, 29,496.00 KTOE in 2010 and up to 53,001.20 KTOE in 2020. The respective annual growth rate would be rather high at 9.45% (during the period 1994-2005), but it would go down to 8.49% (during the period 2005-2010) and 6.04% (during the period 2010-2020). The projected energy demand for various sectors during the period 1994-2020 is summarized in table 3.2.

Table 3.2: Projection of final energy demand

Unit: KTOE

Sector	1994	2000	2005	2010	2020
Industry	1,988.30	4,501.90	7,277.90	11,365.40	21,401.50
Household	795.40	1,445.70	2,283.30	3,295.20	6,136.30
Commercial and Services	569.90	975.00	1,663.40	2,966.30	4,985.10
Transport	2,951.20	4,792.50	7,295.00	10,384.20	18,409.30
Agriculture	336.70	705.10	1,107.30	1,484.60	2,068.40
Total	**6,641.50**	**12,420.40**	**19,626.30**	**29,496.00**	**53,001.20**

Sources: Outputs of the MEDEE-S

Figure 3.1: GDP growth rate projection

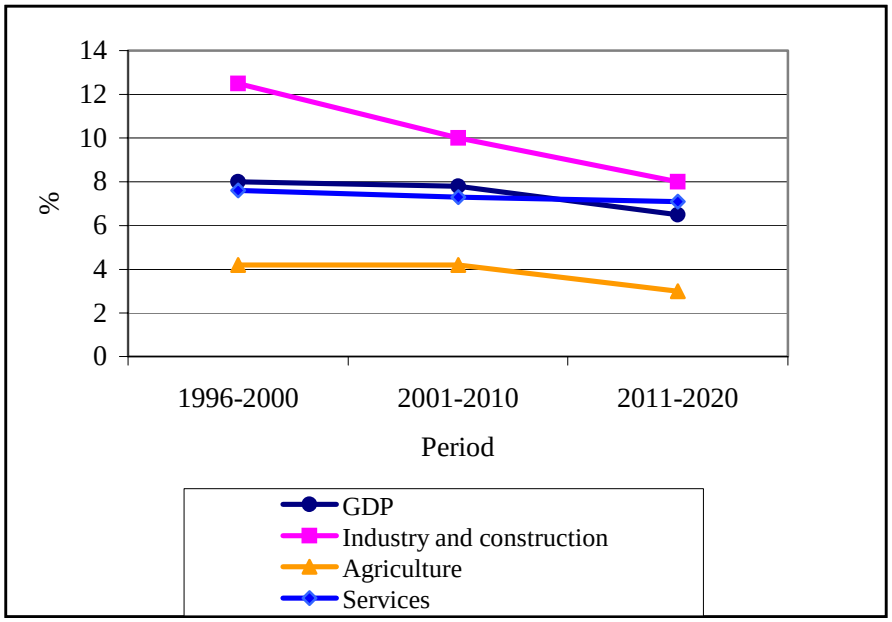
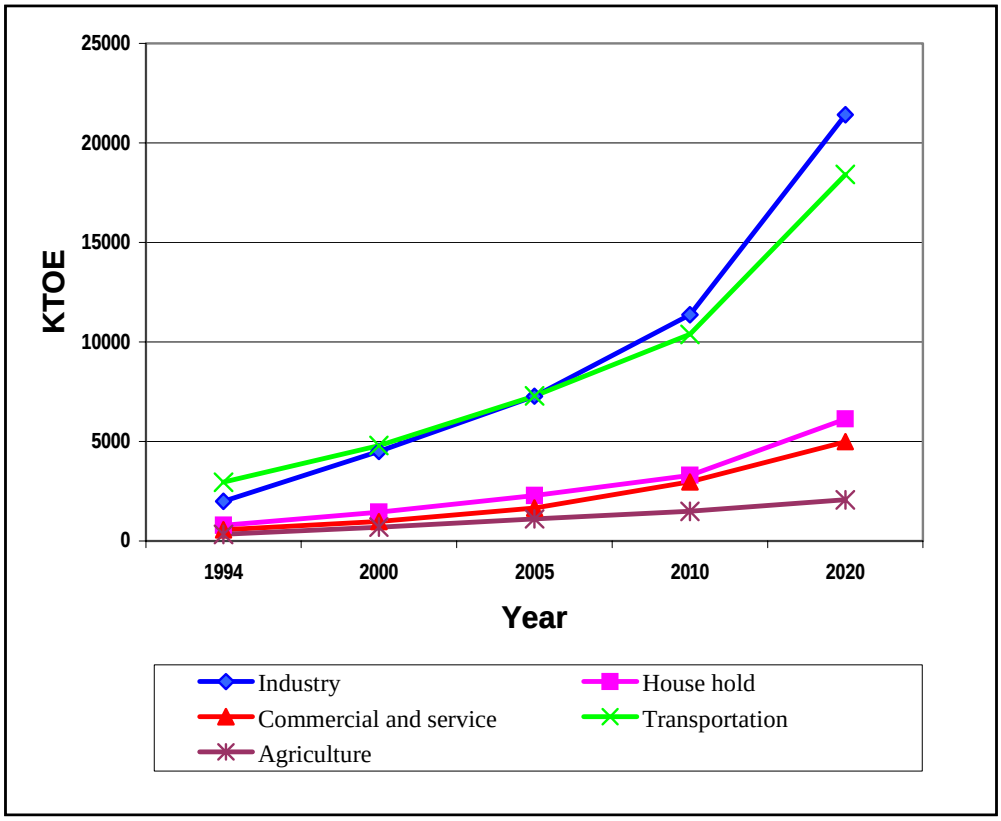


Figure 3.2: Final Energy consumption projection



3.2.2 GHGs mitigation options

The model EFOM-EVN was used to evaluate the GHGs mitigation options in this report. This model realizes the Energy Flow Optimization to calculate the effectiveness of whole energy system for application of energy saving measures to mitigate GHGs emissions in Viet Nam during the period 2000-2020. The options were developed on the basis of surveys in recent years or assumptions in certain conditions. The GHGs mitigation options in energy sector include:

- ***Option E1: Replacement of low-efficiency coal fired boilers by higher efficiency one.***

From 1994 to 2020, the efficiency of 20% of total number of coal boilers would increase by 25% and that would much reduce energy demand in comparison to Business As Usual (BAU). The final energy demand of industrial sector by 2020 would drop down to 21,081 KTOE, i.e. lower than BAU (2,402 KTOE) of about 1.5%. CO_2 mitigation potential in option E1 is about 10.2 Tg during the period of 26 years. The mitigation cost is US$3.65 per ton CO_2.

- ***Option E2: Replacement of low-efficiency oil fired boilers by higher efficiency one.***

From 1994 to 2020, energy efficiency of 20% of the total number of industrial oil boilers would increase by 20%. Consequently, in 2020 oil consumption would decrease by 2.4% in comparison to the Business As Usual (BAU). The CO_2 mitigation potential in option E2 is about 3.5 Tg during the period of 26 years. The mitigation cost is -US$3.65 per ton CO_2.

- ***Option E3: Fuel efficiency improvements with lean burn engine in transportation.***

From 1994 to 2020, applying the lean burn engine to raise air-fuel mixed rate of 14.7:1 up to 22:1. This measure can contribute to reduce atmospheric pollution, especially in big cities, populated areas, where there are many transport facilities. In comparison with BAU scenario, by the year 2020, total demand on oil products in transport sector would be reduced by 5.3%, saving primary energy consumption by 1.2%.

Projected oil consumption would decrease from 29,858 KTOE in BAU down to 28,884 KTOE, i.e. lower than BAU of about 3.3%. CO_2 mitigation potential in option E3 is about 21.9 Tg during the period of 26 years. The mitigation cost is -US$6.78 per ton CO_2.

- ***Option E4: Development of geo-thermal power.***

The development of geo-thermal power is expected to start in 2005. The estimated geo-thermal power capacity is 50 MW by 2005, 100 MW by 2010 and 200 MW by 2020. The estimated investment cost of geo-thermal power plant is US$2500 per kW. CO_2 mitigation potential in option E4 is about 29.2 Tg during the period of 26 years with mitigation cost of US$ 5.15 per ton CO_2.

- ***Option E5: Development of solar power.***

The development of solar energy is expected to start in 2005. The estimated geo-thermal power

capacity is 10 MW by 2005, 50 MW by 2010 and 100 MW by 2020. The estimated investment cost of solar power plant is US$5000 per kW. CO_2 mitigation potential in option E6 during the period of 26 years is about 26.1 Tg with mitigation cost of US$ 6.01 per ton CO_2.

- ***Option 6: Building wind power stations.***

In recent years, some small wind power stations for charging battery used for lighting and communication have been built in some remote islands. In these places, wind power is used instead of oil for electricity generation. It is estimated that option E6 on building of wind power stations in the coming time would bring about CO_2 mitigation potential of about 34 Tg during the period of 26 years with mitigation cost of US$ 4.64 per ton CO_2.

- ***Option 7: Efficiency improvement in coal-cooking stoves.***

This option aims at improving energy efficiency in household cooking stoves, to increase the average efficiency of current coal cooking stoves from 17% up to 25%. The incremental costs to improve energy efficiency in this option owing to saving coal consumption were estimated at US$50/KTOE. CO_2 mitigation potentials of option E7 is about 73 Tg during the period of 26 years with mitigation cost of -US$ 4.15 per ton CO_2.

- ***Option 8: Replace incandescent light bulbs by compact fluorescent lamps.***

This option aim at improving lighting energy efficiency through replacing incandescent light bulbs (ILBs) by compact fluorescent lamps (CFLs) with high-energy efficiency. Average power consumption of the existing bulb is about 75W and electricity consumption is about 110kWh per annum. CFLs use roughly 80 percent less electricity with lifetime estimated to be 8 times more than that of ILBs. However the cost of CFLs is still higher than that of ILBs. CO_2 mitigation potential of option E8 is about 16 Tg during the period of 26 years with mitigation cost of -US$8.31 per ton CO_2.

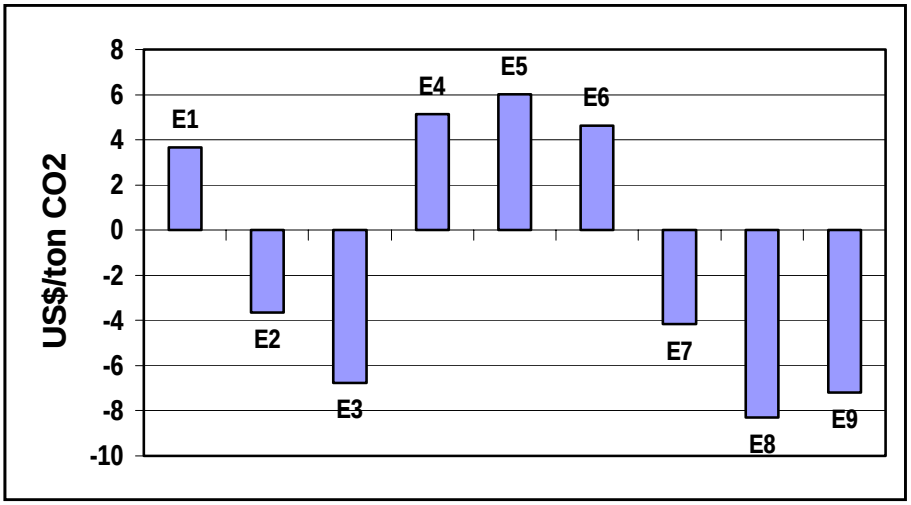
- ***Option 9: More efficient industrial motors.***

Option 9 considers the replacement of existing motors in industry with high energy efficient motors. It is assumed that the average efficiency of standard electric motor can be improved by at least 5 % (from 86 % to 91 %). CO_2 mitigation potential of option E9 is about 70 Tg during the period of 26 years with mitigation cost of -US$ 7.19 per ton CO_2.

Table 3.3: GHG mitigation potential and costs of some options in energy sector

Option	Symbol	GHG mitigation potential (MTg CO_2)	Present total costs (US$mil.)	Incremental costs (US$mil.)	Abatement Cost (US$/t CO_2)
Replacing coal boilers fired in industry	E1	10.2	34.187	37.2	3.65
Replacing oil boilers in industry	E2	3.4	34.137	-12.6	-3.65
Lean burn engine in transportation	E3	21.9	34.008	-148.9	-6.78
Developing geo-thermal power	E4	29.2	34.300	150.5	5.15
Developing solar energy	E5	26.1	34.306	157.0	6.01
Wind power stations	E6	34.0	34.196	158.0	4.64
Improving coal cooking stoves	E7	73.0	34.051	-303.0	-4.15
Replacing incandescent light bulbs by CFL lamps	E8	16.0	34.221	-133.0	-8.31
Improving efficiency of industrial motors	E9	70.0	33.851	-503.0	-7.19
Total		**283.8**			

Figure 3.3: GHG mitigation costs of some options in energy



GHGs mitigation potential of above 9 options is 283.8 Tg CO_2.

3.3. GHG MITIGATION OPTIONS IN FORESTRY AND LAND USE CHANGE

GHGs emission mitigation options in forestry were developed and evaluated based on BAU scenario. According to this scenario, by 2010, 5 million hectares of forest would be planted and total forest area in Viet Nam would increase up to 14.2 million hectares with forest coverage of 43%. Besides, the existing natural forest area would be actively protected from irrational forest exploitation from changing forest into agricultural land and other purposes.

The progamme on plantation of 5 million hectares of forest and protection of existing natural forest guarantees that there would be more appropriate investment for these activities to reserve and enhance carbon sinks in forestry sector. The COMAP model was used in development and evaluation of forestry GHGs mitigation options.

- **Option F1:** ***Active protection of about 3 million hectares of forest including national reserve gardens, rare wood forest, watershed protective forest, important reservation areas, etc.***

According to this option, 3 million hectares of natural forests in the above mentioned areas would be strictly protected.

- **Option F2:** ***Restoration of special protective forests by area delineation for regeneration together with 1 Mha of newly planted forest.***

After 10-year implementation of this option, 1 Mha of protective and specialized forests would be newly planted and delineated for natural regeneration.

- **Option F3:** ***Plantation of 1 Mha of new protective forest within the framework of agricultural and settlement programme.***

The forest planted by this option would be about 1 Mha during the period of about 15 years with the planting rate of 65,000 ha per year.

- **Option F4:** ***Plantation of 1.6 million hectares of short-term rotation production.***

According to this option, the forest planting rate would be implemented as follows: 100,000 ha per year for 5 beginning years, 128,000 ha per year for the next 9 years. Some main planted trees in this option are acacia, eucalyptus, sandalwood tree, fig tree, bamboo, cinnamon tree, etc.

