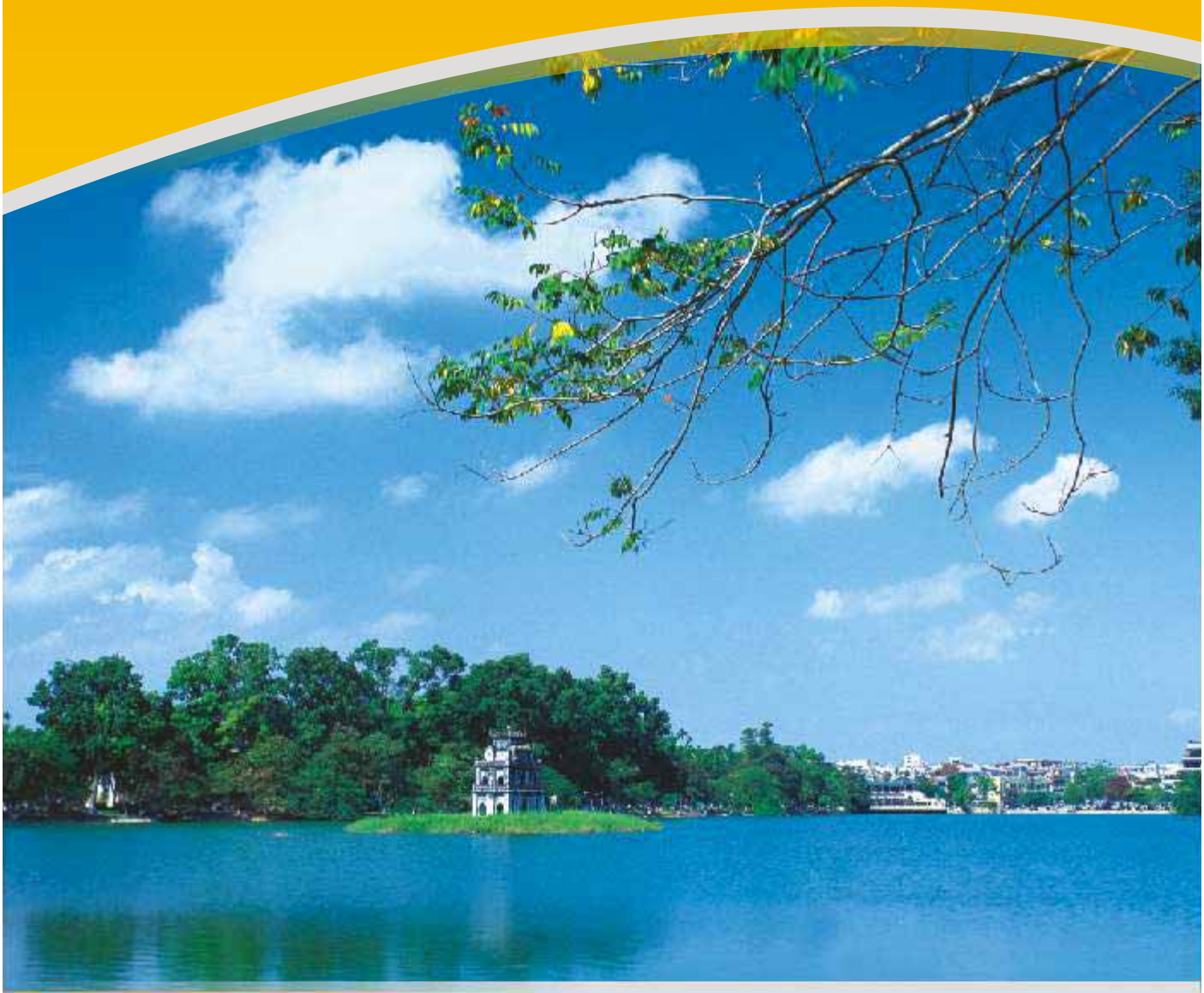
SOCIALIST REPUBLIC OF VIET NAM
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

VIET NAM'S SECOND NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE



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ABBREVIATIONS

CDM	Clean Development Mechanism
CERI	Cost of Emission Reduction Initiatives
CNG	Compressed Natural Gas
COMAP	Comprehensive Mitigation Analysis Process
DO	Diesel Oil
DSSAT	Decision Support System for Agrotechnology Transfer
EB	CDM Executive Board
EFOM-ENV	Energy Flow Optimization Model-Environment
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
GMS	Geographic Management System
GWP	Global Warming Potential
GHG	Greenhouse Gas
HBI	Human Balance Index
IPCC	Intergovernmental Panel on Climate Change
LEAP	Long-range Energy Alternatives Planning System
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land-Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
MARKAL	Market Allocation Model
MONRE	Ministry of Natural Resources and Environment
NGO	Non-governmental Organization
NTP	National Target Program to Respond to Climate Change
RAII	Regional Association II - Asia
REDD	Reducing Emissions from Deforestation and Forest Degradation
STAIR	Strategy, Targets, Assessment, Implementation, Results
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation
US$	United States Dollar
VACNE	Viet Nam Association for Conservation of Nature and Environment
VND	Viet Nam Dong
VNGO	Vietnamese Non-governmental Organizations
WMO	World Meteorological Organization

CHEMICAL SYMBOLS

C	Carbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HFCs	Hydrofluorocarbons
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen oxides
N_2O	Nitrous oxide
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide

UNITS OF MEASUREMENT

BTU	British Thermal Unit
^oC	Degree Celsius
CO_2e	Carbon dioxide equivalent
kg	Kilogram
Tg	Teragram
t	Tonne
tdm	Tonne dry matter
mm	Milimeter
cm	Centimeter
m	Meter
km	Kilometer
m^2	Square meter
km^2	Square kilometer
ha	Hectare
m^3	Cubic meter
TOE	Tonne of oil equivalent
KTOE	Kilotonne of oil equivalent
kV	Kilovolt
W	Watt
kW	Kilowatt
kWh	Kilowatt hour
MW	Megawatt

MINISTERIAL FOREWORD

Viet Nam is among the countries that are warned to be seriously affected by adverse effects of climate change. Impacts of climate change, in particular sea level rise will heavily affect the country's economic production, livelihood, environment, infrastructure, public health, and threaten the achievements of poverty reduction, food and energy security, sustainable development, as well as the fulfillment of the Millennium Development Goals.

Taking the initiative in the response to climate change to protect people's lives and property and to ensure sustainable development, and at the same time actively taking part in international efforts to combat climate change and protect the global climate system are among the key targets of Viet Nam's national development strategy. Viet Nam ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, the Kyoto Protocol in 2002 and approved the National Target Programme to Respond to Climate Change in 2008.

The Government of Viet Nam has designated the Ministry of Natural Resources and Environment as the National Focal Point to coordinate the implementation of the UNFCCC and its Kyoto Protocol in Viet Nam. Viet Nam submitted its Initial National Communication to the UNFCCC Secretariat in December 2003.

With the financial and technical assistance from the Global Environment Facility, the United Nations Environment Programme and the United Nations Economic and Social Commission for Asia and the Pacific, the Ministry of Natural Resources and Environment in cooperation with other concerned ministries and agencies completed the Second National Communication in 2010. It provides information on the National Greenhouse Gas Inventory in 2000, analyses and assesses impacts of climate change, and recommends a number of feasible options for the adaptation to climate change and the mitigation of greenhouse gas emission in some major economic sectors in the near future.

The Ministry of Natural Resources and Environment has the honour to present herewith Viet Nam's Second National Communication to the UNFCCC Secretariat. It is hoped that the information contained in this Communication is useful and will help Viet Nam's government agencies at both central and provincial levels in their formulation of development plans, thus contributing to the country's sustainable development. This Communication may also serve as a necessary reference for agencies, research institutions and communities.

The Ministry of Natural Resources and Environment will continue to maintain close working relationships with all relevant national and international agencies to fulfill Viet Nam's obligations under the United Nations Framework Convention on Climate Change.

Dr. Pham Khoi Nguyen

Minister of Natural Resources and Environment

EXECUTIVE SUMMARY

NATIONAL CIRCUMSTANCES

Viet Nam signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and 1994 respectively. The Kyoto Protocol (KP) was also signed and ratified in 1998 and 2002 respectively. Viet Nam is a non-Annex I Party to the UNFCCC.

The Ministry of Natural Resources and Environment (MONRE) has been assigned by the Government as the National Focal Point to implement the UNFCCC and KP.

The Government has introduced a range of legal and normative documents for environmental protection and climate change response. In late 2008, the Government approved the National Target Program to Respond to Climate Change (NTP).

A National Steering Committee for the implementation of the UNFCCC and KP, chaired by the Vice Minister of MONRE, was also established.