- **Option F5:** ***Plantation of 1.3 million hectares of long-term rotation production.***

According to this option, the forest planting rate would be implemented as follows: 60,000 ha/year for 5 beginning years, 115,000ha/year for the next 9 years. The trees planted in this option would be rubber, canarium tree, tropical pine, oil trees, traditional wood trees such as chestnut, indigo, cinnamon, textured wood, dracontomelum, etc…

- **Option F6:** ***Planting of 4 billion scattered trees (equivalent to about 1.6 million hectares)***

This option would meet on-site wood demand, increase income of local people and improve environment.

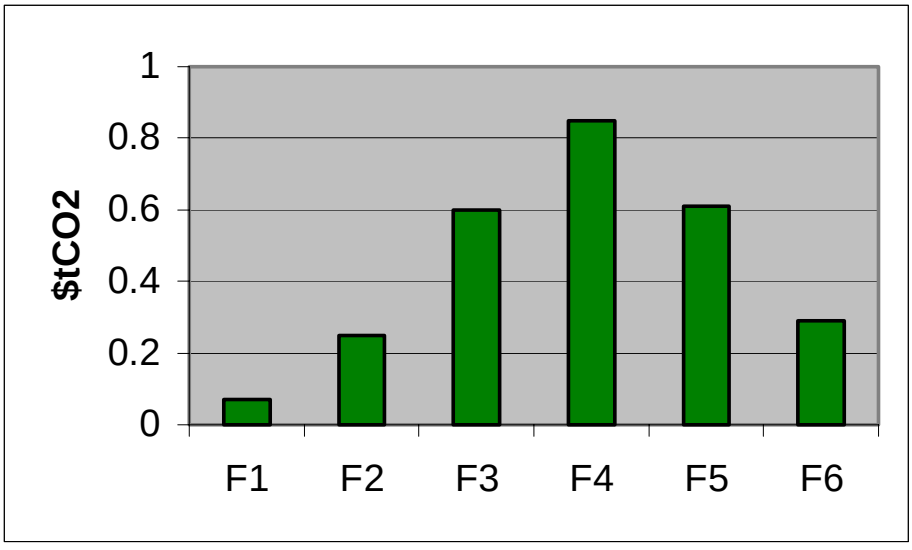
The following table 3.4 summarizes evaluation results of the above mentioned mitigation options through COMAP model.

Table 3.4: Mitigation potential and costs for forestry and land use change sector

Option	Symbol	Area (Million ha)	Emission mitigation potential /Enhancement of absorption sinks ($TgCO_2$)	Cost effectiveness		Net Present Value (NPV)	
				$/tCO_2$	$/ha	$/tCO_2$	$/ha
Protection of forest	F1	3.0	1302.6	0.21	92.10	0.07	31.28
Combination of forest nursing and delineation for regeneration	F2	1.0	372.6	0.11	40.6	0.25	93.72
Planting of protective, specialized forest	F3	1.0	325.8	0.26	83.49	0.60	193.58
Short rotation reforestation	F4	1.6	445.8	-0.15	-27.70	0.85	159.17
Long rotation reforestation	F5	1.3	496.1	0.20	76.14	0.61	235.43
Scattered trees planting	F6	4 bil. trees*	278.7	2.56	409.12	0.29	46.21
Total			**3221.6**				

** 4 billion scattered trees equivalent to 1.6 million hectares*

Figure 3.4: GHG mitigation costs of some options in forestry and land use change



The above results showed that to 2020, the option of protection of natural forest (F1) has the highest GHGs mitigation potential; meanwhile, scattered trees planting (F2) has the lowest potential. With regards to planting of forest for exploitation, the option of long rotation reforestation (F5) has higher GHGs mitigation potential than short rotation reforestation (F4) and becomes the second after the option of protection of natural forest in GHGs mitigation potential.

Total GHGs mitigation potential of 6 options from 1994-2020 is 3221.6 million tons of CO_2 equivalent.

With regards GHG mitigation cost (US$ per tonne CO_2): the lowest cost for reduction of 1 tCO_2 belongs to natural forest protection option (US$0.07/ tCO_2), then comes option of combined forest regeneration and area delineation and nursing (US$0.25/ tCO_2), scattered trees planting ($0.29/ tCO_2), planting specialized protective forest ($0.6/ tCO_2), long rotation reforestation ($0.61/ tCO_2) and short rotation reforestation has the highest cost ($ 0.85 /tCO_2).

3.4. GHGs MITIGATION OPTIONS IN AGRICULTURE

In agriculture, some potential GHGs mitigation options were identified: water management of rice field, improvement of feed for animals and utilization of biogas. These are the most potential CH_4 mitigation options and suitable for sustainable development in rural areas, promote production and bring about economic and environmental benefits to farmers.

GHGs mitigation options in agriculture sector were developed and assessed based on the BAU scenario following the orientation of agricultural development of Viet Nam in the end of the 20th century and beginning years of the 21st century.

- **Option A1: *Water management of rice fields.***

The objective of this option is to have active irrigation and drainage in rice fields based on the water requirements of rice. Irrigated water during the period from the end of tilling and the 15-20 days after flowering would be drained out from rice fields to increase rice production and mitigate GHGs emissions. At present, there are about 5 million hectares of irrigated rice areas. However, the area with active water management is not large. The improvement and upgrading of quality of water management, and building of active water management systems should be implemented in the following regions: plains of North Viet Nam, South Viet Nam, Northern part of Central Viet Nam and coastal zone of the Southern part of Central Viet Nam. It is estimated that the rice area with active water management would be 3.0 million hectares by 2010 and about 5.5 million hectares by 2020.

- **Option A2: *Provision of processed feed for animal.***

The objective of this option is to increase quantity and quality of the processed feed for animals and to increase proportion of micro-matters in order to increase meat and milk production, meanwhile, to reduce GHGs emission from food digestion per one unit of product. It is estimated that the number of cattle to be provided with processed feed would be increased from 2 million heads (by 2010) to 4.4 million heads (by 2020).

- **Option A3: *Setting up biogas stoves in rural areas.***

The objective of the option is to use biogas formed from disintegration of animal manure in the stuffy condition as an alternative fuel for households in rural areas. By implementation of this option, not only the expenditure for firewood in rural areas would be reduced but also the environmental sanitation and the rural life would be improved.

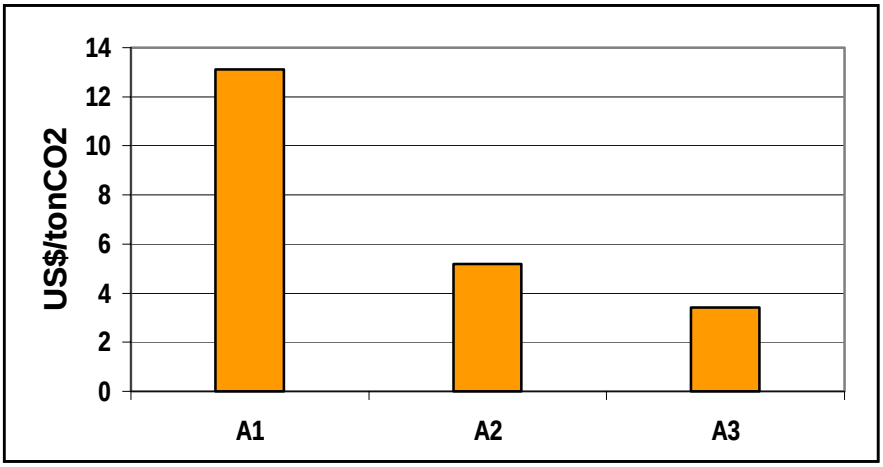
It is projected that biogas tanks would be built in the large rural areas in the plains of North Viet Nam, South Viet Nam, North of Central, South of Central Viet Nam and the Eastern part of South Viet Nam, etc. with a number of 15,000 tanks by 2000 and 500,000 tanks by 2020.

The evaluation of the three GHGs mitigation options in agriculture sector showed that their total mitigation potential is 140.3 million tons of CO_2 equivalent during 26 years, with mitigation costs from US$3.41/ton$CO_2$ to US$13.1/ton$CO_2$ (table 3.5).

Table 3.5: GHGs mitigation potential and costs in agriculture

Options	Reduced methane (in Tg CO_2 equivalent)	Mitigation cost US$/ton CO_2
Water management (A1)	105.0	13.12
Food processing for animal (A2)	8.0	5.19
Utilization of biogas (A3)	27.3	3.41
Total	**140.3**	

Figure 3.5: GHG mitigation costs of some options in Agriculture



3.5. CONCLUSION

1. From former studies and this study, 18 GHGs mitigation options including 9 options for energy sector, 6 options for forestry sector and 3 options for agricultural sector were developed and evaluated.
2. In energy sector, the mitigation options were evaluated through EFOM-ENV model; meanwhile, in forestry sector, the mitigation options were evaluated through COMAP model. The mitigation options in agricultural sector were evaluated by statistical methods. The evaluation results for various sectors, in general, have significant differences in both potentials and costs of GHGs emission mitigation.
3. The evaluation results showed that the potentials in emission reduction/enhance absorption sinks are highest in forestry sector. The option that has the highest potential in GHGs reduction is natural forest protection (1,302 Tg CO_2 equivalent). The costs for reduction of 1Tg CO_2 equivalent of all options in the forest sector are below US$1. Meanwhile, the options in the agricultural sector require higher costs, from US$3.4 to US$13.1 per 1Tg CO_2. From 9 mitigation options in energy sector, the options of investment for improving coal boilers (E1), developing geo-thermal energy (E4) and developing solar energy (E5) wind energy (E6) require the costs of emission reduction from US$3.65/Tg CO_2 to US$6.01/Tg CO_2, while the rest 5 energy options are economically effective with negative cost (from –US$3.65 to – US$10.54 per 1Tg CO_2).
4. The cumulative GHGs mitigation potentials of above mentioned 18 mitigation options are 3,464 MTg CO_2 equivalent during the period from 1994 to 2020.

CHAPTER 4
Climate change impacts and adaptation measures

Sea Dyke embankment

Terraced fields in mountainous area of North Viet Nam

4.1 CLIMATE CHANGE SCENARIOS IN VIET NAM

Recent studies showed that climate change in Viet Nam has the following main manifestations:

- Annual average temperature increases about 0.1^0C per decade. In some summer months, temperature increases about 0.1- 0.3^0C per decade. In winter, temperature has decreasing tendency at early months and increasing tendency at late months.
- Variation tendencies of rainfall are not the same for different regions and different periods. However, it can be seen that in most territory, seasonal rainfall amount decreases in July and August and increases in September, October and November. Drizzling rains clearly decrease in the North and North Central Viet Nam.
- In the past 5 decades, ENSO has stronger and stronger effects on weather regime, climatic features in various areas of Viet Nam.
- Basically, climate change in Viet Nam is in conformity with what occurring in the region as well as in global scale.
- The average simulation of CSIRO is used to develop simulation of climate change in Viet Nam for assessment of climate change impacts and/or development of adaptation measures in various areas.
- With regard to the simulation of temperature changes, it is classified into two regional groups:

  - Coastal region: Northern plain, Coastal zone of the North of Central Viet Nam, Middle part of Central Viet Nam, Southern part of Central Viet Nam and Southern plains;

  - Inland region: Northwest, Northern part of North Viet Nam and Tay Nguyen Highland.

- With regard to simulation of rainfall change, it is also classified into two regional groups:

  - Rainfall caused by Southwest (SW) monsoon: Northwest region, Northern part of North Viet Nam, Northern plain, Tay Nguyen (Central) Highland, Extreme South of Central Viet Nam and Southern plain.

  - Rainfall caused by Northeast (NE) monsoon: North of Central Viet Nam, Middle part of Central Viet Nam and Northern part of South of Central Viet Nam.

The simulations of temperature, rainfall and sea level changes in various regions are shown in table 4.1

Table 4.1: Climate change simulations in Viet Nam

Factors	Region	Season	2010	2050	2070
Temperature is increasing (^{0}C)	Northwest, Northern of North		0.5	1.8	2.5
	Northern plain		0.3	1.1	1.5
	North of Central		0.3	1.1	1.5
	Middle of Central		0.3	1.1	1.5
	South of Central		0.3	1.1	1.5
	High land		0.5	1.8	2.5
	South		0.3	1.1	1.5
Rainfall amount is increasing (+) or decreasing (-) (%)	Northwest, Northern of North	Rainy	0	0-+5	0-+5
		Dry	0	-5-+5	-5-+5
	Northern plain	Rainy	0	0-+5	0-+5
		Dry	0	-5-+5	-5-+5
	North of Central	Rainy	0	0-+10	0-+10
		Dry	0	0-+5	0-+5
	Middle of Central	Rainy	0	0-+10	0-+10
		Dry	0	0-+5	0-+5
	Northern part of South Central	Rainy	0	0-+10	0-+10
		Dry	0	0-+5	0-+5
	Southern part of South Central	Rainy	0	0-+5	0-+5
		Dry	0	-5-+5	-5-+5
	Central Highland	Rainy	0	0-+5	0-+5
		Dry	0	-5-+5	-5-+5
	South	Rainy	0	0-+5	0-+5
		Dry	0	-5-+5	-5-+5
Sea level rise (cm)	All coastal line	-	9	33	45

According to the climate change simulations described in the table 4.1, by 2010, 2050, 2070, temperature in the coastal zone would likely increase of about 0.3; 1.1; 1.5^{0}C correspondingly, meanwhile, in the inland regions the value would be higher and equal to about 0.5; 1.8; 2.5^{0}C. According to this scenario, by 2070 in the regions affected by SW monsoon, rainfall amount would not be clearly changed, but in the regions where rainfall is affected by NE monsoon, total rainfall would likely increase from 0-+5% in dry season and 0-+10% in rainy season.

Sea level would rise 9 cm in 2010, 33cm in 2050 and 45cm in 2070.

On the basis of the above-mentioned simulations, climate change impacts on the following sectors are assessed: agriculture, water resources, coastal zone, forestry, aquaculture and energy.

4.2. CLIMATE CHANGE IMPACTS ON WATER RESOURCES AND ADAPTATION MEASURES

4.2.1. Climate change and river runoff

Viet Nam is located in down streams of two big international rivers: Mekong and Red Rivers. The Mekong river basin area is about 795,000 km^2 (including Tonlesap and its delta), annually, water runoff to the East Sea is 505 billion m^3. The Red River has a basin of 169.000 km^2; annually it transports to the East Sea 138 billion m^3 of water. So, for whole territory, the total runoff reaches 835 billion m^3.

The spatial and temporal distribution of runoff is very uneven. More than 80% of run-off concentrates in summer (5-6 months), the rest 20% of run-off distributes for 6-7 months in dry season. In some areas (for instance, in the mountainous areas of Thua Thien, Bac Quang provinces), run-off is high, the module reaches 75-80 l/s/km^2, but in some areas, run-off module is small and only reaches 10-12 l/s/km^2, such as in the rivers of Binh Thuan province.

Beside surface water, the ground water that can be exploited annually is 50 billion m^3, i.e. equivalent to module of 4.8 l/s/km^2 or the depth of ground water of 150 mm annually.

Viet Nam has carried out studies and assessment of climate change impacts on water resources in Viet Nam.

In this study, the models (RRMOD and SSARR) were used for calculating and assessing the variation of annual run-off, low flow and flood flow according to the respective scenarios.

- ***The Red River and Mekong River***

Assessment results are described in the table 4.2 for the Red and Mekong Rivers.

Table 4.2: Run-off change in the Red and Mekong Rivers by 2070

Location – River	Annual run-off m^3/s			Low flow m^3/s			Flood-top discharge m^3/s		
	At present	In 2070	%	At present	In 2070	%	At present	In 2070	%
Red River at Son Tay									
- Case 1	3766	3985	+5.8	560	502	-10.3	37.800	42,300	+12,0
- Case 2	3766	3267	-13.0	560	489	-12.6		43,500	+15,0
- Case 3	3766	3019	-19.0	560	479	-14.5		37,000	-5,0
Mekong River at Pakse									
- Case 1	10209	10645	+4.2	1723	1686	-2.0	148.000	171,000	+15,0
- Case 2		8701	-15.0		1443	-16.2		176,000	+19,0
- Case 3		8645	-15.3		1312	-24.0		137,000	-7,0

Note

For annual run-off and low flow

- Case 1: Temperature increases and annual total rainfall increases
- Case 2: Temperature increases and rainfall decreased in rainy season, rainfall in dry season increases.
- Case 3: Temperature increases and rainfall decreases in both seasons
- **For flood flow (peak discharge)**
- Case 1: Daily rainfall increases by 20%
- Case 2: Daily rainfall increases by 25%
- Case 3: Daily rainfall decreases by 10%

Table 4.2 shows that annual run-off changes from +4% down to -19%, the change of low flow is rather significant from -2% down to -24%.

Because daily rainfall increases from 12 to 19%, the peak discharge increases significantly and return period also decreases. The flood peak, which formerly had return period of 100 years, now only 20 years. The flood peak, which formerly had return period of 20 years, now only 5 years, etc., i.e. the frequency of flood occurrence would be higher.

- ***Medium and small rivers***

Calculation results (table 4.3) show that by 2070, for medium and small rivers, the biggest decrease of annual run-off would be recorded in the East of South Viet Nam (29-33%), Central Viet Nam from Quang Binh to Quang Ngai province (23-40.5%), North Viet Nam and North of Central Viet Nam (2-11.5%), and biggest increase in extreme South of Central Viet Nam (49%), Central Highland (6-16%).

4.2.2. Assessment of climate change impacts on potential evapotranspiration

In this report, the potential evapotranspiration (PET) was calculated using the modified Penman formulae.

The following table 4.4 summary calculation results of increment of potential evapotranspiration in some areas for scenarios of air temperature increases by 1^0C, 2.5^0C.

Table 4.3: Changes of Potential Evapotranspiration (PET) in accordance with air temperature increases at some meteorological stations (%)

Unit: %

No.	Station	Increase rate	
		1^0C	2.5^0C
1	Ha Noi	3.3	8.4
2	Vinh	3.2	8.5
3	Dong Hoi	3.1	8.0
4	Hue	3.2	8.1
5	Da Nang	3.2	8.2
6	Quy Nhon	3.2	8.1
7	Nha Trang	3.2	8.2
8	Phan Thiet	3.3	8.3
9	Buon Ma Thuot	3.1	8.1
10	Tan Son Hoa	3.1	7.7

All over Viet Nam, when air temperature increases by 1^oC, 2.5^0C, PET would increase by 3%, 8% successively.

Table 4.4: Change of annual run-off due to climate change impacts

Basin	At present (mm)	By 2070	Change (%)
- Ma & Chu	890	797	-11.5
- Hoat	760	758	-2.1
- Yen	838	829	-2.1
- Lach Bang	788	777	-2.4
- Hoang Mai	741	723	-3.5
- Bung	725	689	-5.0
- Ca	1130	1093	-4.3
- Rao Cai	1440	976	-33.3
- Rac	1730	1596	-7.8
- Gianh	2330	1790	-23.2
- Ta Trach	2362	1350	-42.9
- Tra Khuc	2072	1256	-39.4
- An Chi	2073	1235	-40.5
- Hinh	1677	2511	+49.7
- Cai Nha Trang	1420	1504	+5.9
- Luy	438	653	+49.0
- Se San	1310	1397	+6.6
- Srepok	1080	1255	+16.2
- Ba	720	778	+8.0
- Nam Ngam	1781	1710	-4.0
- Nam Pong	373	293	-21.5
- Dong Nai	1119	794	-29.1
- Be	1053	708	-32.8
- Sai Gon	656	363	-44.7
- Vam Co	447	221	-50.6

- Y_0 (mm): The depth of annual run-off
- For the case “at present”, the data series of 1961-1990 was used

4.2.3. Adaptation measures

1. Building reservoirs with the total additional capacity of 15-20 billion m^3 for containing flood water to mitigate losses caused by floods, meanwhile, regulate water during low-flow season. Firstly, the high priority should be given to the East of South Viet Nam, Central Highland and mountainous areas in North Viet Nam.
2. Upgrading and raising the scale of drainage system;
3. Upgrading existing sea and river-mouth dykes, and step by step building new sea dykes;
4. Actively limiting the population growth rate and organiring new resettlement areas to avoid the effects of sea level rise.(especially in coastal area);
5. Reclaiming areas, especially in hilly midland areas in the North Viet Nam, for agricultural production;
6. Using water scientifically and effectively with special attention paid to increasing run-off during low-flow season, which is regulated by reservoirs.
7. Exploiting while protecting water sources.
8. Conducting studies in long-term water resources prediction, seasonal, inter-annual predictions of water sources for planning rational and safe use of surface water sources.

4.3 CLIMATE CHANGE IMPACTS ON AGRICULTURE AND ADAPTATION MEASURES:

4.3.1 Impacts on agriculture

- ❏ Criteria concerning cropping season and distribution of crops

In response to climate change simulation, the length of period with air temperature lower than 20^0C would decrease 10-20 days by 2010, 20-30 days by 2050 and 30-50 days by 2070. On the contrary, the length of period with air temperature $\geq 25^0$C would increase 10-15 days by 2010, 15-45 days by 2050 and 30-80 days by 2070 (table 4.5).

Table 4.5: Differences of length of the period with average temperature lower than 20^0C and higher than 25^0C of 2010, 2050 and 2070 in comparison with present, in various ecological zones.

Year	2010		2050		2070	
Region	No. of days T≤ 20^0C	No. of days T ≥ 25^0C	No. of days T≤ 20^0C	No. of days T≥ 25^0C	No. of days T ≤ 20^0C	No. of days T ≥ 25^0C
North Mountainous and Midland	-10	+14	-20	+28	-50	+70
Red River delta	-12	+10	-34	+30	-50	+50
North Central coast	-7	+16	-25	+45	-35	+80
South Central coast	-20	+6	0	+18	0	+30
Central Highland	-15	+7	0	+14	0	+56
South Viet Nam	0	0	0	0	0	0

Table 4.6: Differences of annual sum of temperature and absolute minimum temperature of 2010, 2050 and 2070 in comparison with present.

Unit: ^{o}C

Year	2010		2050		2070	
Differences in comparison to present	Annual sum of temperature	Absolute temperature	Annual sum of temperature	Absolute temperature	Annual sum of temperature	Absolute temperature
Mountainous and midland in the North	180	+2.7	660	+3.0	910	+4.5
Plain in the North	110	+1.0	400	+1.8	550	+2.2
North of Central	110	+0.5	400	+1.3	550	+1.7
South of Central	110	+0.5	400	+1.3	550	+1.7
Central Highland	180	+1.2	660	+1.7	910	+3.2
South Viet Nam	110	+1.1	400	+2.0	550	+2.3

Similarly, annual sum of temperature would increase 110^0C - 180^0C by 2010, 400 - 660^0C by 2050 and 550-910^0C by 2070 (table 4.6). In the mountainous and midland areas of North Viet Nam and Central Highland, the sum of temperature would increase much more than other areas. Meanwhile, absolute minimum temperature would also increase with the same rate of average temperature.

Thus, the adaptation time of tropical crops would extend, while the one of subtropical crops would decrease.

4.3.2 Climate change impacts on crop distribution

1. The planting boundary of tropical trees/crops would move towards higher mountainous region and northwards. On the other hand, the adaptation area of subtropical plants would become narrower. By 2070s, the mountainous tropical trees would be able to grow at the altitude 100-550 meters higher and move 100-200 km northwards in comparison with present.
2. Due to abnormal changes of rainfall intensity, flood inundation and drought would occur more frequently.
3. Significant cultivation areas in Mekong and Red River deltas would be under salt water due to sea level rise.

4.3.3 Adaptation measures

1. Development of crop patterns suitable to climate change.
2. Effective use of irrigation water.
3. Upgrading of irrigation system for agriculture.
4. Development of new varieties that could stand against severe environmental conditions.
5. Reserve and storage of local crop varieties, establishing crop seed bank.
6. Development of farming techniques appropriate to climate change.

4.4 CLIMATE CHANGE IMPACTS ON FORESTRY AND ADAPTATION MEASURES

4.4.1 Impacts on forest ecosystem

Forest cover is the product of the long evolution and interaction process between natural factors where climate plays the dominant role. Climate change with increasing temperature, change of rainfall amount and sea level rise would affect forest coverage and forest ecology in various aspects.

- Sea level rise would make mangrove forest decrease, and adversely affect indigo forests and forest planted on the sulfated land of provinces in the South of Viet Nam.
- It is possible that there would be changes in boundary distribution of primary forest as well as secondary forest. For instance, dpterocarpaceae wood trees would expand to thwards and to higher altitudes. Deciduous forest with drought stand varieties would develop more due to the lack of soil moisture and high plant evapotranspiration.
- The increasing temperature in combination with abundant solar radiation would promote photosynthesis process that leads to acceleration of assimilation process of verdurous trees. However, due to increase of evapotranspiration, soil moisture would reduce, the biomass growth index of forest trees would get down.
- The extinction danger of animal and plant would increase, some important plants like aloe wood,

boswood, textured wood, siadora Vietnamese, etc. would likely being exhausted.

- The increase of temperature and drought would lead to increasing danger of forest fire, development and spreading of plant pests and diseases.

4.4.2 Adaptation measures

1. Enhancing reforestation, firstly in watershed, regreening bare lands and hills, protecting and developing of mangrove forest.
2. Protecting natural forest and going forward to closing natural forest exploitation. Preventing forest fire.
3. Establishing bank of seeds of natural forest trees in order to protect some valuable varieties.
4. Enhancing timber processing and limiting use wood as material.
5. Selecting and developing plant varieties suitable to natural conditions taking into account climate change.

4.5 CLIMATE CHANGE IMPACTS ON AQUACULTURE AND ADAPTATION MEASURES

4.5.1 Impacts on aquatic eco-system

Impacts of sea level rise effects of increasing temperature and rainfall change

Salinity intrusion would lead to consequences:

- Habitat of fresh water living creatures would become smaller due to occupation of sea water.
- Mangrove forest would reduce and affect ecosystem of some aquacultural species.
- The fixing-organic-matter capacity of seaweed ecological system would that results in decreasing sources of photosynthesis products and nutrition for living creatures in sea-, river-beds. Thus, quality of living habitat of various living aqua-creatures would get worse.
- The increase of water temperature would lead to clearer thermal vertical stratification that, in its turn, would affect biological habit of living creatures.
- With increasing temperature, some species would move northwards or “dive” to deeper depth that would change vertical distribution structure of aqua-creatures.
- Increasing temperature would also accelerate mineralization and organic decomposition processes and affect food system of living creatures. The living creatures should consume more energy for respiration, as well as for other living activities that reduce the productivity and commercial quality of aquacultural and sea products.
- Increasing temperature would cause the degeneration or destruction of coral reef; change

physiological, bio-chemical processes occurring in interaction between coral reef and ALGAS.

- Due to big rainfall intensity, salt concentration of seawater would reduce by 10 - 20% during a long period (it could prolong from some days to some weeks). As a result, brackish water and coastal living creatures, especially, dual crust mollusks (like arca, oyster, etc.) would die massively because they could not stand against changes of salt concentration.

4.5.2 Impacts of climate change on income from sea products and fisheries

- Due to sea level rise, hydro-physical hydro-biological and hydro-chemical regimes would be degraded, and as a result, the existing coenosium would change its structure and components, supplemental reserve would reduce seriously. It is predicted that economic sea product capacity would reduce at least one third in comparison to the present.

- Due to increasing temperature, benefit resources distribution would be more dispersed. Meanwhile, the number of tropical fishes with low commercial value, except tuna, would increase. The number of sub-tropical fishes (with high commercial value) would decrease or even disappear. Most fishes in coral reef would vanish.

- Phyto plankton the first link of food chain for plankton and juvenile fish would be destroyed leading to the sharp decreases of plankton - the main flood source for animals in the middle and above layers. The following consequences may occur:

    - Migration of fishes to another sea areas (passive migration)
    - Reduction of body weight of fish.
    - Destruction of organic relation within coenosium, especially, in the shallow or coastal sea area.

4.5.3 Adaptation measures:

1. Researching on prediction of movement of fishes and providing fishermen with fish monitoring equipment such as fish detectors, fishing-place positioning equipment.
2. Importing and developing valuable aquaculture varieties that could adapt to high temperature, for instance sugpo prawn, green clawed crayfish, lobster, white bass, black bass, etc... At the same time increase the depth of fish lakes, and ponds to create suitable temperature and mitigate losses due to fast evaporation from water surface.
3. Changing farming structure in some wet areas from rice monoculture to fish-rice rotation system.
4. Taking into account sea level rise and increase of temperature while building infrastructures, quays, ports, store houses, etc.
5. Developing plan on brackish water aquaculture for Central Viet Nam with 2000 km of coast and sandy land to create an effective and multiform business without affecting agricultural land.
6. Building back-up dyke behind sea dyke to create transitional belts between agricultural land and

sea. In these areas, the main cultivation would be aquaculture, where gravitation flow would supply water and pumping would drain surplus water out.

7. Building storm shelter port systems along the coast as well as in islands.
8. Establishing natural ecological reserves, especially coral reefs and atolls.