Natural conditions

Geography

Viet Nam is located in Southeast Asia with a land area stretching from latitudes 8°27' and 23°23' N to longitudes 102°08' and 109°30' E. The country borders China to the north, Laos and Cambodia to the west; and the East Sea to the east, south, and southwest. Viet Nam has a total area of one million km^2 of sea waters comprising two major archipelagos, Hoang Sa (Da Nang city) and Truong Sa (Khanh Hoa province). Viet Nam also has more than 3,000 islands along the coastline.

Viet Nam's S-shaped territory extends 1,662 km from north to south with a land area of approximately 331,051.4 km^2. The country has two major river deltas - the Mekong River Delta and the Red River Delta.

Located in the Red River Delta, Hanoi is Viet Nam's capital and the country's political, cultural, scientific and educational center. The city covers an area of 3,348.5 km^2 and has a population of 6.116 million with a density of 1,827 people per km^2 (according to 2008 statistics).

Climate

Viet Nam features monsoon tropical climate with annual mean temperature varying from 12.8°C to 27.7°C. Average annual rainfall ranges from 1,400 to 2,400 mm. Each year, on average, the country is affected by six to eight typhoons or tropical cyclones.

Water resources

Taking into account only perennial rivers and streams over 10 km in length, Viet Nam has about 2,360 rivers and streams with an average density of 0.6 km/km^2. There are nine major river systems in Viet Nam. The largest system, Mekong River, enters Viet Nam before draining into the East Sea.

Annual flows of all rivers in Viet Nam average 835 billion m^3. Groundwater reserve is 50 billion m^3 per year.

Social and economic overview

Population

In 2000, Viet Nam's population was 77.6 million. The population growth was 1.36%. In 2008, the population reached 86.2 million.

Agriculture

Total area of agricultural land is around 9.3 million ha, accounting for 28.2% of the national land area. Animal husbandry and cultivation are fundamental sectors of agriculture.

Forestry

The total area of forest land was about 11.6 million ha in 2000, making up 35.2% of the national land area. As of December of 2008, the forest area was 13.1 million ha, equating to a 38.7% forest coverage rate.

Industry

The annual industrial growth is 10-15%. Industry accounted for 36.7% of the total GDP in 2000.

Transportation

Road transportation is the dominant mode of transport. In 2000, road transportation capacity accommodated 620.7 million passengers and 144.6 million tonnes of cargo.

Energy

Primary energy consumption increased 6.5% per annum from 32,235 KTOE in 2000 to 50,221 KTOE in 2007. End-use energy consumption grew at the same rate from 2000 to 2007.

Economic growth

Between 2000 and 2008, Viet Nam's economy grew at an average rate of 7.5% per annum.

Health and education

In 2000, there were 13,117 clinics. Average life expectancy of Vietnamese people is 67.8.

Viet Nam's basic education lasts for 12 years and is divided into three levels of primary, lower secondary and upper-secondary schools. The literacy rate for Vietnamese adults (above 15 years old) is 94%.

NATIONAL GREENHOUSE GAS INVENTORY

The National greenhouse gas inventory for the year 2000 was conducted in accordance with the Revised Guidelines of Intergovernmental Panel on Climate Change (IPCC) for energy, industrial processes, agriculture, land use, land-use change and forestry (LULUCF), and waste sectors, with respect to the most important greenhouse gases: CO_2, CH_4 and N_2O.

Total greenhouse gas emissions in 2000 amounted to 150.9 million tonnes of CO_2 equivalent (tCO_2e), of which 65.1 million tCO_2e came from agriculture, 52.8 million tCO_2e from energy, 15.1 million tCO2e from LULUCF, 10.0 million tCO_2e from industrial processes, and 7.9 million tCO_2e from waste.

National GHG inventory in 2000 by sector

Unit: thousand tonnes

Sector	CO_2	CH_4	N_2O	CO_2e	Percentage
Energy	45,900.00	308.56	1.27	52,773.46	35.0
Industrial processes	10,005.72	0	0	10,005.72	6.6
Agriculture	0	2,383.75	48.49	65,090.65	43.1
LULUCF	11,860.19	140.33	0.96	15,104.72	10.0
Waste	0	331.48	3.11	7,925.18	5.3
Total	**67,765.91**	**3,164.12**	**53.83**	**150,899.73**	**100**

Emissions from energy, agriculture and LULUCF sectors are projected to total 169.2 million tCO_2e in 2010, 300.4 million tCO_2e in 2020 and 515.8 million tCO_2e in 2030. The energy sector accounts for the bulk of emissions with 91.3% of projected total emissions for 2030.

CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

Climate change scenarios

Published in 2009, climate change scenarios for Viet Nam's climate zones in the 21st century include projections of temperature, rainfall and sea-level rise. The following climate change impact assessments were made based on the medium climate change scenario.

Water resources

Annual flows of rivers in the North and Northern area of North Central Coast are set to increase. In contrast, annual flows of rivers in the southern area of North Central Coast to the northern area of South Central Coast are bound to decrease.

Flood flows in most rivers tend to increase while flows during dry season are declining.

Annual potential evapotranspiration rapidly scales up in the South Central Coast and the Mekong Delta regions, reflecting the highest level of increase.

After 2020, the groundwater level may drop drastically.

Adaptation measures must focus on planning for the sustainable development of water resources in river basins and prioritize the review of existing, and the development of new systems of reservoirs, dams, and dykes, to incorporate climate change factors.

Coastal zones

With rising sea level, the annual flood-ridden area will expand. The Mekong River Delta would be most impacted, containing as much as 90% of the national floodplain area. Sea-level rise may also lead to higher risks of saltwater intrusion of rivers and underground water resources, causing serious social and economic losses.

Climate change may have serious impacts on coastal ecosystems, reserves and mangrove forests.

By the year 2100, climate change will affect approximately 4.4% of Viet Nam's population, cause the loss of 5,469 km^2 of arable land and the submersion of 168 km^2 of aquaculture area and 320 km^2 of forest land would be submerged.

Adaptation strategies for Viet Nam are classified into three categories: full protection, adaptation and withdrawal.

Agriculture

Total annual temperature is projected to increase between 8% and 11% by 2100. In most regions, the number of days when temperatures exceed 25°C will increase notably while the number of days when temperatures drop below 20°C will decrease. Water demand for agriculture may increase two or three-fold compared with that of 2000.

Tropical plants will tend to shift further north and towards higher altitudes.

Crop water shortage would be exacerbated with decreased coverage of hygrophytes and rising evapotranspiration rates.

Spring crop outputs are set to decline at a faster rate than summer crop outputs. Winter maize productivity may increase in the Red River Delta but decrease in Central Coast and the Mekong River Delta.

Climate change may also threaten the life cycle (i.e. growth and reproduction) of cattle and increase the incidence and spread of diseases.

Adaptation measures include:

- Short-term measures (controlling erosion, building reservoirs, picking crops and crop growing seasons that suit new climate conditions, developing new cropping and stockbreeding techniques, etc.).

- Long-term measures (developing alternative cropping patterns, crossbreeding; modernizing cultivation techniques).

- Management and planning (developing new crop-livestock systems, designing new agricultural incentive systems, setting up insurance policies for crops and cattle, etc.).

Forestry

Climate change will have a diverse range of impacts on forest ecosystems and flora.

By 2100, native forest cover comprised of closed tropical moist semi-deciduous forests and closed evergreen forests, amongst others, will decrease. The ecosystems of closed tropical moist semi-deciduous forests are likely to be most affected by climate change.

In 2100, Chukrasia tabularis forests are projected to cover only 0.3 million ha, a decrease of 70% decrease. Pinus merkusii forests, are projected to cover approximately 2.3 million ha, equivalent to a fall of 58%.

Climate change will heighten risks of forest fires in all regions, primarily during the dry-hot season. In addition, warmer conditions will facilitate the spread of forest pests, hampering the growth of forest ecosystems.

Adaptation measures for forestry focus on promoting the sustainable management and development of forests, undertaking research, selecting and expanding coverage of drought and pest resistant species, and establishing a forest fire management and prevention program.

Aquaculture

Climate change adversely impacts the ecosystems of coral reefs, maritime and estuarine sea grass beds, and causes reductions in fish stocks.

Sea-level rise would exacerbate salinization in coastal zones, causing the retreat of mangrove forests with accompanying losses in habitat for numerous species.

Furthermore, the advance of saltwater leads to the replacement of freshwater species by their brackish and saline water counterparts in estuaries and coastal lagoons.

Finally, rising temperatures weaken aquatic species and foster the growth of harmful microorganisms.

Adaptation measures must focus on developing specific aquaculture planning for different eco-regions, preserving marine biodiversity and ecosystem, cultivating species more tolerant to higher water temperatures, and building capacity in aqua-farming management.

Energy and transportation

Rising temperatures will raise energy consumption for climate-sensitive sectors.

Electricity transmission and distribution networks, along with oil-rigs, oil and LNG pipelines and shipments will be negatively impacted by rising sea levels and extreme weather. Hydroelectric power generation will be affected by changing river flows, posing new challenges to the management of reservoirs.

Due to rising sea levels, industrial facilities, equipments, power stations and transmission lines in coastal zones face the risk of flooding. This would increase maintenance and repair costs, and affect energy supply, consumption, and national energy security.

A rise of 100 cm in sea level could lead to the submersion of 11,000 km of road infrastructure, paralyze the country's transportation activities and cause considerable damage to the economy.

Adaptation measures focus on mainstreaming climate change issues into national development strategies, planning in energy and transportation, enhancing energy efficiency and conservation, and making improvements, reinforcements and modification to energy and transportation infrastructure in regions vulnerable to climate change.

Human health

Climate change impacts human health directly through changing climate conditions, abnormal heat waves and increased occurrence of natural disasters. Indirectly, rising sea level and temperature affect agricultural land, food security, and increase the risks of food shortages while warmer conditions facilitate the spread of infectious diseases and epidemics.

Adaptation measures need to focus on reviewing and developing new standards and regulations for urban wind load, heat load and drainage. In vulnerable areas, urban planning must be updated to take into consideration impacts of natural disasters. Capacity building for local community health-care institutions needs to be strengthened. Weather forecasts, and more importantly disaster and disease break-out warnings, need to be improved and their accessibility enhanced. Research and development should be encouraged and information on climate change and epidemics should be widely disseminated.

GREENHOUSE GAS MITIGATION OPTIONS

The three focal sectors for greenhouse gas (GHG) mitigation options are agriculture, energy and LULUCF.

The LEAP model was used for the energy sector while the COMPAP model was used for LULUCF sector. In agriculture sector, GHG mitigation options were assessed using

statistical tools and methodologies in accordance with Dr. J. Sathaye's guidebook on GHG mitigation assessment.

28 mitigation options have been developed and assessed for GHG sources and sinks, including 15 for energy sector (including transportation), five for agriculture sector and eight for LULUCF sector.

The total mitigation potential for the above-mentioned 28 options is 3,270.7 million tCO_2e, to which energy contributes 192.2 million tCO_2e, agriculture 56.5 million tCO_2e and LULUCF 3,022 million tCO_2e. Mitigation potential uncertainty levels are placed in order of increasing magnitudes, from energy to agriculture to LULUCF.

GHG abatement and carbon sink expansion costs vary quite drastically. Costs in energy sector range from US$-24.9/$tCO_2$ to US$23.8/$tCO_2$, in agriculture sector from US$-10.9/$tCO_2$ and US$9.7/$tCO_2$, and in LULUCF sector, between US$0.4/$tCO_2$ and US$1.4/$tCO_2$.

ENVIRONMENTALLY SOUND TECHNOLOGIES APPLICATION

In Viet Nam, the efficiency of energy, material and fuel consumption is very low, owing to the continued use of old technologies and equipments as well as inadequate energy management and utilization.

In recent years, many manufacturing industries have turned towards new, modern and environmentally sound technologies. However, the widespread use of old technologies and processes continues to increase environmental pollution and GHG emission.

In order to develop a low-carbon economy, environmentally sound technologies are being considered for adoption.

In energy supply, it is essential to increase the use of high-efficiency technologies in conjunction with using and developing sources of renewable energy.

Energy consumption needs to promote energy efficiency and conservation.

As of October 2010, Viet Nam has had 34 Clean Development Mechanism (CDM) projects registered by the CDM Executive Board (EB) with a total emission reduction of 17.5 million tCO_2e. Amongst the transferred and applied technologies for CDM projects are associated gas recovery from oil extraction, methane recovery from waste treatment, recovery of excess heat from cement production for electricity generation, wind, solar and biomass energy generation. The use of these technologies has contributed to Viet Nam's GHG emissions reductions and sustainable development.

SYSTEMATIC OBSERVATION AND CLIMATE CHANGE RESEARCH

Viet Nam has a network of hydrological and meteorological stations, comprising of surface-based meteorological stations, upper-air meteorological stations, agro-meteorological stations, hydrological stations, marine meteorological stations, environmental observing stations, and air and water quality monitoring stations. However, the stations are distributed unevenly between regions, with varied station densities.

There are currently 174 meteorological surface stations, 248 hydrological stations, 17 marine meteorological stations and 393 independent rain gauge stations all over the country. Of the 174 surface-based meteorological stations, 145 stations have observation time series data for over 30 years, 16 stations have data series for 20 to 30 years, and the rest have data records for below 20 years.

Viet Nam's hydro-meteorological forecast system has three hierarchical levels: central, regional and provincial.

The current telecommunication network includes the global telecommunication system, the Internet and the national information system.

As a member of the World Meteorological Organization (WMO) and Regional Association II - Asia (RAII), Viet Nam has been actively engaged in implementing the scientific and technological programs of both WMO and RAII. The country has established bilateral cooperation with other countries in hydro-meteorology.

In an effort to strengthen hydro-meteorological capacity, the Government issued Decision 16/2007/QÑ-TTg dated 29 January 2007 on approving the Master Plan of the National Natural Resources and Environmental Observation Network until 2020. This master plan aims to expand and enhance the quality of Viet Nam's hydro-meteorological network.

Viet Nam has undertaken a substantial amount of research related to climate change and climate change response carried out by governmental agencies, science academies, universities, institutes and NGOs with international assistance at different levels and in various forms.

EDUCATION, TRAINING AND PUBLIC AWARENESS-RAISING

Major national educational and training institutions have begun incorporating climate change studies in their official curricula for specialized students.

Awareness raising activities have been gradually broadened in both content scope and participant diversity. Several major climate change-related publications (books, periodicals, leaflets, video clips) have been translated, published and widely distributed. A climate change journal is published periodically. A number of specialized websites covering climate change issues, such as www.noccop.org.vn, www.vacne.org.vn and www.nea.gov.vn have been set up to provide timely global and national news updates.

Climate change information has been disseminated via the mass-media nationally and locally. In addition, climate change issues have been regularly mainstreamed into news topics, social events and captured much interest throughout Vietnamese society, particularly the younger generations. The Viet Nam NGO Climate Change Working Group was established in February 2008 to facilitate inter-agency coordination and foster discussions between NGOs on climate change.

Many NGOs have shown interest in climate change response activities as reflected by the organization of numerous workshops, training courses, educational games and competitions to different target groups.

LIMITATIONS, CONSTRAINTS AND CAPACITY BUILDING NEEDS

Limitations and constraints

National GHG inventory

- Reliable and synchronous data and information are sparse, and the data collection process is slow.

- The data collection system for greenhouse gas inventory is incomplete and there is a shortage of Ministry and sector-level GHG inventory technical experts.

- Research, assessment and verification for certain country-specific emission factors remains incomplete.

Climate change impact and response measures

- The application of the MAGICC/SCENGEN 5.3 model in the development of climate change scenarios, which produces maps on a standard low resolution grid, makes it difficult to accurately reflect the intra-regional nuances of climate change in Viet Nam.

- The database for impact assessments and adaptation measures development, particularly data used in adaptation measure cost-benefit analyses, is incomplete.

- Adaptation impact assessment and response measure development models and tools are lacking, in particular for cross-sector or inter-regional assessments.

- There is a shortage of technical experts with the capacity to run impact assessment and adaptation measure development models.

GHG mitigation options

- Insufficient long-term planning information and data.

- Some IPCC emission factor defaults for energy technologies may not be suitable when applied to Viet Nam's in current national circumstances.

- The technical capacity to apply models for the development and assessment of mitigation options and mitigation projects remains limited.

Adoption of environmentally sound technologies

Outdated technologies continue to be in widespread use. Furthermore, the combination of insufficient investment and a dearth of technical experts complicate the comprehensive transfer and application of modern, environmentally sound technologies.

Systematic observation and climate change research

- The current hydro-meteorological observations network is insufficient and inadequately distributed, while existing observational infrastructures and telecommunication systems are insufficient and lack uniformity.

- Sector employees have limited technical capacities.

- Comprehensive multi-sectoral approaches to assess climate change impacts and develop adaptation measures are lacking.

Education, training and public awareness-raising

- Climate change education, training and awareness-raising plans and programs are unavailable at the national level.

- Higher-education curricula and content remain experimental in nature. Students at the primary and secondary education levels do not have any available climate change course material or curricula.