4.6 CLIMATE CHANGE IMPACTS ON COASTAL ZONE AND ADAPTATION MEASURES

The impacts of sea level rise on coastal zone were assessed on the basis of IPCC scenario for the year 2100 with sea level rise by 1 meter.

4.6.1 Impacts of sea level rise on flood and inundation:

- Sea level rise by 1m would cause inundation, particularly in the Mekong Delta.
- Sea level rise would affect the wet land in coastal zone of Viet Nam, most seriously in the arena forest of Ca Mau province, Ho Chi Minh City, Vung Tau and Xuan Thuy sea areas (in Nam Dinh Province)
- The coastal population would be affected by annual flood and inundation, especially in the Mekong River Delta.

4.6.2 Impacts of sea level rise on mangrove

- Sea level rise might make a large number of existing forests totally under water.
- Other climate change features would also affect characteristics and structures of mangrove. Warmer winter would create favorable conditions for development of mangroves in coastal zone of North Viet Nam, but in coastal zone of Central Viet Nam, the increasing dry, hot and drought weather would adversely affect the growth and development of mangrove forest. Aggregation and erosion occurring in many coastal places would increase and stronger wave that would adversely affect mangrove forest.

4.6.3 Impacts of sea level rise on planning of residential areas and construction

- With regards to planning of residential and urban areas: sea level rise would make a great area of land in the Mekong, Red River deltas and Central coastal zone become narrower, unless an enough high dyke system would be built. On the other hand, storm surge would be stronger, threaten structures in the coastal zone and low lands.
- With regard to design and construction: sea level rise would threaten industrial, transport and national defense structures that were designed according to present sea level. The increase of flood and inundation would negatively affect the foundations of structures. The increase of typhoons, tornadoes would require to strengthen the resistance of structures that lead to increase of their costs.

4.6.4 Adaptation measures

Strategic options:

There are 3 strategic options for active adaptation to sea level rise:

a) Full protection: implement all-sided protection measures to maintain present situation, effectively response to sea level rise. This option requires to make all dykes higher and strengthen coastal management. To prevent salinity intrusion, pumping for drainage and making land foundation higher would be very necessary.

b) Adaptation: reform infrastructures and habits of the people living in the coastal zone to adapt to sea level rise. To accept some losses, paying special attention to build "adaptive" infrastructures and transfer to suitable farming techniques.

c) Withdrawal (also called "avoidance"): Avoid natural impacts of sea level rise by resettlement, moving houses, and infrastructures from threatened areas. This option would also include natural mitigation from inundation area inland.

In accordance with reality, in each locality one or two above-mentioned strategies could be used and implemented. However, in nation-wide scale, there should be combination of all three strategies.

4.7 CLIMATE CHANGE IMPACTS ON ENERGY, TRANSPORTATION SECTORS AND ADAPTATION MEASURES

4.7.1 Impacts of sea level rise

Activities of oil drill platforms in the sea, transport system of oil and associated gas and gas power plants built on the coast would be affected, and that may increase expenditures on maintenance, repair and operation... The seaports including wharves, quays, and stores that were designed according to present water level should be modified, or even moved to other places. The North-South railway and transport lines close to the sea, electricity transformer stations and transmission lines in the coastal areas would be also affected. Run-off regimes of big rivers where hydropower stations were built would change that obviously affect water regulation mechanism there. Sea level rise would inundate lowland, leading to increasing energy for pumping out water for drainage.

4.7.2 Impacts of increasing temperature

Increasing temperature would affect expenditures of coalmine ventilation and cooling, increase expenditures for cooling and thus decrease efficiency and productivity of thermal power plants. Power consumption for living, industrial and commercial activities would be also higher due to intensive use of electric ventilators, air conditioners.

Increasing Evapotranspiration in combination with abnormal fluctuation of rainfall regime, leading to changes in water reserve and discharge of hydropower reservoirs, would affect hydropower generation. At the same time, these would also raise expenditure on agricultural irrigation and drainage.

4.7.3 Impacts of typhoon rains

Climate change would lead to changes in some characterization of typhoon and typhoon season: typhoon season would start later and more frequent in low latitudes and especially typhoon intensity would be more abnormal.

Changes in characteristics of typhoon season would affect directly energy sector, firstly offshore drill platforms, system to transport oil and gas to the shore, electricity transmission and distribution system. Hundreds of high voltage and low voltage poles would be danger.

Too high rainfall intensity also creates potential danger for reservoir regulation, causing flood, inundation and threatens the safety of downstream areas, especially of the Red River and Mekong River deltas.

Inundation due to heavy rainfall would result in increasing expenditure on water drainage pumping. Heavy rainfall may cause flash floods, landslides, destruction of dam structures and various hydropower systems that result in increasing expenditure on maintenance and repair. Flood and inundation area also potential cause to destroy infrastructure system and power distribution system.

4.7.4. Adaptation measures

- Taking into account climate change factors in planning of energy and transport development.
- Upgrading and reconstructing transport infrastructure in areas often threatened by sea level rise and flood.
- Ensure demand side management of energy (DSM) based on high efficiency of energy use, economical and rational use of energy, ensuring energy security and safety.
- Developing strategies to response and adapt to the vagary of weather.

4.8. CLIMATE CHANGE IMPACTS ON HUMAN HEALTH

4.8.1 Direct impacts of climate change

a. Warmer climate would have adverse impacts on human health. Extreme weather would lead to some dangers threatening old people; people suffered from cardiac disease, mental disorder. Warming climate would change seasonal structure; warming winter in North Viet Nam would result in changes of biological rhythm of the people.

b. The increase of natural disasters such as typhoon, storm surge, strong wind, and heavy rain would threaten the life of people in many regions, particularly in coastal, mountainous areas....

4.8.2 Indirect impacts

❑ *Impacts through disease carrier and spreading sources*

There are many infectious diseases affected by global climate change such as: malaria, synaptic filariasis, dengue fever, Japanese encephalitis, arboviral diseases that are considered to be common in humid tropical region.

The increase of temperature would facilitate the growth and development of various viruses and insects - disease carriers. Therefore, the infectious diseases such as diseases in digestion and respiration system or viruses diseases easily spread, leading to increasing patients and death rate.

❑ *Impacts on life and production*

At first, the food and foodstuff production should be taken into account. Agricultural area would be reduced or dyke system should be built to prevent cultivated fields from sea level rise, especially in the plains of South Viet Nam. Consequently, provision of food and foodstuff would be more difficult with higher price due to increase of production expenditure, that significantly affect the income of population in this sector.

In the condition of sea level rise, transportation, industrial production ... in coastal areas would meet with difficulties, affecting jobs, income and consumption of the people, indirectly affecting human health over large areas of the country.

4.8.3 Adaptation measures

a) Accelerating the implementation of the programme “Eliminating hunger and reducing poverty”, improving socio-economic standard of the people, especially of those in remote areas with many economic difficulties. Meanwhile, improve public knowledge on family sanitation and culture through national programmes such as “Clean water and environmental sanitation”, “Garden – pond – breeding facilities”, “Biogas”, etc.

b) Developing national plan and programme for medical control and monitoring in areas that have high danger of infections, in order to take timely response measures and prevent the spreading of diseases.

c) Establishing green, clean and beautiful areas (parks, green trees, springs, flowers, etc.) in the dense populated areas; meanwhile, set up house-building criteria, considering climate change.

d) Promoting public awareness on climate change so that every person could take adaptation measures for himself.

e) Implementing strict quarantine at the borders, airports to prevent infection and disease transmission from outside.

CHAPTER 5

CLIMATE OBSERVATION AND MONITORING SYSTEM IN VIET NAM

5.1 OBSERVATION SYSTEM

Climate observation and monitoring system in Viet Nam set up since the end of the previous century, consists of meteorological surface station network and some other specialized stations. Hanoi meteorological station was established first, in 1898. Currently, after more than 100 years of establishment and development, the meteorological station network in Viet Nam consists of 166 meteorological surface stations, 253 hydrological stations and hundreds of other specialized stations.

At 166 meteorological surface stations, the observation of all or some meteorological factors is carried out. The regional distribution of the stations is as below (table 5.1):

Table 5.1: Regional distribution of meteorological stations

No	***Region***	Number of stations	Proportion (%)
1	North Viet Nam	81	48.8
2	North of Central Viet Nam	34	20.5
3	South of Central Viet Nam and Tay Nguyen (Central) Highland	35	21.1
4	South Viet Nam	16	9.6

Resource: Study on planning of Hydro-Meteorological network in Viet Nam -1997

The stations have been established in the different periods, but mostly from 1945 to 1975 (tables 5.2).

Table 5.2: Number of meteorological stations and their establishment periods

No	Period	Number of stations	Proportion (%)
1	1898 – 1945	47	28.3
2	1945 – 1975	92	55.4
3	1975 – 1987	24	14.5
4	1987 – 2000	3	1.8

Source: Study on observation and monitoring of climate change in Viet Nam - 2000

Most of meteorological data series are long enough for climate research and climate change monitoring. There are more than 130 stations that have 30-year and longer observation data series, in which more than 60 stations with 60-year and longer observation periods.

Meteorological surface stations are classified into 3 categories based on the number of observational meteorological parameters, times of observations per day and responsibility on observation data transmission.

Class-1 meteorological stations conduct all meteorological element observations (solar radiation, cloud, sun-shine duration, wind, atmospheric pressure, air and soil temperatures, precipitation, evaporation, humidity and weather phenomena) 8 times a day and transmit observed data to international and/or domestic meteorological forecasting centers.

Class-2 and Class-3 meteorological stations conduct 4-8 observations a day for some meteorological factors and weather phenomena. These stations may (or may not) be involved in data transmission system.

Specialized meteorological stations include 10 upper-air meteorological stations, 5 weather radar stations, 37 agrometeorological stations, 20 marine hydro-meteorological stations, and 920 rain-gauge sites.

Upper-air stations conduct 1-2 observations a day on some meteorological factors (temperature, humidity, and wind) within the atmospheric layers below 25-30 km.

Agrometeorological stations conduct observations on both hydro-meteorological factors and the growth and development of some crops, mainly wetland rice and foodstuff crops to serve agricultural production, ensure national and regional food security.

Marine hydro-meteorological stations conduct 4 observations a day on sea level, sea temperature and salinity.

Rain-gauge station network in Viet Nam consists of 765 sites with direct rain measurement instruments and 137 sites with rain recorders. The stations are unevenly distributed and concentrated more densely in plains than in mountainous areas (table 5.3).

Hydrological network with 250 stations classified into 4 categories conduct observations on water level, run-off, temperature and some parameters on water quality to serve flood forecasting and warning, water use and management, water resources, etc.

Table 5.3: Regional distribution of rain-gauge stations

Region	Number of stations	
	Conventional instrument	Recorder
North Viet Nam Mountainous and Midland region	267	52
North Viet Nam plain	87	14
North of Central Viet Nam	110	25
Coastal area of Central Viet Nam	83	16
Tay Nguyen Highland	56	12
East of South Viet Nam	51	7
West of South Viet Nam	111	11
Total	***765***	***137***

Source: Study on planning Hydro-Meteorological network in Viet Nam – 1997

- ***Water and air environment monitoring stations established in recent 20 years include:***
  - 1 ground atmospheric monitoring station belongs to WMO Basic Pollution Monitoring Network;
  - 3 urban/industrial zone pollution monitoring stations;
  - 22 rainfall and dust deposition sampling stations
  - 51 river water quality monitoring stations.
  - 48 salinity monitoring sites
  - 11 reservoir environment monitoring stations
  - 6 marine environment stations

  The environment factors observed are the following:
  - Cumulated dust deposition, rainfall chemical compositions , SO_2, NO_x and CO;
  - Hydro-chemical constituents (BOD, COD, pH, DO), heavy metals hydrocarbon, coliform, salinity, etc.

  Viet Nam has started observations on connective ozone and UV in recent 10 years.

Viet Nam has conducted the planning of observation network to do measurements on meteorological, hydrological and environmental factors, including planning of surface meteorological stations, hydrological stations, marine hydro-meteorological stations, environment monitoring stations, particularly planning and building of weather radar stations. After completion, this weather radar system will monitor the weather all over the territory of Viet Nam.

Recently, the transmission, collection and processing of data have been gradually modernized with the development of information technology. Databases have been established to serve the requirements of

economic development. These databases have also contributed effectively to the research into climate variation and change tendencies, as well as to serve the making of this National Communication.

However, before the urgent requirements of reality, the development, strengthening of new and advanced technologies are very necessary for timely forecast and warning of natural disaster. This is also an aspect which Viet Nam as well as other developing countries need the assistance from developed countries.

5.2 CHANGES AND TENDENCY OF SOME MAIN CLIMATIC FACTORS.

5.2.1 Changes and tendency of typhoons

During the second half of the 20th century, in average, every year 4-5 typhoons affected Viet Nam.

The changes of typhoons have following features:

There were 24 years with typhoon number under normal (negative standard deviation) and 26 years with typhoon number above normal (positive standard deviation).

There were 7 years with very small number of typhoons (≤ 3 typhoons) and 7 years with big number of typhoons (≥ 10).

The decade 1971-1980 had the biggest number of typhoons. 1978 had the biggest number of typhoons in one year during the second half of the 20th century (13 typhoons). But, also in this decade, in 1976, there was not any typhoon landing on Viet Nam coast.

During three consecutive decades 1961-1970, 1971-1980, 1981-1990, the number of typhoons increased obviously in comparison to previous decades, but during the decade 1991-2000, the number of typhoons decreased. In other words, the increasing tendency of typhoons started since 1950's had not appeared in the last years of previous decade.

During recent years, typhoon trajectory was moving southward and typhoon season was shifting to the later months of the year.

5.2.2 Changes and tendency of number of North Earth fronts in winter

Cold front (often called as winter monsoon and, in short, as monsoon) mainly affects North Viet Nam. Therefore, in reality, changes of winter monsoon are changes of cold fronts passing Hanoi. In average, annually there are 30 of them. According to data series from 1955 to 2000, the changes in frequency of winter monsoon have the following features:

- There were 12 years with number of winter monsoons above normal (positive standard deviation) and 20 years with number of winter monsoons below normal (negative standard deviation);
- There were 5 years with number of winter monsoons much higher than normal (≥ 34); and 5 years with number of winter monsoons much lower than normal (≥ 26);
- In general, the frequency of winter monsoon varied rather evenly during decades in the second half of the 20th century.