- The diffusion of basic information on climate change relies on efforts by specialist bodies, NGOs and international collaborative projects. Public awareness-raising has been limited

Capacity-building needs

Institutional and administrative

Legislation to guide and support the implementation of the UNFCCC and climate change response programs in Viet Nam must continue to be concretized, while coordination between ministries, sectors and provinces needs to be enhanced and strengthened for the development of climate change response action plans.

Technology development and transfer

- It is necessary to assess the level of technological demand in climate change mitigation and adaptation to seize opportunities to steer development towards a low-carbon economy through the implementation of climate change, particularly CDM, projects

- Technical experts and professionals need to be trained in order to facilitate the prompt and successful adoption of new technologies.

Financial capacity

Develop long-term and medium-term financial plans in climate change action plans to ensure the implementation of climate change response activities so as to maximize international financial support (bilateral and multilateral) through the implementation of climate change projects and programs in Viet Nam.

Education, training and public awareness

It is necessary to formulate plans and develop awareness-raising programs for the whole population, climate change education and training programs in school curricula, and continue to organize climate change knowledge-building campaigns and educational competitions through the mass-media.

International support for national communications and future needs

As a developing country, Viet Nam has received financial assistance from the GEF through the UNEP for the preparation of national communications under the UNFCCC. The development of the Second National Communication also received technical support from the UNESCAP.

Viet Nam highly appreciates and values the assistance provided by the GEF and the UNEP and technical support from UNESCAP and related international organizations.

The approval and implementation of the NTP reflect Viet Nam's proactive stance in climate change response, as it looks forward to increased technical and financial support from developed countries and international organizations.

Areas where continued capacity building would directly benefit the preparation and quality of future communications to the UNFCCC are:

- Scenario building using new and highly reliable models and tools for the entire territory and for each specific economic region.

- Determination of Viet Nam-specific emission factor values, through survey and analysis, in order to reduce national greenhouse gas inventory uncertainty levels.

- Assessment of vulnerability for ecosystems, economic and social impacts from climate change and development of appropriate adaptation measure that include policy measures.

- Application of cost-benefit analysis to assess climate change response measures and solutions.

CHAPTER 1
NATIONAL CIRCUMSTANCES

1.1. Natural Conditions

1.1.1. Geography

Viet Nam is located in Southeast Asia with a land area stretching from latitudes 8°27' and 23°23' N to longitudes 102°08' and 109°30' E. The country borders China to the north, Laos and Cambodia to the west; and the East Sea to the east, south, and southwest. Viet Nam has over one million km² of sea waters and two major archipelagos, Hoang Sa (Da Nang city) and Truong Sa (Khanh Hoa province) with over 3,000 islands, islets and reefs.

Viet Nam, with its characteristic S-shaped coastline, extends 1,662 km from north to south with a land area of approximately 331,051.4 km². The territory measures 600 km from east to west at its widest and 50 km at its narrowest sections. Three quarters of Viet Nam consists of hills and mountains with elevations ranging from 100 to 1000 m, while the remainder consists of fertile plains, heavily cultivated and densely populated. Two major river deltas produce and supply most of the food for domestic consumption and export. These are the Mekong River Delta and the Red River Delta, which spread over 40,000 km² in the south, and 15,000 km² in the north, respectively.

The north of Viet Nam has many long and high mountain ranges with, most notably, the Hoang Lien Son Range rising to 3,143 m at Fan Si Pan peak, and the Truong Son Range , which runs over 1,100 km from the source of River Ca to the Southern Central Coast.

Located in the Red River Delta, Hanoi is Viet Nam's capital and the country's political, cultural, scientific and educational center. The city covers an area of 3,348.5 km² and has a population of 6.116 million, with a density of 1,827 inhabitants/km² (according to 2008 statistics).

1.1.2. Climate

Viet Nam is situated at the South-eastern tip of the Eurasian continent and spans over 15 degrees of latitude in the Northern hemisphere tropics, closer to the Tropic of Cancer than the Equator and features tropical monsoon climate. Due to its diverse topography and elongated shape the country and the pronounced effects of the East Sea, climatic conditions can vary greatly between regions.

Annual mean temperatures vary from 12.8°C to 27.7°C. Mean temperatures for the coolest month vary from 10°C to 16°C in northern highlands, and from 20°C to 24°C in southern highlands. Summer mean temperatures vary between 25°C and 30°C.

Average annual precipitation varies between regions, ranging from 600 to 5000 mm, and is usually measured at between 1,400 to 2,400 mm, with 80 to 90% occurring during the rainy season. In Viet Nam, there are 60-200 rainy days each year.

Due to intra-year variability in rainfall and rainy days, some regions experiencing flooding during the rainy season may nonetheless suffer from drought in the dry season.

Average annual hours of sunshine vary from 1,400 to 3,000 hours. The sunniest region has twice as many hours of sunshine as the least sunny one. Sunshine hours decrease going from south to north and from lowlands to highlands. Offshore islands tend to have more sunshine hours than the mainland.

Annual average relative humidity is generally between 80% and 85%.

Between 1956 and 2000, there were, on average, six to eight typhoons or tropical cyclones affecting Viet Nam each year. In recent years, typhoon seasons have ended later and the country has been affected by an increased number of higher intensity typhoons. Typhoon tracks have gradually moved southwards with some exhibiting increasingly abnormal movements.

1.1.3. Water resources

Vietnam has a dense network of rivers, with an average drainage density of 0.6 km/km^2, comprising of 2,360 perennial rivers and streams over 10 km in length. There are nine large river systems in Viet Nam, namely Mekong River, Red River, Ma River, Ca River, Thai Binh River, Dong Nai River, Ba River, Bang Giang - Ky Cung River and Thu Bon River.

The Mekong River, the largest river system, rises in Tibet, China, passes through Myanmar, Laos, Thailand, Cambodia and enters Viet Nam through two major branches - Tien River and Hau River - before draining into the East Sea. The river has a total basin area of 68,820 km^2 in Viet Nam

The Red River is the second largest system in Viet Nam. It rises in Yunnan, China, and has a total national basin area of 72,800 km^2.

Multi-year period mean annual flows of all rivers in Viet Nam total 835 billion m^3. River flow from external sources contributes to 61.4%, or 513 billion m^3, while domestic sources make up the remaining 38.6%, or 322 billion m^3.

Total groundwater potential is estimated at 50 billion m^3 per year. The geographic distribution of groundwater is uneven as it is mostly concentrated in the Red River and Mekong River deltas.

1.2. Social and economic overview

1.2.1. Demographics

Viet Nam is home to 54 ethnic groups; among them, the Kinh is the largest group which accounts for 86.2% of the country's population. As of 2000, Viet Nam's population was 77.6 million. By 2008, the population had reached 86.2 million. Population growth in 2000 and 2008 were 1.36% and 1.22%, respectively. Table 1.1 illustrates several population characteristics of Viet Nam.

Table 1.1. Population characteristics

Year	Total population (thousand persons)	Growth rate (%)	Percentage (by gender and by area)			
			Male	Female	Urban	Rural
2000	77,635.4	1.36	49.2	50.8	24.2	75.8
2001	78,685.8	1.35	49.2	50.8	24.7	75.3
2002	79,727.4	1.32	49.2	50.8	25.1	74.9
2003	80,902.4	1.47	49.1	50.9	25.8	74.2
2004	82,031.7	1.40	49.1	50.9	26.5	73.5
2005	83,106.3	1.31	49.1	50.9	26.9	73.1
2006	84,155.8	1.24	49.2	50.8	27.1	72.9
2007	85,171.7	1.23	49.2	50.8	27.5	72.5
2008	86,210.8	1.22	49.2	50.8	28.1	71.9

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.2. Agriculture

As of 2000, land for agriculture covered approximately 9.3 million ha, equivalent to 28.2% of the national territory (Table 1.2), of which 7.6 million ha were dedicated to growing rice.

Animal husbandry and cultivation are two main sub-sectors of agricultural production. However, farming and processing methods remain underdeveloped.

Nevertheless, agricultural production has still been able to exceed the domestic demand for food, ensuring national food security, and generating income from export.

Table 1.2. Land use by region in 2000

Unit: thousand ha

Regions	Total area	Land use			
		Agriculture	Forestry	Special	Residential
Red River Delta	1,478.8	857.6	119.0	233.0	91.3
Northeast	6,532.6	897.9	2,673.9	204.2	58.8
Northwest	3,563.7	407.4	1,037.0	58.5	15.5
North Central	5,150.1	725.3	2,222.0	231.3	52.8
South Central	3,306.7	545.6	1,166.3	211.9	32.4
Central Highlands	5,447.6	1,233.6	2,993.2	137.1	33.1
Southeast	3,473.3	1,708.8	1,026.2	233.3	58.1
Mekong River Delta	3,971.3	2,970.2	337.8	223.5	101.2
Total	**32,924.1**	**9,345.4**	**11,575.4**	**1,532.8**	**443.2**

Source: Statistical Yearbook 2001, General Statistics Office of Viet Nam, 2002

In recent years, Viet Nam's traditional cultivation practice has gradually been replaced by a market-based agricultural commodity production in order to improve product quality and value. Crop area and output for major crops are presented in Tables 1.3, 1.4, and 1.5.

Table 1.3. Production of cereals

Year	Area (thousand ha)		Gross output (thousand tonnes)	
	Rice	Maize	Rice	Maze
2000	7,666.3	730.2	32,529.5	2,005.9
2001	7,492.7	729.5	32,108.4	2,161.7
2002	7,504.3	816.0	34,447.2	2,511.2
2003	7,452.2	912.7	34,568.8	3,136.3
2004	7,445.3	991.1	36,148.9	3,430.9
2005	7,329.2	1,052.6	35,832.9	3,787.1
2006	7,324.8	1,033.1	35,849.5	3,854.6
2007	7,207.4	1,096.1	35,942.7	4,303.2
2008	7,414.3	1,125.9	38,725.1	4,531.2

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.4. Area of industrial crops

Unit: thousand ha

Year	Tea	Coffee	Rubber	Sugarcane	Peanut	Soybean	Cotton	Cashew
2000	87.7	561.9	412.0	302.3	244.9	124.1	18.6	195.6
2001	98.3	565.3	415.8	290.7	244.6	140.3	27.7	199.2
2002	109.3	522.2	428.8	320.0	246.7	158.6	34.1	240.2
2003	116.3	510.2	440.8	313.2	243.8	165.6	27.8	261.5
2004	120.8	496.8	454.1	286.1	263.7	183.8	28.0	295.9
2005	122.5	497.4	482.7	266.3	269.6	204.1	25.8	348.1
2006	122.9	497.0	522.2	288.1	246.7	185.6	20.9	401.8
2007	126.2	509.3	556.3	293.4	254.5	187.4	12.1	439.9
2008	129.3	530.9	631.5	271.1	256.0	191.5	5.2	402.7

Source: Statistical Yearbook 2006, General Statistics Office of Viet Nam, 2007
Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.5. Production of industrial crops

Unit: thousand tonnes

Year	Tea	Coffee	Rubber	Sugarcane	Peanut	Soybean	Cotton	Cashew
2000	314.7	802.5	290.8	15,044.3	355.3	149.3	18.8	67.6
2001	340.1	840.6	312.6	14,656.9	363.1	173.7	33.6	73.1
2002	423.6	699.5	298.2	17,120.0	400.4	205.6	40.0	128.8
2003	448.6	793.7	363.5	16,854.7	406.2	219.7	35.1	164.4
2004	513.8	836.0	419.0	15,649.3	469.0	245.9	28.0	204.7
2005	570.0	752.1	481.6	14,948.7	489.3	292.7	33.5	240.2
2006	648.9	985.3	555.4	16,719.5	462.5	258.1	28.6	273.1
2007	705.9	915.8	605.8	17,396.7	510.0	275.2	16.1	312.4
2008	760.5	1055.8	659.6	16,128.0	533.8	268.6	6.9	308.5

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Animal husbandry is developing towards large-scale industrial farming. Product quality and value are gradually meeting growing consumer demand. Table 1.6 shows the number of cattle and poultry between 2000 and 2008.

Aquaculture is the fastest growing form of animal husbandry, with gross output rising from VND21.78 trillion in 2000 to VND50.1 trillion in 2008 (Table 1.7).

Table 1.6. Number of cattle and poultry

Year	Buffalo	Cow	Pig	Horse	Goat, sheep	Poultry
	thousand heads					million heads
2000	2,897.2	4,127.9	20,193.8	126.5	543.9	196.1
2001	2,807.9	3,899.7	21,800.1	113.4	571.9	218.1
2002	2,814.5	4062.9	23,169.5	110.9	621.9	233.3
2003	2,834.9	4,394.4	24,884.6	112.5	780.4	254.6
2004	2,869.8	4,907.7	26,143.7	110.8	1,022.8	218.2
2005	2,922.2	5,540.7	27,435.0	110.5	1,314.1	219.9
2006	2,921.1	6,510.8	26,855.3	87.3	1,525.3	214.6
2007	2,996.4	6,724.7	26,560.7	103.5	1,777.7	226.0
2008	2,897.7	6,337.7	26,701.6	121.0	1,483.5	247.3

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.7. Aquaculture, farming area and output value

Year	Area of farming (thousand ha)	Output value (billion VND)
2000	641.9	21,777.4
2001	755.2	25,359.7
2002	797.7	27,600.2
2003	867.6	30,602.3
2004	920.1	34,438.9
2005	952.6	38,726.9
2006	984.4	42,035.5
2007	1,018.8	46,932.1
2008	1,052.0	50,081.9

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.3. Forestry

The total forest area in 2000 was about 11.6 million ha, accounting for 35.2% of the country's total land area. The implementation of Viet Nam's Forestry Development Strategy 2006-2020 has reinforced society-wide participation in forest development and conservation across the country. As of December 2008, the total national forest area was 13.1 million ha, equating to a 38.7% forest coverage rate.

The strategy seeks to achieve the sustainable expansion, management, conservation, development and utilization of 16.2 million hectares of land reserved for forestry planning. Forest coverage would thereby increase to 42-43% by 2010 and 47% by 2020, and include 5.68 million ha of protection forests, 2.16 million ha of special-use forests and 8.4 million ha of production forests.

Forestry gross output value for 2000-2008 is presented in Table 1.8 below.

Table 1.8. Gross output value of forestry

Unit: billion VND

Year	Total	Contribution		
		Forest Planting and Care	Forest production	Services and other activities
2000	5,901.6	1,161.9	4,412.1	327.6
2001	6,014.0	1,182.9	4,493.6	337.5
2002	6,107.6	1,182.5	4,529.5	395.6
2003	6,174.8	1,275.6	4,402.0	497.2
2004	6,242.4	1,330.0	4,368.5	543.9
2005	6,315.6	1,332.0	4,435.7	547.9
2006	6,408.4	1,354.1	4,492.2	562.1
2007	6,603.1	1,395.5	4,629.0	578.6
2008	6,752.0	1,439.8	4,720.4	591.8

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.4. Industry

Industrial contribution to GDP in 2000 was 36.7%. Despite achieving impressive annual growth of 10-15%, Vietnamese industry is still considered underdeveloped due to obsolete equipment and machinery with high energy intensity. Viet Nam has designed policies with strong incentives to create a favourable environment for investors in order to attract investment.

Table 1.9. Industrial output value (at constant 1994 price)

Year	Total (billion VND)	Year-on-year development index (%)
2000	198,326.1	117.5
2001	226,406.2	114.2
2002	261,092.4	114.8
2003	305,080.4	116.8
2004	355,624.1	116.6
2005	416,562.8	117.1
2006	486,637.1	117.0
2007	568,140.6	116.7
2008	647,231.7	113.9

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.10. Main industrial products

Year	2000	2002	2004	2006	2008
Coal (million tonnes)	11.6	16.4	27.3	38.8	39.8
Crude oil (million tonnes)	16.3	16.9	20.1	16.8	14.9
Natural gas (million m^3)	1,596.0	-	6,269.0	7,000.0	7,944.0
Cement (million tonnes)	13.3	21.1	26.1	32.7	40.0
Steel (thousand tonnes)	1,583.0	2,503.0	3,279.0	3,837	5,073.0
Agicultural pumps (piece)	3,496.0	3,578.0	10,038.0	5,118.0	2,196.0
Transformer (piece)	13,535.0	18,633.0	50,146.0	28,149.0	46,915.0
Diesel motor (pieces)	30,329.0	107,433.0	182,443.0	170,047.0	275,236.0
Electricity rotaring engine (piece)	45,855.0	64,085.0	132,320.0	120,893.0	165,302.0
Paper, cover (thousand tonnes)	408.5	489.6	809.3	1,030.6	1,899.7

Source: Statistical Yearbook 2006, General Statistics Office of Viet Nam, 2007
Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.5. Transportation

While the transportation sector has experienced rapid development, it has been unable to match the tremendous growth in demand for transportation across the country. Road transportation is the dominant mode of passenger and freight transportation, followed by waterway. Road transportation volume increased from 620.7 million passengers and 144.6 million tonnes of freight in 2000 to 1,602.7 million passengers and 443.3 million tonnes of freight in 2008.

Passenger volume and freight load for various mode of transportation are listed in Tables 1.11 and 1.12.