Table 5.4: Some characteristics of frequency of monsoon during 5 recent decades

Decade	Frequency of monsoon		
	Annual mean	**Highest**	**Lowest**
1956-1960	30	33	29
1961-1970	30	37	26
1971-1980	30	33	24
1981-1990	29	30	27
1991-2000	30	37	24

Source: Study on observation and monitoring climate change in Viet Nam -2000

5.2.3 Changes of temperature and its tendency

- The change of temperature is rather big in winter, especially in December, January, and February and rather small during summer months, smallest in June, July, and August. The change of annual mean temperature is the smallest and commonly has standard deviation of 0.3-0.6^{0}C.
- The change rate depends on geographical location and concrete conditions of the season. In winter, the standard deviation varies from 1-2^{0}C in different regions. In summer, the change is small and rather even in various regions; the standard deviation varies from 0.4-0.8^{0}C.
- There is no significant difference between high and low mountainous areas, between islands and neighboring mainland in the change of temperature.
- The tendency of temperature could be seen through behaviors of annual and monthly mean temperature during recent decades:
- In general, the mean annual temperature of 4 recent decades (1961-2000) was higher than that in 3 previous decades;
- The tendency of temperature is not the same in different seasons.

Summer temperature has an increasing tendency during 3-4 recent decades. Winter temperature has an increasing tendency only in the decade 1991-2000. There are differences between regions in tendency of temperature that appear through comparison of temperature of the decade 1991-2000 to that of the decade 1981-1990. According to preliminary estimation, the average increasing rate of temperature was about 0.07- 0.15^{0}C per decade.

5.2.4 Changes and tendency of rainfall

- In the same period, rainfall changes in more rainfall regions are bigger than in less rainfall regions.
- In the same location, rainfall changes in months with more rainfall are bigger than in months with less rainfall. Changes of annual rainfall far exceed changes of monthly rainfall in the absolute value.
- Changes of rainy season are clearer than changes of heat season.

It is not rare occurrence that rainfall in some months of dry season is higher than in months in rainy season. The beginning and ending dates of rainy/ dry season vary from 3-4 months or even 5-6 months. The peak of rainy season may be one of 5-6 months of this season, from April / May to October / November. Particularly, in Central Viet Nam, this period is narrower.

- Comparing average rainfall between decades, it is noticeable that there is a significant difference in annual rainfall as well as in month rainfall.

5.2.5 Sea level rise:

Research of many countries over the world and in the region showed that sea level rise is of concern in Viet Nam sea area. Observation data at Hon Dau and Cua Ong marine hydro-meteorological stations shows that in average, sea level rises from 2.5 to 3 cm per decade.

5.3 CONCLUSION

Analysis of climatic data of the second half of the 20^{th} century showed the following tendencies: typhoon trajectory is moving to the south and typhoon season shifts to the end of the year; temperature base increases by 0.07 - 0.15^{o}C per decade; rainfall and winder monsoon changes have no clear tendency, while sea level rises in average from 2.5 to 3.0 cm per decade.

CHAPTER 6

EDUCATION, TRAINING AND IMPROVEMENT OF PUBLIC AWARENESS

Training workshop on Climate Change

6.1 EDUCATION AND TRAINING ON ENVIRONMENT AND CLIMATE CHANGE

Climate change is considered as a serious challenge to global environment. Consequently, climate and climate change are considered as important components of environment in education and training programme.

In recent years, Viet Nam has conducted environment education in school, mainly in universities and vocational schools.

"Human and environment ", "Basic environment", "Ecological environment"... are compulsory subjects in universities for disciplines relating to natural resources. In national universities, there are Environment Faculties conducting education and training courses on environment for experts and personnel working in various institutions.

National Environmental protection Agency (MONRE) also organized various short-term training courses on environment.

A Scientific journal “Environment” is issued quarterly.

Competitions on painting, composing songs, documentary films on environment attract the participation of the public.

Many universities in the country organized short-term training courses on climate and climate change for teachers and students. Some publications on climate change, including the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, etc. are delivered to various experts and people through meetings, conferences, workshops, etc.

In the long term, Viet Nam is planning to conduct education on environment broadly within its education system, from schools to universities. The educational and training activities will be strengthened day by day to enhance awareness of the people on environment and climate change.

At present, the training on environment and climate change is of great concern. Some short-term courses were organized for environment management officials from local and central agencies and enterprises. However, this should be strengthened and projects with international support on capacity building are necessary. There have not been strong institutions specialized in climate change research. The establishment of these institutions should be included in capacity building projects.

6.2 ENHANCEMENT OF PUBLIC AWARENESS ON CLIMATE CHANGE

In 1994, the Government of Viet Nam designated the Hydro-Meteorological Service (HMS) as the focal point of activities concerning the implementation of UNFCCC. In recent years, Viet Nam has deployed many activities to promote the implementation of UNFCCC, in which public awareness is of great concern. The main activities are:

- Establish National Team on Climate Change, including representatives of Ministries and sectors as follows:

- Ministry of Planning and Investment
- Ministry of Science, Technology and Environment
- Ministry of Industry
- Ministry of Transportation and Communication
- Ministry of Agriculture and Rural Development
- Ministry of Education and Training
- Ministry of Foreign Affairs
- Ministry of Finance
- Ministry of Public Health
- Ministry of Justice
- Union of Viet Nam Science and Technique Associations

The National Team is the national consultantcy agency on climate change issues, headed by Director General of HMS.

- Formulate "National Programme to implement the United Nations Framework Convention on Climate Change", including strategy, policy, action plan and adaptation measures to mitigate climate change in Viet Nam, at the same time, to actively access to modern technologies and international financial resources from financial mechanism concerning climate change to serve the sustainable socio-economic development.

- Implement following projects:

The international support projects also have important contribution to assist Viet Nam in strengthening climate change activities as follows:

- "Climate change in Asia: Viet Nam" funded by Asian Development Bank (ADB) during the period of 1992 – 1994. The project conducted the National Greenhouse Gas Inventory in 1990, assessed impacts of climate change on socio-economy of Viet Nam.
- "Potential impacts of climate change on socio-economy" funded by the United Nations Environmental Programme (UNEP) during the period of 1993- 1995.
- "Training on Climate Change - CC: TRAIN" funded by the Global Environment Facility (GEF) during the period of 1994 – 1995. Within the project, the national policy for implementation of UNFCCC was preliminarily developed.
- "Viet Nam Coastal Zone Vulnerability Assessment " funded by the Netherlands Government, implemented in the period of 1994 – 1996. Within the project, the vulnerabilities of Viet Nam coastal zone due to sea level rise were estimated and some management solutions were suggested.
- "Asian Least cost Greenhouse Gas Abatement Strategies (ALGAS)" funded by UNDP/GEF/ADB,

and implemented within the period of 1995 - 1997. The objectives of the project were to strengthen capabilities of participating countries in conducting national greenhouse gas inventories, assessing mitigation options and developing greenhouse gas mitigation strategy with the least costs.

- "Economics of Greenhouse Gas Limitations" funded by GEF and implemented within the period of 1997 – 1998. Its objectives are to establish methodology framework for the assessment of greenhouse gases abatement.
- "Viet Nam Initial National Communication" funded by GEF, started from 1999 aiming at developing the first Viet Nam National Communication to submit to the UNFCCC Secretariat.

Besides, there were many direct and indirect activities to enhance the public awareness on environment protection and mitigation of impacts of climate change as follows:

- TV and radio programmes on climate change broadcaster on central and local TVs and radio stations.
- "Energy Saving Programme" carried out since 1997 by Ministry of Science, Technology and Environment. Many activities were implemented to enhance public awareness on effective energy use.
- "National Environment Week" organized annually to encourage people to participate in the environment protection activities.
- The "Tet Planting Festival" is organized annually in spring with the spirit "Raising people for 100-year benefit, planting trees for 10-year benefit".

These activities also contribute to raise the public awareness on climate change and environment.

6.3 POPULARIZATION AND DISSEMINATION OF THE CLIMATE CHANGE ISSUES IN THE NATIONAL ENVIRONMENT PROTECTION STRATEGY FOR THE PERIOD 2001-2010.

The Environmental Protection Law was approved by Viet Nam National Assembly in 1993 with the aims to protect sound environment, improve environment, ensure ecological balance, overcome consequences and caused by human and nature, and exploit and use environmental resources rationally and economically.

This law was followed by the "Guidelines for the implementation of Environmental Law" approved by the Prime Minister on 18 October 1994. After consecutive years of successful implementation of this law, in 2000, Viet Nam developed National Environmental Protection Strategy for the period of 2001-2010. The general objectives of the strategy are to continuously protect and improve environment in order to raise the living quality and health of the people, and to ensure the sustainable development of the country.

The National Environmental Protection Strategy relates closely to following activities on climate change:

- Developing the plan for sustainable industrial development, rational resources utilization, effective production and waste management;

- Managing and controlling air, water and noise pollution in industrial enterprises;
- Implementing clean production strategy;
- Enhancing awareness in enterprises on requirement of minimization and effective management of waste, training on environment and climate change for managers;
- Developing plan for management of solid, dangerous waste storage and effective waste treatment system for all class I and class II cities and densely populated urban areas;
- Ensuring waste collection from households and its effective treatment;
- Preventing pollution from medium and small enterprises and from agricultural activities and husbandry;
- Improving effectiveness of energy generation and utilization;
- Enhancing utilization of clean energy consumption technology;
- Conserving and utilizing effectively land resources, avoiding from soil degradation;
- Mitigating greenhouse gases emissions and ozone depletion substances;
- Promoting forestation in watershed;
- Increasing forestation and protecting degraded coastal forests, particularly, mangroves;

The popularization and dissemination of National Environmental Protection Strategy also contribute actively to implementing obligations of a Party to the United Nations Framework Convention on Climate Change.

Based on National Environmental Protection Strategy, many policies and programmes were developed and implemented at various levels, from the central to local governments.

CHAPTER 7

GREENHOUSE GAS MITIGATION ORIENTATION IN ENERGY, AGRICULTURE AND FORESTRY SECTORS

Afforestation

Oil waste processing plant of 20ton/day
in Ho Chi Minh City

The direction of economic development of Viet Nam to 2020 has been set by the 9th National Congress of the Communist Party of Viet Nam as follows: Promote industrialization, modernization, build independent and self-supporting economy, change the country into an industrialized one; priority is given to development of production force, while building production relationship in accordance with socialist orientation; highly strengthening of internal forces, while trying to acquire foreign assistance and actively merge into international economy to attain fast, effective and sustainable development; protect and improve environment....

On the basis of above-mentioned economic development direction, the orientation and measures to mitigate greenhouse gases emissions from energy, forestry and agriculture sectors have been developed in this Initial National Communication and will be elaborated in following communications.

7.1. ENERGY

7.1.1 Energy development strategy of Viet Nam during the period of 1996-2020

- ***Objectives:***
  - To ensure energy supply for socio-economic development and livelihood of the people, firstly, for industrialization and modernization.
  - To bridge the gaps in energy consumption between rural and urban, mountainous and plain areas, to maintain energy supply security for all the parts of the country.
  - To utilize effectively and rationally various energy forms on the basis of policy system of energy demand management to ensure least costs.
  - To mitigate impacts on environment of energy sector to ensure the sustainable development of national economy as well as of all socio-economic activities of the country.
- ***Energy development policy***
  - Fuel supply: diversify fuel sources, priority is given to exploitation of domestic fuel sources, mainly anthracite, hydropower, oil-gas, in which hydropower and oil-gas are two spear heads; priority is given to exploitation of domestic fuel sources.
  - Electricity generation: Maximize the exploitation of economic and technical potential of hydropower; invest and apply modern, effective and environment friendly technology to secure the clean environment for building and operating of oil and coal thermal power plants. Conduct studies, technology transfer, prepare for establishment of an atomic power plant before or after 2020. Shift electricity generation structure by increasing the portion of thermal power (mainly gas power plant) to ensure stability of the national power system.
  - Transmission: consolidating and upgrading the electricity interface, transport and distribution system; conducting the construction of a specialized gas-pipe system to household consumers and processing

plants; participating in regional energy interface and exchange such as power line and gas pipeline networking.

- Renewable energy: Enhancing studies on development of renewable energy such as wind, solar radiation, biomass and small hydropower not only in mountainous areas, but also for networking.
- Technology innovation and energy saving: Increasing efficiency of energy exploitation, transformation and economical use of energy. Identifying policies encouraging households to use energy effectively. Developing plans for designing, manufacturing and utilizing power-economical equipment.
- Development and renovation of energy institutional framework: developing and elaborating legal framework regulating energy activities following market orientation with state regulation. Building management system of energy activities, separating state management function from business and production management function.

7.1.2 Energy development orientation taking into account the requirements of greenhouse gas mitigation

Mitigation of GHG emission is a part of the national strategy on environment. From viewpoints of sustainable development in combination with environmental protection and energy development policies, all activities of energy sector should ensure both maintaining high economic growth and meeting the environment benefit in general, including GHG mitigation.

In order to implement environmental policy in combination with GHG mitigation strategy, the principles of energy development strategy should be as follows:

Ensuring the maintenance of rapid, stable and sustainable economic growth and contribution to mitigation of GHG emission, protection of climate system.

This principle should be implemented through following solutions:

- Efficient and economical use of energy;
- Effective and rational use of power resources, development and maximal exploitation of hydropower and gas;
- Development of new and renewable power forms;
- Determination of environment standards, evaluation of environmental benefit and costs for energy projects.

7.1.3 Program and orientation of GHG mitigation

- ***Short term (2000- 2010)***

- **Improving efficiency of energy use and conservation.**
  - Improving lighting efficiency;
  - Testing and popularizing efficient lighting appliances;
  - Supporting the manufacture, lighting management and training;
- **Saving energy in enterprises**
  - Strengthening capacity, carrying out programs on energy efficiency;
  - Providing information on energy and effective energy services;
  - Monitoring the implementation of effective energy and environment projects;
  - Improving efficiency of industrial boilers;
  - Using industrial motors with high efficiency;
- **Implementation of Demand-side Management (DSM) Programs**
  - Management of additional load to reduce the differences of electricity power and consumption between rush hours and leisure times;
  - Reduction of losses in electricity dissemination and distribution;
  - Implementation of program on urban energy efficiency;
  - Implementation of program on high-efficiency household appliances;
- **Effective energy use in buildings**
  - Conducting energy audit in big buildings;
  - Standardizing and encouraging the use of high-efficiency equipment;
- **Development and use of renewable energy sources**
  - Conducting collection of information, analysis, evaluation and feasibility studies for geo-thermal power plants in Central Viet Nam;
  - Development of small hydropower plants and household hydropower;
  - Building hybrid wind-diesel power generation in islands;
  - Development of household solar energy;

- **Energy saving in transport sector**
  - Developing public transport for cities and upgrading infrastructure to meet 25-30% of transportation needs;
  - Encouraging economical-fuel vehicles;
  - Improving the quality of means of communications;
  - Controlling gas emissions from vehicles;

- ***Long-term (2010-2020)***

- **Improvement of lighting efficiency**
  - Setting up lighting norms and saving regulations;
  - Supporting lighting manufacture, management and education;
- **Implementation of the Demand-Supply Management (DSM) programs**
  - Reducing electricity losses in transmission and distribution;
  - Conducting programs on urban efficient energy consumption and rural electrification;
  - Conducting the program on high efficient household appliances;
- **Effective energy use in buildings**
  - Strengthening capacity in construction designing taking into account energy efficiency;
  - Setting up energy norms for construction materials;
  - Popularizing and issuing regulations on using economical power equipment;
- **Improvement of energy efficiency of enterprises**
  - Improving efficiency of industrial boilers;
  - Using high efficient industrial motors;
  - Using high efficiency vehicles;
- **Economical use of energy in transport sector**
  - Developing public transport in cities in order to meet 50-60% of needs;
  - Upgrading transport infrastructures;
  - Substantially improving the quality of transport communications;
  - Controlling gas emission from vehicles;

- **Exploitation of new energy sources**
  - Maximal exploitation of small hydropower;
  - Developing geo-thermal power;
  - Developing wind power with industrial scale;
  - Popularizing the use of biomass;

Table 7.1 Energy development orientation taking into account GHG emission mitigation

Content	Short-term and medium-term (5-10 years)	Long-term (more than 10 years)
Improving efficiency of energy use and conservation	- Improving lighting efficiency - Improving energy use efficiency of enterprises - Implementing DSM program - Efficient energy use in high buildings	- Improving lighting efficiency - Implementing DSM program - Efficient energy use in high buildings - Improving energy use efficiency of enterprises
Using renewable energy sources	- Exploitation of geothermal energy - Exploitation of renewable energy: hydropower, wind, solar	- Hydropower, natural gas - Wind and biomass - Geothermal energy
Saving energy in transport sector	- Public transport meets 25 - 30% of transportation needs - Encouraging economical use of energy - Controlling waste gases - Promoting quality of means of communications	- Public transport meets 50-60% of transportation needs - Upgrading infrastructure - Controlling waste gases - Promoting quality of means of communications

7.2 AGRICULTURE

7.2.1 Orientation of agricultural development

- ***Strategic objectives:***
  - To build diversified, commodity agriculture, develop in sustainable way, speedily access and effectively apply new scientific and technological achievements, high technology, and increase competitiveness in domestic and international markets.
  - To build new rural areas with developed infrastructure, modern direction and rational economic structure: agriculture – industry - developing services.
  - To ensure employment, poverty eradication, a civilized, democratic and equitable rural society, and wealthy life.

- ***Immediate objectives:***
  - Growth rate of agricultural production: 4-4.5% per year
  - Growth rate of industry and services in rural areas: 10 – 12% per year
  - Food: 40 million tons per year (by 2005: 36 million tons)
  - Export turnover: US$ 9-10 billion by 2010, in which agro-forestry occupies US$ 6-7 billion.
  - Effectively making use bare and hilly land.
  - Development of industry, services in rural areas and rural agriculture economy structure continues to shift following direction in which:
    - More than 50% of agricultural rural labor force transfers to industry and services.
    - 100% of communes has primary schools, secondary schools, and health centers, and to make compulsory to everyone at primary and secondary education in some important regions.
    - Basically eradicate all serious venereal diseases.
    - Almost all households could access to electricity and clean water.

7.2.2. Agricultural development orientation taking into account GHG mitigation

- ***Basic requirement***

To meet demands on food, foodstuff of the people as well as of the export, meanwhile to mitigate GHG emission from agricultural sector.

- ***Contents***

- **Study and develop new agricultural farming techniques, both increasing agricultural production and crop yield and mitigating GHG emission.**
  - Selecting short-duration, high yield and quality rice varieties, replacing transplantation by direct sowing practices, transfer from rice mono-culture system to system of two rice crops and one secondary crop or one rice and one secondary crop.
  - Applying pill-form fertilizer (NPK) instead of fertilizer casting as before.
  - Studying and enhancing food processing for animals, while selecting high quality, productive breeds.

- **Improvement of irrigation-drainage management in rice fields:**

In the irrigated rice fields, implementation of water drainage during maximal stem spreading and after grain-filling phases would save water, increase rice yield and mitigate methane emission.

- **Establishing data bank and equiping calculation facilities to serve specialized research in agriculture and climate change.**

- **Improving meal and eating tradition of the people so that the meal would include not only rice but also various vegetables, foodstuff to ensure providing of adequate calories and reduce pressure on rice cultivation; some rice fields could be used to cultivate secondary crops and other trees instead of rice.**

Table 7.2 Agricultural development orientation taking into account GHG emission mitigation

Content	Short term and medium term	Long term
Development and application of agricultural farming practices to increase production and mitigate GHG emission	- Studying and developing rice cultivation techniques: direct sowing, short duration varieties, and change of cropping patterns, applying pill-form fertilizer. - Studying measures in husbandry: food, breeds	- Applying technical measures for main rice-cultivated and other areas. - Processing high quality food for animals, selecting high productive breeds
Improvement of irrigation/ drainage management in rice fields	Studying irrigation management by draining water during the two phases in the Red River and Cuu Long (Mekong) River deltas.	Irrigation and drainage management for other areas
Strengthening capacities of agricultural research institution	Strengthening experimental measurement stations and data/documentation offices	Strengthening computing facilities
Improvement of composition of daily meals (not only rice)		Studying meals with various food-stuff, vegetables besides rice

7.3 FORESTRY

7.3.1 Orientation of forestry sector development

❑ *General objectives*

The 9th National Congress of the Communist Party of Viet Nam has set up the direction of forestry development. In the coming years: promote the activities to develop forestry resources, increase the forest coverage to 36% and 43% by 2005 and 2010, fulfill the allocation of land and forest for household, combine agriculture with forestry, prevent forest fire and deforestation. Promote the planting of economic forests, create sources for wooden pillars in mining, materials for paper industry and making furniture and exported art objects.

Following this direction, the general objectives of forestry development of Viet Nam in the first 20 years of the XXIst century are the following:

- Socialization of forestry sector; strengthening of forest protection and restoration to secure the environment protection capacity. Maintenance of natural forest areas, conservation of biodiversity.
- Popularize the application of new scientific and technological achievements, high technology of the world in forestry production and business to meet the diversified and increasing needs of national economy.
- Contribute to hunger eradication and poverty alleviation, step by step improving the living standard of the people living in forest areas or near forests, creating firm basis for people's national defense.

❑ ***Concrete objectives***

- Formate and stabilize of national forest boundaries; Fulfill allocating forest land to local households for planting; Fulfill the planning of forest-products processing network.
- To the year 2010, organize about 3 millions of agricultural households to participate in forestry business with agro-forestry combination, to create jobs for about 6-7 million people.
- High socialization of forestry, in which forest types are arranged reasonably, with harmonic existence of forest and community in the area, regulating ecology and business, production objectives.
- Promote the productivity of natural and planted forests. Develop programs of planting scattered tree in order to contribute to improve ecological environment, protect natural forest and to meet the firewood needs.

7.3.2 Forestry development orientation taking into account GHG emission mitigation

Based on forest development strategy of Viet Nam for the period of 2001-2020, the activities related to forestry development, environment protection and GHG emission mitigation/GHG sink increase are the following:

- Focus on implementing the program of plantation of 5 million hectares of forest (Project 661) which was approved by Viet Nam National Assembly in 1997, with the aims to increase the forest coverage up to 43% by the end of the period.
- Develop action plan to prevent the degradation of forest resources, restore the forest by measures such as conservation of existing forest, delimitation for forest restoration, planting of new forest, limiting exploitation of natural forest, and preventing forest fire.
- Stabilize the structure of 3 kinds of forests, including protection forest, special-use forest and production forest.
- Implement integrated social policies such as: allocating forest land to the local households for planting, settlement program, "poverty alleviation" with the aims to actively support the program of planting 5 million hectares of forest.

- Improve the living standard of the people in mountainous areas. Attract as much as possible the local households to participate in activities to protect forest, plant forest and carru out forestry business.
- Socialize at high level the forestry on the basis of a multi-component economy. Renovate the production relationship in forestry.

Table 7.3: Orientation for implementation of forest development strategy taking into account greenhouse gas emission mitigation

Content	Short and medium term	Long term
Promotion of the implementation of 5 million hectare afforestation program, to increase the forest coverage up to 43%	+ Planting of 2 million hectares of specialized protective forest, including: Planting watershed protective forest, sand and sea wave preventing forest belts, urban environment gardens, special-use forest. + Planting of 3 million hectares of production forest	
Conservation of existing forests	Strict conservation of natural forest areas including national conservation gardens, rare wood forest, watershed protective forest, etc.	Conservation of existing forest structure, including 12 million hectares of natural forest and 3 million hectare of planting forest
Integrated restoration of forest	Planting of short- and long-term rotation forest, natural forest regeneration, and planting of scattered trees.	Planting long-term rotation forest; forest regeneration, planting of scattered trees (4 billion trees) Stabilization of existing forest structure
Forest fire prevention and preparedness	Studying various forest fire prevention measures	Setting up a forest fire warning and forecasting system

References

1 Ministry of Science, Technology and Environment, 2001-Report on the results of Program KHCN-09

2 Ministry of Agriculture and Rural Development, 1997-Project on 5 million ha forestation

3 Ministry of Agriculture and Rural Development, 1997-Report summarizing the work of forestation.

4 Duong Quang Thanh, 1995- Long-term optimal strategy to reduce CO_2 emission in energy sector.

5 Duong Hong Dat, 2001- Viet Nam Agriculture steps into XXI century.

6 Ha Xuan Thong, 1999- Assessment of climate change impacts on aqua product

7 Nguyen Cong Tan, 1995- Viet Nam Agriculture before investment and development opportunities

8 Nguyen Mong Cuong, 1999- Preliminary results of experiments on measurement of methane emission on rice field during 1998-1999 at Hoai Duc station

9 Nguyen Ngoc Huan, 2000- Vulnerability Assessment of Viet Nam coastal zone

10 Nguyen Trong Hieu, 2000- Summarize the results of research, observation and monitoring of climate change tendency in Viet Nam

11 Nguyen Trong Sinh, 1994- Climate change impacts on water resources and strategy of sustainable exploitation

12 National Politics Publishing House, 2001 - Documents of the 9th National Congress of the Communist Party of Viet Nam

13 Phung Tuu Boi, Forest Inventory and Planning Institute, 1998- Data on forestry development and land use change in 1994 of Viet Nam

14 General Department of Land Administration, 1996- Report on land use to 2010

15 Hydro-Meteorological Service, 2000 - Summarize the results of research, observation and monitoring of climate change tendency in Viet Nam.

16 Hydro-Meteorological Service, Hanoi, 1987 - Planning of basic hydro-meteorological network

17 Hydro-Meteorological Service, Hanoi, 1991 - Planning of basic rain gauge network.

18 Hydro-Meteorological Service, 2001 - Proceedings of Workshop on Planning of hydro-meteorological observation network.

19 Statistics General Department, Statistical Yearbooks of 1990, 1994, 1995, 1998, 1999, 2000

20 Tran Thanh Xuan, 2001- Assessment of climate change impacts on river runoff in Viet Nam.

21 Tran Viet Lien, 1995- Climate change impacts on human health in Viet Nam

22 Institute of Development Strategy, 2001 - Scientific foundation of socio-economic development strategy of Viet Nam for 2010-2020

23 Institute of Development Strategy, 1998 - Orientation of strategy and development of energy in Viet Nam to 2020

24 Institute of Meteorology and Hydrology, Hanoi, 1997 - Assessment on implementation of planning hydro-meteorological and environment monitoring network

25 Institute of Agriculture Economy, 1997- Economic effectiveness of rice field irrigation and drainage

and husbandry foodstuff production

26 Institute of Energy, 1994- Energy balance of Viet Nam

27 Institute of Energy, 1995- Master plan on electricity development

28 Institute of Agriculture Planning and Projection, 1996- Basic data on Agriculture

29 Vu Nang Dung, 1997- Orientation of agriculture development of Viet Nam to 2010

30 Asia Development Bank, 1998- Viet Nam - Asian Least cost Greenhouse Gas Abatement Strategy Project Final Report

31 Asia Development Bank, 1995 - Greenhouse Gas Emission Inventory Manual.

32 Asia Development Bank, 1997 - Viet Nam National Greenhouse Gas Inventory 1993

33 Asia Development Bank, 1994- "Climate in Asia: Viet Nam"

34 Centre on Global Change, National Physical Laboratory, 1997- Greenhouse Emission in India

35 Hans Wharfing, 1992 - Forestry in Viet Nam. An Introductory Guide

36 IPCC, 1996 - IPCC Guidelines for National Greenhouse Gas Inventories, Volume 1,2,3.

37 J. Sathaye and Stephen Meyers, 1995- "Greenhouse Gas Mitigation Assessment: A Guidebook"

38 Mitra A.P., 1996- "Methane emission on rice paddy in India"

39 R.T.Watson, 2001 - IPCC Report for COP_6 (II), Bonn

40 The US country Study Program, 1995 - Greenhouse Gas Inventory, Interim Results.

41 UNEP RiSo, 1998 - " The Economics of GHG limitation: Viet Nam Country Report "

42 UNEP, 1998 - "Hand book on Methods for Climate change Impact Assessment and Adaptation Strategies - Version 2.0"

Abbreviations, measurement units, exchange units

ADB	Asian Development Bank
AIJ	Activities Implemented Jointly
ALGAS	Asian Least Costs Greenhouse Gases Abatement Strategy
BAU	Business As Usual
BOD	Biochemical Oxygen Demand
C	Carbon
CFC	Chlorofluorocarbon
CFL	Compaq Fluorescent Lamp
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbonic
COD	Chemical Oxygen Demand
COMAP	Comprehensive Mitigation Analysis Process
CSIRO	Commonwealth Scientific and Industrial Research Organization
DOC	Degraded Organic Carbon
DSM	Demand Side Management
EFOM -ENV	Energy Flow Optimization Model - Environment
ENSO	EL NINO - Southern Oscillation
EURO	Euro
EVN	Electricity of Viet Nam
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographical Information System
GHG	Greenhouse Gas
GWP	Global Warning Potential
HMS	Hydro-Meteorological Service (of Viet Nam)
HFCs	Hydrofluorocarbons
IMH	Institute of Meteorology and Hydrology
ILB	Incandescent Light Bulb
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquefied Petroleum Gas
MEDEE-S	Model for Energy Demand Evaluation