Table 1.11 Volume of passengers carried by type of transport

Unit: million persons

Year	Total	Type of transport			
		Railway	Road	Inland waterway	Aviation transport
2000	763.6	9.8	620.7	130.3	2.8
2001	821.8	10.6	677.3	130.0	3.9
2002	878.5	10.8	727.7	135.6	4.4
2003	1,076.0	11.6	931.3	128.6	4.5
2004	1,202.9	12.9	1,041.9	142.6	5.5
2005	1,349.6	12.8	1,173.4	156.9	6.5
2006	1,493.8	11.6	1,331.6	143.2	7.4
2007	1,638.0	11.6	1,473.0	144.5	8.9
2008	1,784.7	11.3	1,602.7	160.5	10.2

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.12. Volume of freight by type of transport

Unit: thousand tonnes

Year	Total	Type of transport				
		Railway	Road	Inland waterway	Maritime transport	Aviation transport
2000	223,823.0	6,258.2	144,571.8	57,395.3	15,552.5	45.2
2001	252,146.0	6,456.7	164,013.7	64,793.5	16,815.3	66.8
2002	292,869.2	7,051.9	192,322.0	74,931.5	18,491.8	72.0
2003	347,232.7	8,385.0	225,296.7	86,012.7	27,448.6	89.7
2004	403,002.2	8,873.6	264,761.6	97,936.8	31,332.0	98.2
2005	460,146.3	8,786.6	298,051.3	111,145.9	42,051.5	111.0
2006	513,575.1	9,153.2	338,623.2	122,984.4	42,693.4	120.8
2007	596,800.9	9,050.0	403,361.8	135,282.8	48,976.7	129.6
2008	648,681.5	8,426.9	443,294.5	137,176.8	59,653.6	129.7

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.6. Energy

1.2.6.1. Primary energy consumption

The total demand for primary energy is increasing (Table 1.13, Figure 1.1).

Primary energy consumption increased at an average rate of 6.5% per annum from 32,235 KTOE in 2000 to 50,221 KTOE in 2007.

Figure 1.2 shows how the structure of primary energy supply, based on its input type, has changed over the years. In the case of coal, this share increased from 13.6% in 2000 to 19.4% in 2007.

Table 1.13. Total primary energy consumption by type of energy

Unit: KTOE

Year	2000	2001	2002	2003	2004	2005	2006	2007
Coal	4,372	5,024	5,517	6,562	7,344	8,376	9,045	9,736
Gasoline and Oil	7,917	8,415	9,616	10,490	12,082	12,270	12,184	14,234
Gas	1,441	1,566	2,151	2,776	4,255	4,908	5,239	5,976
Hydropower	4,314	5,573	5,569	4,422	4,141	3,835	4,619	5,179
Non-commercial energy	14,191	14,297	14,399	14,694	14,734	14,794	14,860	14,870
Imported electricity	0	0	0	0	0	33	83	226
Total	**32,235**	**34,875**	**37,252**	**38,944**	**42,556**	**44,216**	**46,030**	**50,221**

Source: Institute of Energy, Ministry of Industry and Trade, 2009

Coal, gasoline and oil are primary fuels for electricity generation. The share of each fuel type in electrical power generation and their fluctuations over time are described in Table 1.14.

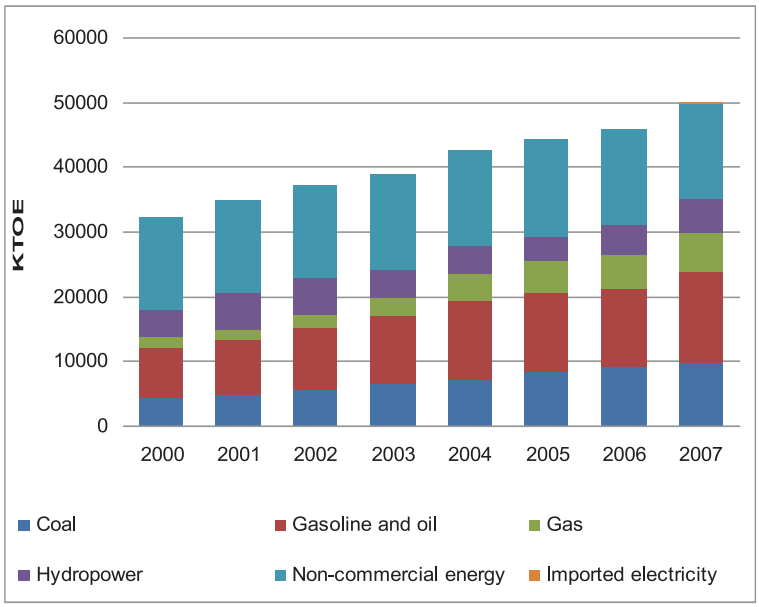


Figure 1.1. Primary energy consumption by type of energy

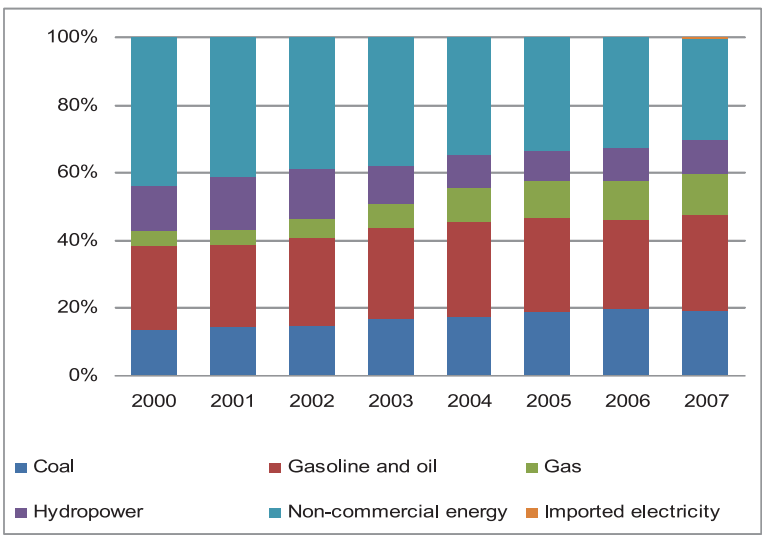


Figure 1.2. Structure of primary energy from 2000 to 2007

Table 1.14. Fuel supply for electricity generation

Unit: KTOE

	Year	2000	2001	2002	2003	2004	2005	2006	2007
Coal	**Total**	4,373	5,024	5,517	6,562	7,344	8,376	9,045	9,736
	Electricity generation	1,150	1,281	1,500	2,225	2,493	3,025	3,517	3,646
	Ratio %	26.3	25.5	27.2	33.9	34.0	36.1	38.9	37.5
Petroleum	**Total**	7,917	8,415	9,616	10,490	12,082	12,270	12,184	14,234
	Electricity generation	1,310	1,407	1,257	744	726	700	483	821
	Ratio %	16.5	16.7	13.1	7.1	6.0	5.7	4.0	5.8
Gas	**Total**	1,441	1,566	2,151	2,776	4,255	4,908	5.239	5,976
	Electricity generation	1,102	1,106	1,602	2,136	3,375	4,154	4,636	4,916
	Ratio %	76.4	70.6	74.5	76.9	79.3	84.6	88.5	82.3

Sources: Electricity of Viet Nam, 2008; Viet Nam Oil and Gas Corporation, 2008

1.2.6.2. End-use energy consumption

Total end-use energy consumption was 26.28 million TOE in 2000 and 40.75 million TOE in 2007. Share of coal consumption increased from 12.3% to 14.9%, gasoline and oil from 26.3% to 34.4%, gas from 0.1% to 1.3% in 2007 and electricity from 7.3% up to 12.9%. End-use energy consumption by fuel for 2000-2007 is presented in Table 1.15 and Figure 1.3.

Table 1.15. End- use energy consumption by type of energy

Unit: KTOE

Year	2000	2001	2002	2003	2004	2005	2006	2007
Coal	3,223	3,743	4,017	4,337	4,851	5,351	5,528	6,090
Gasoline and Oil	6,920	7,427	8,884	10,235	11,888	12,254	12,317	14,016
Gas	19.4	18	18	18	270	515	310	543
Electricity	1,927	2,223	2,600	3,002	3,405	4,051	4,630	5,256
Biomass	14,191	14,297	14,399	14,694	14,734	14,780	14,841	14,848
Total	**26,280**	**27,708**	**29,918**	**32,286**	**35,148**	**36,951**	**37,627**	**40,752**

Source: Institute of Energy, Institute of Industrial Strategy and Policy, Ministry of Industry and Trade, 2009

The average growth rate of end-use energy consumption for 2000-2007 was 6.5% per year, while average GDP growth was 7.5% for the same period. This equates to an energy elasticity (growth rate of energy consumption/growth rate of GDP) of 0.87 for this period. Figure 1.3 illustrates the composition of end-use energy consumption by type of energy.