MONRE	Ministry of Natural Resources and Environment of R.S Viet Nam
MW	Mega Watt
NPV	Net Present Value
NMVOCs	Non-Methane Volatile Organic Components
NLSK	Biomass Energy
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxide
O	Oxygen
PFCs	Perfluorocarbons
PJ	Peta Joules
SF_6	Sulfur hexafluoride
SIF	Seasonal Integrate Flow
SO_2	Sulphurous oxide
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on climate Change
UNITAR	United Nations Institute of Training and Research
US$ (USD)	US Dollar
VNCCCT	Viet Nam Climate Change Country Team
VND	Viet Nam Dong (Currency Unit of Viet Nam)
W	Watt
WB	World Bank
WMO	World Meteorological Organization
M$	US$ Million
D/kwh	VN Dong/kilowatt hour
KgC	Kg carbon
Km	Kilometer
Km^2	Square Kilometer
Kt	Kilo tone
KtC	Kiloton carbon
Ktoe	Kiloton oil equivalent
KV	Kilovolt
kw	Kilowatt
Kwh	Kilowatt-hour
^oC	Degree Celsius

TC/ha	Ton carbon/hectare
tdm	Ton of dry matter
TgC	Tetra gram carbon
TOE/year	Ton of Oil Equivalent/ year
TOE/person	Ton of Oil Equivalent/ person
MTOE	Million Ton of Oil Equivalent
TWh	Tetra Watt hour

Unit		Exchange Unit
cm	Centimeter	
m	Meter	
km	Kilometer	10^3 m
ha	Hectare	$10^4 m^2$
km^2	Square Kilometer	$10^6 m^2$
kg	Kilogram	$10^3 g$
t	Ton	$10^6 g$
Kt	Kiloton	$10^9 g$
Gg	Giga gram	$10^9 g$
Tg	Tetra gram	$10^{12} g$
Ster	Ster	0.75 m^3
g/km	Gram per kilometer	Gram/km
Gg	Giga Grams	Billion gram
Gj	Giga Joules	Billion Joules
GWh	Giga watt-hour	Billion watt - hour

ANNEXES

ANNEX 1:

NATIONAL GREENHOUSE GAS INVENTORY IN 1994

Unit: thousand tons

Sources of emission and Absorption	CO_2 Emission	CO_2 Absorption	CH_4	N_2O	NOx	CO	NMCOV	SO_2	Total CO_2 equivalent (CO_2+CH_4+N_2O)
Total GHG	**90,931.2**	**50,327.0**	**2,508.164**	**34.057**	**227.117**	**5,208.22**	**272.15**	**1911.14**	**103,839.32**
1. Energy	**21,580.0**		**167.274**	**1.756**	**128.766**	**2,129.84**	**267.367**	**298.84**	**25,637.1**
2. Industrial processes	**3,807.2**				**0.241**	**0.861**	**4.788**	**1612.30**	**3,807.19**
4. Agriculture			**2,092.9**	**27.4**	**50.3**	**1,503.6**			**52,450.0**
5. Forestry and land use change	**65,544.0**	**50,327.0**	**179.88**	**1.24**	**47.80**	**1,573.92**			**19,383.0**
6. Wastes			**68.11**	**3.66**					**2,564.9**

NATIONAL GREENHOUSE GAS INVENTORY IN 1994

(Continued)

Sources of GHG emissions	CO_2 Emission	CO_2 Absorption	CH_4	N_2O	NOx	CO	NMCOV	SO_2	Total CO_2 equivalent (CO_2+CH_4+N_2O)
Total GHG	**90,931.2**	**50,327.0**	**2508.164**	**34.057**	**227.117**	**5,208.22**	**272.15**	**1911.14**	**103,839.3**
1. Energy (Fuel combustion + fugitive)	**21,580.0**		**167.274**	**1.756**	**128.766**	**2,129.836**	**267.367**	**298.84**	**25,637.1**
A. Fuel consumption	**21,580.0**		120.510	1.756	**128.766**	2,129.836	267.367	**298.84**	24,655.1
1. Energy and transform industries	4,115.1		0.109	0.045	11.759	0.836	0.246	2.98	4,131.309
2. Industry and others	7,671.2		0.433	0.081	22.061	5.199	0.931	5.36	7,705.373
3. Transport	3,634.4		0.465	0.043	35.822	158.724	30.342	1.36	3,657.525
4. Commerce	1,974.7		0.242	0.022	2.421	19.198	1.964	1.12	1,986.592
5. Household	1,806.0		118.777	1.545	40.011	1.931.933	231.216	286.69	4,779.307
6. Agriculture/forestry/aqua product	887.7		0.098	0.007	14.537	12.355	2.446	0.51	891.958
7. Others	1,486.5		0.385	0.013	2.155	1.590	0.222	0.81	1,512.815
B. Fugitives			46.764						982.04
1. Coal			39.749						
2. Oil and gas			7.015						
2. Industrial processes	**3,807.2**				**0.241**	**0.861**	**4.788**	**1612.30**	**3,807.19**
3. Solvents									

NATIONAL GREENHOUSE GAS INVENTORY IN 1994

(Continued)

4. Agriculture			**2,092.9**	**27.4**	**50.3**	**1,503.6**			**52,450.0**
A. Eriteric fermentation			336.6						7,070.00
B. Manure management			129.0						2,710.00
C. Rice paddy			1559.7						32,750.00
D. Savanna burning			15.9	0.2	7.1	417.5			400.00
E. Burning of agricultural residues			51.7	1.2	43.2	1.086.1			1,460.00
F. Agricultural land				26.0					8,060.00
5. Forestry and land use change	**65,544.0**	**50,327.0**	**179.88**	**1.24**	**47.80**	**1573.92**			**19,383.0**
A. Change in forest and woody biomass stocks		39,272.0							-39,272.0
B. Change in forest and grassland	56,720.9		179.88	1.24	47.80	1573.92			60,881.0
C. Uncultivated land		11,050.0							-11,050.00
D. CO_2 emission from soil	8,824.0								8,824.0
6. Wastes			**68.11**	**3.66**					**2,564.9**
A. Solid waste			66.298						1,392.3
B. Waste water			1.027						21.6
C. Industrial waste water			0.79						16.6
D. Human waste				3.66					1,134.6

ANNEX 2 :

PORTFOLIO
OF SOME PROJECTS ON CLIMATE CHANGE

Project 1: Development of renewable energy

Background:

Viet Nam has big potential of renewable energy: 2000 MW of small hydro-power, 80 MW of biomass power, 100 MW of household hydro-power, 1 MW household solar battery, rich wind power sources in coastal zones and islands.

Project on renewable energy aim at rapid application of new energy technology through elimination of barriers and reduction of implementation costs. The project includes 2 components: (i) Investment of technology (ii) Capacity building through exploitation of renewable energy sources. The project will also aim at mitigation of GHG emissions and raise living standard of the people in remote and isolated areas.

Project objectives:

- To exploit renewable energy potential to serve socio-economic development and raise the living standard of the people, particularly in remote areas.
- To mitigate greenhouse gases emissions.

Activities:

- ***Investment of technology:***
  - Small hydropower network: 200 small hydropower systems in villages.
  - Wind-diesel combination: Replacing the existing diesel systems in islands by wind-diesel combination systems with rational distribution mechanism.
  - Small household-scale hydropower stations.
  - Household-scale solar energy system.

- ***Capacity strengthening to eliminate barriers:***
  - Developing appropriate policies and supporting the use of this kind of energy.
  - Developing trading skills, marketing strategy, distribution and consumption services.
  - Developing technology and personnel training
  - Encouraging demands, raising public awareness.
- ***Expected outputs:***
  - Set up electricity network using wind, solar and hydropower;
  - Train technical staff in manufacture, distribution and consumption, etc.;
  - Improve living standard of the people in the remote and isolated areas; Created employment for the labors.
- ***Implementation budget:***

Total budget: US$ 50,000,000

In which: GEF: US$ 10,000,000

WB: US$ 20,000,000

Government inputs: US$ 20,000,000

Implementation duration: 2003-2007

Project 2: Energy saving in Industry

Background:

- ❑ At present, technology of Viet Nam industry is still backward with low energy use efficiency. The potential for energy saving is very high. In comparison with present high technology, energy saving potential in Viet Nam industry is 10-13%, in electricity saving is 4-6%. Therefore, the improvement of efficiency in industrial enterprises would significantly mitigate GHGs emissions.
- ❑ This project is one of important projects of the on-going Energy Saving Program in Viet Nam. The project outputs could help big enterprises to save energy, decrease products' prices and increase their competitiveness as well as mitigate waste gas emissions, including GHGs emissions.

Project objectives:

To demonstrate, introduce energy saving and efficient measures in industrial industries in order to mitigate energy consumption and protect environment.

Activities:

- ❑ Auditing energy in 80 big plants, occupying 50% of energy consumption.
- ❑ Installing an energy management system.
- ❑ Educating and training staff.
- ❑ Demonstrating co-generation capacity

Expected outputs: The project is divided into 2 phases:

For the first phase, the estimated outputs are as follows:

- ❑ Install energy management systems at plants within the project framework;
- ❑ Train energy auditing staff and operators for energy management systems.

For the second phase:

On the basis of the results of the first phase, a demonstration model of co-generation at big well-equipped plants will be established.

Implementation budget: For the first phase: US$ 3.3 million

Expected implementation duration: The first phase: 2 years

Project 3: Encouraging utilization of renewable energy in rural areas

Background:

The project is implemented within the framework of Viet Nam Energy Saving Program. The project aims at popularization of knowledge of renewable energy forms, development of organization and management including institutional and financial mechanisms to introduce and apply new energy technologies, to assist elaboration of local technologies.

Objectives:

- To develop cooperative program among relevant agencies to remove the barriers for utilization of renewable energy.
- To introduce renewable energy technologies.

Project activities

- Developing cooperative programs among relevant agencies.
- Developing legislative mechanism, strengthening implementing capacity to remove barriers in utilization of renewable energy.
- Advertising, encouraging the enlargement of market of renewable energy technologies.
- Encouraging domestic design and manufacture of renewable energy equipment.

Expected outputs:

- Strengthen capacity and raise awareness of utilization of renewable energy;
- Prepare pre-feasibility report on utilization of renewable energy in rural areas.

- ***Budget:*** US$ 460,000

Implementation duration: 2003 - 2005

Implementing agencies: Energy Saving Program, Ministry of Science, Technology and Environment, Provincial Departments of Science, Technology and Environment, Viet Nam Electricity.

Project 4: Project on forest plantation on sandy soil in the coast of the Southern Central Viet Nam

Background:

In 1998, the National Assembly of the Socialist Republic of Viet Nam approved the 5-million hectare forestation Programme. According to the programme, during the period of 1998-2010, among 5 million hectares of newly planted forest, there would be 60.000 hectares of coastal protective forest. It is mainly forest bands for preventing sand movement in the central coastal zones.

The coastal zone in the Southern Central Viet Nam, bounded by the coast and the National Road No 1, is mainly covered by sea sand. In this zone, there are many moving sand areas and unused sand dunes or few shrubs. That is why not only crops and infrastructure but also living habitats of the local people are threatened by sand wind and typhoons.

It is an urgent need to plant and improve coast protective forest in order to mitigate the losses caused by sand moving. This area is one of the first priority areas in the forestation programme of Viet Nam.

Project objectives:

- ❑ To improve productivity of the cultivated lands located behind the newly planted forest and the improvement of environment would make a part of unused land due to sand invasion cultivable to produce more products for the local people.
- ❑ To provide a significant portion of firewood for the local people through secondary products gained from forest nursery practices (pruning, trimming).
- ❑ To create jobs and income for the local people involved in forest plantation and protection.
- ❑ To contribute to bio-diversity improvement and environmental conservation in large coastal zone.

Activities:

- ❑ Planting 11,015 hectares of sea pines, sandalwood trees on the sandy soil of the Southern Central Viet Nam coastal zone at 55 planting sites.
- ❑ Building logistic bases for forest plantation (operation roads, temporary nursery gardens, houses, etc.
- ❑ Providing equipment and materials for forest planting.

Expected outputs:

Plant 11,015 hectares of protective forest consisting mainly of sea pines, sandalwood trees in 4 provinces: Quang Nam, Quang Ngai, Phu Yen and Khanh Hoa. In which:

- Quang Nam: 4,043 hectares
- Quang Ngai: 1,959 hectares
- Phu Yen: 2,810 hectares
- Khanh Hoa: 2,203 hectares

Project budget: US$ 11.5 million

Expected duration: 5 years, starting in 2003, ending in 2007.

Project 5 : Improving cooking stoves of the rural - mountainous community

Background:

80% population of Viet Nam lives in the rural and mountainous areas. Normally, the people use biomass fuel such as firewood, agricultural residuals in cooking. The use of this kind of fuel would remain in many decades to come. The main reason is the alternative energy sources such as electricity, gas etc. are still very expensive or unable to be widely popularized in rural and mountainous areas of Viet Nam.

Forest is a main source of firewood for households. However, forest is exhausting day by day so far.

Although firewood source is more and more limited, the use of firewood is wasteful and inefficient. Most of households use traditional cooking stoves - the opening stoves that have been used for thousands years. Low burning efficiency of these stoves leads to high fuel consumption and emission of harmful gases that may have adverse impacts on the health, particularly of the old, women and children.

Therefore, it is very important, necessary and urgent to introduce widely the improved cooking stoves (improvement in both burning efficiency and heat conductibility) suitable to traditional cooking habits of local people.

Project objectives:

- ❏ To save fuel used for households;
- ❏ To release and reduce smoke and dust in kitchen of rural households. To reduce illness caused by emitted smoke from stoves.
- ❏ To contribute to protect forest resources.
- ❏ To mitigate GHGs emissions through reduction of fuel consumption.
- ❏ To create opportunities and jobs for poor people in rural areas, contribute to alleviate poverty as well as the hardship of women.

Activities

It is planned to carry out the project in nation-wide scale for 7 ecological zones with the following main activities:

- ❏ Developing institutional framework for cooking stoves improvement program of national scale.
- ❏ Conducting an investigation and feasibility study for pilot sites, carrying out widely application of improved stoves.
- ❏ Setting up systematic dissemination on mass media (radio, newspapers, television).
- ❏ Organizing training courses on improved cooking stoves.
- ❏ Transferring technology – marketing.

Expected outputs:

- ❏ One million rural households could be able to use improved cooking stoves through direct and indirect financial support.
- ❏ Create jobs for about 3 thousands people through manufacturing and trading improved cooking stoves, contribute to poverty alleviation.
- ❏ Strengthen capacity for research and technology transferring institutions.
- ❏ Contribute to forest protection, especially the 5-million hectare afforestation program (up to 2010).
- ❏ Reduce about 30 % of GHGs emissions in comparison with the present thank to fuel saving.

Budget:

The total budget is US$ 350,000:

•	Project preparation and demonstration	US$ 50,000
•	Region-scale implementation	US$ 100,000
•	Nation wide scale implementation	US$ 200,000

Expected duration: from 2003 to 2009, consisting of 3 phases:

1. 2003 - 2004
2. 2005 - 2007
3. 2008 - 2009

Project 6: Using biogas as fuel to mitigate greenhouse gas emission in rural areas

Background:

The orientation of Viet Nam husbandry from now to 2030 is following:

Developing husbandry following commodities production approach, focusing on raising pig, poultry, dairy cattle, cow and expanding husbandry areas as farm scale, delineating areas for concentrated husbandry.

Up to now, Viet Nam has rather significant number of cattle heads and poultry. According to statistical data of 1999: pig: 19 millions, buffalo: 3 millions, cow: 4 millions, poultry: 179 millions. However, waste from domestic cattle is not processed, but often exposed to the sun or gathered in a neat heap resulting in pollution and bad condition of hygiene in rural areas. On other hand, most of rural inhabitants use straws, firewood, coal for cooking and this is also a significant CO_2 emission source.

Therefore, the building of biogas tanks in husbandry areas could not only process cattle waste to make environment clean, but also reduce firewood for cooking, liberate women's labor in rural areas.

Project objectives:

- ❑ To build biogas systems containing cattle waste to generate methane used as fuel for cooking in rural areas in order to reduce methane and CO_2 emissions.
- ❑ To protect clean environment in rural areas.
- ❑ To help farmers to save fuel consumption.
- ❑ To raise awareness of the people on environment and GHG mitigation.

Activities:

- ❑ Popularizing benefits of the use of biogas instead of conventional fuel and raising awareness of the people on environment and GHG mitigation.
- ❑ Selecting technologies and models for building appropriate biogas tanks for specific locality.
- ❑ Building 500,000 biogas tanks with various volumes from 5 to 12 m^3 in different rural areas, focusing on the concentrated husbandry areas.
- ❑ Organizing training courses for the technicians who will guide the construction and use of biogas stoves.
- ❑ Conducting measurement, monitoring the reduced methane emission thanks to using biogas.

Expected outputs:

- ❑ Raise awareness of the farmers on environment and GHG.

- ❑ Build 500,000 well-operated biogas tanks, saved expenditure on cooking fuel for rural households.
- ❑ Reduce methane and CO_2 emission from 2 sources: management of fertilizer and burning materials in the rural areas with the total of 2.7 million tones of CO_2 equivalent during a period of 20 years.
- ❑ Improve environment in rural areas and liberate women's labor thanks to reducing cooking time.

Project budget: US$ 1,500,000

In which:

- Farmer's input	:	U S $ 300,000
- Government input	:	U S $ 500,000
- GFF input	:	U S $ 700,000

Expected duration: from 2003 to 2004.

Project 7: Research on co-generation technology (electricity and heat) from biomass fuel in Viet Nam

Background

Renewable energy, including biomass energy is considered as clean energy sources and solutions to mitigate GHGs. Because while burning biomass, there is the neutralization of CO_2 emission, and SOx emission almost equals to zero due to the absence of sulfur in the composition of the fuel.

Viet Nam has big potential in biomass fuel source. Annually, the agricultural cast-off is more than 40 million tones, equivalent to about 20 million tones of coal dust. It is estimated that annually, the agricultural cast-off would increase about 2%. At present, there is more than 10% of the above cast-off such as rice husk, sugar cane dregs in rice and sugar mills that are very suitable for development of co-generation technology (or combined electricity-heat generation). Thus, while applying the above mention technology, beside the adequate provision of energy to the mills, the surplus electricity would be added to the national electricity network or sold out directly to the surrounding additional charge. The potential of technical capacity from this fuel form is about 300 MW for the period from 2001 to 2010.

Objectives:

- ❑ To strengthen capacity of sustained exploitation and effective utilization of the existing local biomass fuel in order to be less dependent on fossil fuel and to mitigate GHGs emissions.
- ❑ To create a reliable electricity and heat supply source with competitive, cheap prices (thank to reduction of transportation losses) for of rice and sugar mills, and consequently, to reduce production cost, improve product quality and to increase the competitiveness of enterprises.

Activities:

- ❑ Assessment of the present status of biomass fuel development plan for energy co-generation in Viet Nam.
- ❑ Preparation of pre-feasibility and feasibility reports, building of demonstration models for 3 - 4 factories with capacity of 10 MW.

Expected outputs:

- ❑ Generate electricity with expected potential capacity of 300 MW, being less dependent on coal.
- ❑ Neutralize CO_2 emission (non-CO_2 emission) by using the existing biomass such as rice husk, straw, sugarcane dregs, etc.; SO_X emission would be almost zero because there is not sulfur in biomass fuel.

Project budget:

Total: US$ 135,000 including:

- Phase 1: Assessment of current status and planning: US$ 60,000;
- Phase 2: Pre-feasibility and feasibility studies: US$ 75,000

Expected duration: 3 years, from 2003 to 2006. The period is divided into 2 phases:

- Phase 1: Planning from 2003 to 2004
- Phase 2: Preparation of feasibility report from 2004 to 2006.

Project 8 : Project on energy conservation and saving in small and medium-sized enterprises

Background:

- The project is implemented within the framework of Energy Saving Program and GEF Strategy for the period of 2000 - 2010.
- The potential of energy saving and GHG mitigation in small and medium scale enterprises of Viet Nam is very high. It is estimated that the value may reach 13% for thermal energy and 6% for electricity energy.
- Awareness on energy saving is not yet high, financial capacity is low.

Objectives:

- To support the saving of energy in the small and medium scale enterprises.
- To strengthen the implementing capacity and policy mechanism to facilitate the adaptability of efficient energy technology in small and medium scale enterprises.
- To set up Energy Information Center for small and medium scale enterprises.
- To monitor the implementation of energy efficiency and environment projects in small and medium scale enterprises.

Activities:

- Identifying the sector of small and medium scale enterprises to be put under energy audit.
- Removing barriers of technology application and successful implementation in small and medium scale enterprises in order to reduce energy consumption and mitigate GHGs.
- Developing an education and training program for managers, auditors and experts in small and medium scale enterprises.
- Developing energy-saving projects for small and medium scale enterprises.

Expected outputs:

- Fulfill energy audit in small and medium scale enterprises;
- Train energy auditors and energy managers for small and medium scale enterprises.
- Set up Energy Information Center for small and medium scale enterprises.

- ***Estimated budget:*** US$ 1.5 million

- ***Implementation duration:*** 2003 - 2006 (3 years).

  Estimated after-project investment: US$ 5.5 - 8.5 millions

Project 9 : Wind power stations for the people in remote island (Coto island, Quang Ninh province)

Background:

Coto Island - one of the big islands in Quang Ninh province - is located in the archipelago in Northeast Viet Nam, about 60 miles from the land with the area of 3850 hectares. By 2000, the island's population is 2308. The island has rich economic potential. However, the living standard of people is still low with few supplementary jobs. The main income sources of the island's inhabitants are from agriculture and fishery. The cultural life is poor. Electricity for living is diesel generated. Because of the far distance, diesel supply is very difficult resulting in rather high price of electricity (VND 2,500 per kWh). The island could not access to national electricity network due to long distance from main land.

Wind power potential of the island:

In Coto island, during winter, from October to March, the dominating wind is Northeast with frequency from 50% to 70 % per month and average speed of 5.5 mps. Thus, the places open to the northeast or favorable for northeast wind have very high wind power potential.

Project objectives

To generate electricity using wind energy in combination with diesel to reduce electricity price as well as to protect environment.

Activities:

- ❏ Survey to prepare pre-feasibility and feasibility justifications
- ❏ Detailed design
- ❏ Install equipment, operate and hand over the project

Expected outputs:

- ❏ Install wind motors with capacity of 500 kW (phase 2002 - 2005) and 1000 kW (phase 2005 - 2010).
- ❏ By the end of the first phase, 95 % of households could be accessible to electricity for living; By the end of the second phase, electricity supply could meet 95% demands for living and 90% demands for production.

Budget: The estimated budget is US$ 200,000

Estimated duration: Phase 1: 2003 - 2006

Phase 2: 2007 - 2011

Project 10: Project on planting protective forest in the watershed of Ngan Sau, Ngan Pho Rivers

Background:

Viet Nam is located in the Southeast Asia with a population of more than 70 million. About three fourth of its territory is hilly and mountainous areas. The existing forest area is 9.3 million hectares. Forest plays an important role in economy, society, ecological environment and national security. In recent years, the irrational utilization of forest resources resulted in unforeseen consequences. The high rate of forest degradation in both area and quality led to decreasing of forest cover in Viet Nam.

The degradation of forest quality, especially forest in river watershed has resulted in bad consequences such as unusual floods and inundation, soil erosion, etc. and that in their turn threat the sustainability of national economy, normal life of millions people in downstream and bio-diversity.

The 5-million hectare forestation programme was approved by the National Assembly of the Socialist Republic of Viet Nam in 1998. According to the plan, among 5 million hectares of newly planted forest there would be 1,735,000 hectares of watershed protective forest planted during the period of 1998-2001

It is an objective and urgent need to quickly restore forest in Ngan Sau and Ngan Pho river watershed in order to set up and stabilize the protective forest system in this area; to improve and raise the living standard of the local people and to contribute actively in flood/inundation prevention, stabilize political life and social security in the west boundary area of Ha Tinh province, in particular, and the country, in general.

Project objectives:

- To develop and improve the protective forest system in Ngan Sau, Ngan Pho Rivers watershed in order to prevent soil erosion, protect water sources and local environment, to enhance the absorption sinks and minimize the possible impacts on droughts, floods and inundation.
- To increase forest coverage in this area from 51% at present to 64% by 2010.
- To improve forest quality, to increase the ratio of rich and medium forest from 31% at present to 46% by 2010.
- To create jobs for 5180 households living nearby forest area, to attract more than 8,700 labors into forest protection, planting protective forest and doing agro-forestry production.

Activities and expected outputs:

Activities:

- ❑ Protecting 84,410 hectares of the existing forest and 36,021 hectares of the newly planted forest (in the period from 2001 to 2012);
- ❑ Delineating areas for growing and restoring 20,442 hectares of forest during the period of 2001 - 2012, in which 5,214 hectares is in very important and 15,228 hectares is in important areas. XXX
- ❑ Planting forest and carrying out agro-forestry including planting concentrated forest and building forest gardens, forest farms in Huong Khe, Huong Son, Duc Tho districts.

Expected outputs:

- ❑ Protecting 80,241 hectares of natural forest and 4,169 hectares of exist planted forest in project area.
- ❑ Planting 42,114 hectares of new forest, in which:

Delineating areas for forest restoration:		20,442 hectares
Newly planted forest	:	15,579 hectares
Building forest gardens, forest farms	:	6,093 hectares

Project budget: US$ 7,01 million

Expected duration: from 2003to 2012.

Project 11: Irrigation management of wetland rice field to reduce methane emission

Backgrounds:

Viet Nam agriculture is based on two main branches: cultivation and husbandry. Cultivation plays an important role, in 1994, it produced 77.3% of total agricultural products. In cultivation, there are rather multiform cereal crops with various varieties. Rice is the main food cereal crop in Viet Nam.

Together with application of new technology, Viet Nam regularly improves of the irrigation systems, particularly those for wetland rice fields.

The channel systems at various levels (I, II and III, IV and V) are set up and put into operation to serve food and foodstuff production.

The National Strategy for improvement of irrigation systems to 2020 has been developed.

One of the main objectives is to ensure water used in agriculture with improved irrigation and drainage techniques in order to get high crop yield. Conservation of water resources is also one of main policies of the Government to attain sustainable development (Law on Water Resources).

This project aims at reducing methane emission by rational irrigation and drainage management with draining out water in two growing periods: stem spreading and before harvest. Meanwhile, the project also brings about the following benefits: (i) saving water and (ii) increasing rice yield - the targets mentioned in the National Strategy and National Agricultural Programme.

Project objectives

- ❏ To reduce methane emission from wetland rice fields.
- ❏ To develop a comprehensive technical manual for irrigation management in wetland rice fields with the aim of increasing rice yield.
- ❏ To strengthen capacity of technical and management staffs to implement appropriate irrigation-techniques procedures.
- ❏ To raise public awareness on climate change.

Activities:

- ❏ Setting up a mechanism, legislation from the central down to provincial levels in regulated irrigation management, meanwhile establishing the project-management committees at various levels;
- ❏ Conducting surveys and selecting the areas feasible for implementation of the regulated irrigation management.

- ❑ Conducting experimental measurement and monitoring on methane emission reduction from the wetland rice field.
- ❑ Building pilot active irrigation/drainage management systems.
- ❑ Organizing educational and training courses for water management technicians.

Outputs:

- ❑ Detailed technical manual on water irrigation for wetland rice fields;
- ❑ Upgraded irrigation systems, especially those of third and fourth levels;
- ❑ Trained staff of water management, policymaking, project management and supervision.
- ❑ Strengthened capacity on water management.
- ❑ Project achievements are extended to other areas.
- ❑ Reduced methane emission: 37,000 tones during the period of 20 years.

Project budget: ***Total budget is US$ 5,025,000***

- ❑ Input from GEF is US$ 1,525,000
- ❑ Input from Viet Nam government is US$ 3,500,000

Expected duration: from 2003 to 2004 (02 years)

Project 12: Exploitation of geo-thermal energy in Viet Nam

Background:

Viet Nam has potential in geo-thermal energy that can be utilized in electricity generation, particularly in various areas of Central Viet Nam. It is estimated that in this region, a capacity of 50 MW can be developed from geo-thermal hot water sources. However, it is necessary to evaluate this potential in details in order to make plan for further exploitation.

Project objectives:

- To assess feasibility of developing 50 MW from geo-thermal hot water sources in provinces of Central Viet Nam.
- To establish maps on geo-thermal energy potential.

Activities:

- ***Exploration drilling to collect data on:***

Maps of regional geo-thermal energy;

Evaluation of heat and temperature of geo-thermal liquid.

Assessment of socio-economic impacts resulted from the construction and operation of geo-thermal energy plants.

Development of plan and projection on the exploitation of the national geo-thermal energy.

Expected outputs:

- Clearly identify potential of geo-thermal energy of the country.
- Comprehensive projection on exploitation of geo-thermal energy.

Implementation budget:

PDFB of GEF : US$ 300,000

Government inputs: US$ 100,000

Implementation duration: 2003-2004

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