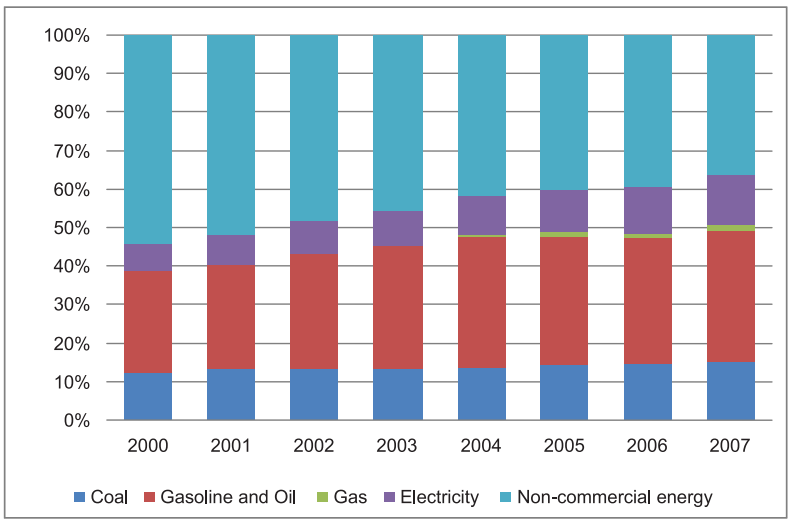


Figure 1.3. End-use energy consumption by type of energy

Table 1.16 and Figure 1.4 show end-use energy consumption by sector (industry, transportation, residential sector, agriculture and commercial/institutional sector) for 2000-2007.

Table 1.16. End- use energy consumption by sector

Unit: KTOE

Year	2000	2001	2002	2003	2004	2005	2006	2007
Industry	8,032	8,667	9,457	9,951	11,125	12,216	12,372	13,964
Agriculture	401	401	454	482	552	627	620	640
Transportation	3,867	4,074	4,969	6,005	7,238	7,331	7,508	8,637
Commercial/ institutional sector	1,151	1,317	1,487	1,498	1,542	1,601	1,538	1,582
Residential sector	12,829	13,248	13,551	14,350	14,692	15,176	15,589	15,929
Total	**26,280**	**27,708**	**29,918**	**32,286**	**35,148**	**36,951**	**37,627**	**40,752**

Source: Institute of Energy, Ministry of Industry and Trade, 2009

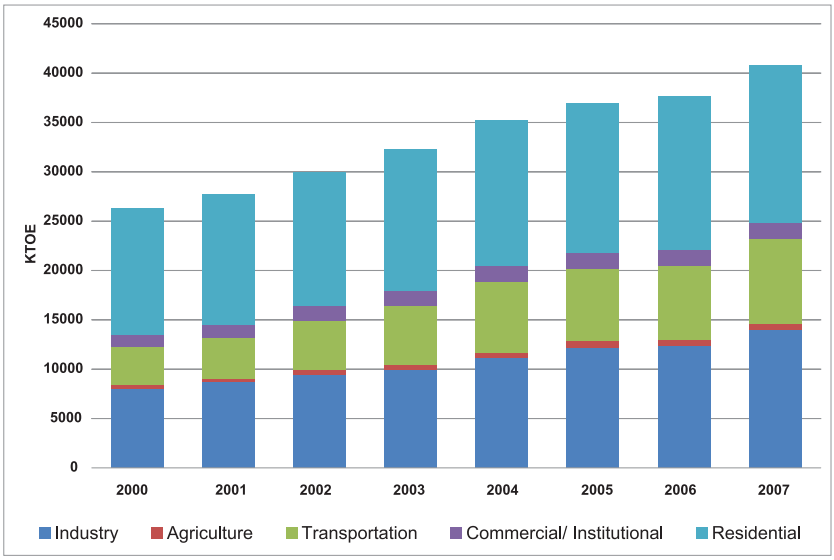


Figure 1.4. End-use energy consumption by sector

The structure of energy consumption by sector changed between 2000 and 2007. In 2000, industry, transportation, agriculture, residential, commercial/institutional sectors' shares of energy consumption were 30.6%, 14.7%, 1.5%, 48.8% and 4.4%, respectively. By 2007, energy consumed by industry, agriculture and transportation had risen to 34.3%, 1.6% and 21.2% respectively, while the shares of residential, commercial/institutional sector energy consumption both declined to 39.1% and 3.9%, respectively. Figure 1.5 shows the changes in the structure of energy consumption by sector for 2000-2007.

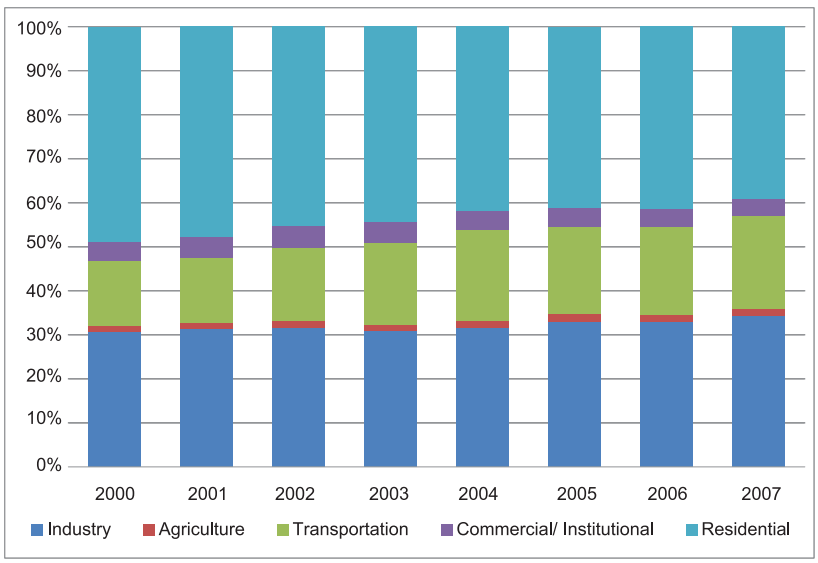


Figure 1.5. Structure of energy consumption by sector

1.2.7. Economic growth

Between 2000 and 2008, Viet Nam's economic growth averaged 7.5%. Growth rates for the whole economy and its sectors are shown in Table 1.17. Share of GDP by sector are shown in Table 1.18.

Table 1.17. GDP growth and growth rates by sector

Unit: %

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
GDP growth	6.79	6.89	7.08	7.34	7.79	8.44	8.17	8.44	6.18
Agriculture /Forestry /Aquaculture	4.63	2.98	4.17	3.62	4.36	4.02	3.69	3.40	4.07
Industry and Construction	10.07	10.39	9.48	10.48	10.22	10.69	10.38	10.06	6.11
Service	5.32	6.1	6.54	6.45	7.26	8.48	8.29	8.68	7.18

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

Table 1.18. Share of GDP by sector

Unit: %

Year	Agriculture/Forestry /Aquaculture	Industry and Construction	Service
2000	24.53	36.73	38.74
2001	23.24	38.13	38.63
2002	23.03	38.49	38.48
2003	22.54	39.47	37.99
2004	21.81	40.21	37.98
2005	20.97	41.02	38.01
2006	20.40	41.54	38.06
2007	20.34	41.48	38.18
2008	22.10	39.73	38.17

Source: Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.8. Human health

The number of healthcare institutions has increased from 13,117 in 2000 to 13,460 in 2008. The numbers of doctors and patient beds are also increasing (Table 1.19). Life expectancy was 67.8 years in 2000.

Table 1.19. Number of doctors and patient beds

Year	2000	2002	2004	2006	2008
Number of doctors	39,200	44,500	50,100	52,800	57,300
Number of doctors /10,000 people	5.0	5.6	6.1	6.3	6.6
Number of patient beds	192,000	192,940	196,300	198,400	219,800

Source: Statistical Yearbook 2006, General Statistics Office of Viet Nam, 2007

Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.2.9. Education

Viet Nam's formal educational system consists of 12 years of schooling and is sub-divided into primary, secondary and upper-secondary.

Higher education consists of vocational schools, professional secondary schools, community colleges, and universities.

The post-graduate system consists of master's and doctoral programs.

The literacy rate is 94% for Vietnamese adults (above 15 years old).

Table 1.20. Number of teachers, students, community colleges and universities

Year	2000	2006	2008
Number of teachers (thousand)	32.3	53.4	60.7
Number of students (thousand)	899.5	1,666.2	1,675.7
Number of colleges and universities (institutions)	178	322	393

Source: Statistical Yearbook 2001, General Statistics Office of Viet Nam, 2002

Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

1.3. Sustainable development strategy in Viet Nam

The Government of Viet Nam issued Viet Nam's Sustainable Development Strategy (Agenda 21) in August 2004 in order to simultaneously implement sustainable development targets stipulated in the 9th National Party Congress Resolution and honor international commitments.

Viet Nam's Sustainable Development Strategy is a framework that orients the country towards sustainable development through the tight, reasonable and harmonious combination of three elements: economic development, social equity and environmental protection. On that basis, ministries, sectors, and provinces have formulated their Agenda 21 programs.

In December 2003, to protect the environment, Viet Nam issued the National Environment Protection Strategy by 2010 and orientation by 2020.

Implementing the Kyoto Protocol, Viet Nam has issued a number of legal documents.

These include Directive 35/2005/CT-TTg dated 17th October 2005 on organizing the implementation of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, Decision 47/2007/QÑ-TTg dated 6th April 2007 on approving the plan for the organization of the implementation of the Kyoto Protocol under the United Nations Framework Convention on Climate Change in the 2007 - 2010 period, Decision 130/2007/QÑ-TTg dated 2nd August 2007 on several financial mechanisms and policies applied to Clean Development Mechanism investment projects.

To proactively respond to climate change, Viet Nam approved the National Target Program to Respond to Climate Change through Decision 158/2008/QÑ-TTg dated 2nd December 2008. The Program's strategic objectives are to assess climate change impacts on sectors and regions in specific periods and to develop feasible action plans to effectively respond to climate change in the short-term and long-term to ensure sustainable development of Vietnam, to take opportunities to develop towards a low-carbon economy, and to join the international community's efforts in mitigating climate change and protecting the climatic system.

Overview of national circumstances in 2000 is presented in Table 1.21 below.

Table 1.21. Overview of national circumstances in 2000

	Element	2000
1	National territory (km^2)	331,051.4
2	Agricultural land area (million ha)	9.35
3	Forest land area (million ha)	10.92
4	Population (million persons)	77.6
5	Urban/rural population ratio (%)	31.9
6	Life expectancy at birth (year)	67.8
	❖ Male	66.5
	❖ Female	70.1
6	Human Development Index (HDI)*	0.711
8	Poverty rate (%)**	17.2
9	GDP (current prices; billion VND)	441,646
10	GDP per captia (USD)	402
11	Share of GDP, major sectors of the economy (%):	
	❖ Industry	36.73
	❖ Service	38.74
	❖ Agricultue/Forestry/Aquaculture	24.53
12	Rice gross output (million tonnes)	32.5
13	Coal gross output (million tonnes)	11.6
14	Crude oil gross output (million tonnes)	16.3
15	Total electricity output (million kWh)	26,682

Source: - Statistical Yearbook 2001, General Statistics Office of Viet Nam, 2002

- Statistical Yearbook 2008, General Statistics Office of Viet Nam, 2009

** 2007/2008 Human Development Report, UNDP, 2008*

***Comprehensive strategy for growth and poverty reduction, 2003*

CHAPTER 2
NATIONAL GREENHOUSE GAS INVENTORY FOR THE YEAR 2000

2.1. Introduction

2.1.1. Institutional arrangement for national GHG inventory

The Ministry of Natural Resources and Environment (MONRE) is designated as the National Focal Point to coordinate the national greenhouse gas inventory for the base year 2000 with other relevant Ministries and sectors.

The National GHG Inventory Working Group is composed of technical experts from the public and private sectors, and non-governmental organizations (NGOs).

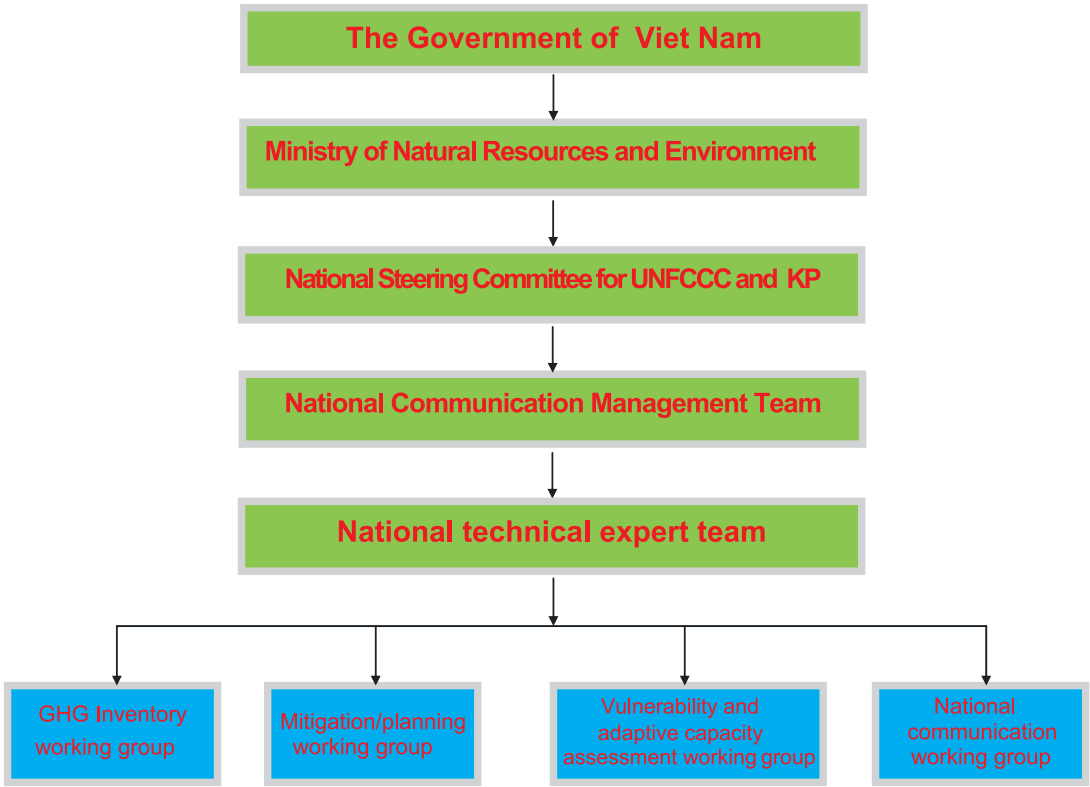


Figure 2.1. Institutional arrangement for Second National Communication

2.1.2. Methodology and data sources

The national GHG inventory for the year 2000 was carried out in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas and IPCC Good Practice Guidance for the energy, industrial processes, agriculture, LULUCF and waste sectors, covering the main greenhouse gases which are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Activity data for the national GHG inventory was compiled from published data in National Statistical Yearbooks, from ministries, agencies and published research results from institutes, research centres, companies and private businesses.

The majority of emission factors used are default values taken from the Revised 1996 IPCC Guidelines. In addition, certain country-specific emission factors were also developed and used for the inventory, such as CH_4 emission factor for rice paddies.

2.2. GHG emission inventory by sector

2.2.1. Energy

GHGs emitted by the energy sector were recorded from two sources: fuel combustion and fugitive emissions in the course of extraction and transportation.

2.2.1.1. GHG emission from fuel combustion

Total commercial end-use energy consumption reached 6,953 KTOE in 1994. In 2000, total primary energy consumption was 32,235 KTOE (Table 1.13), while end-use energy consumption reached 26,280 KTOE (Table 1.15), with commercial end-use energy consumption increasing two-fold from 1994 levels to 12,089 KTOE.

Estimates for GHG emissions from fuel combustion in 2000 are 45.9 million tonnes of CO_2, 68.4 thousand tonnes of CH_4 and 1.27 thousand tonnes of N_2O (Table 2.1).

Table 2.1. GHG emissions from fuel combustion by fuel type in 2000

Unit: thousand tonnes

Fuel	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2e
Oil	25,426.30	1.65	0.13	145.26	485.10	92.63	25,501.25
Coal	17,879.70	4.65	0.26	49.78	69.90	7.67	18,057.95
Gas	2,607.10	0.04	0.01	5.34	0.71	0.18	2,611.04
Biomass	-	62.02	0.87	21.86	1,053.45	123.91	1,572.12
Total	**45,913.11**	**68.36**	**1.27**	**222.24**	**1,609.16**	**224.39**	**47,742.36**

The main sources of CO_2 emissions were coal and oil combustion while CH_4 and N_2O were emitted primarily from biomass combustion.

Table 2.2. GHG emissions from fuel combustion by sub- sector

Unit: thousand tonnes

Sub-sector	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Energy industries	11,174.15	0.15	0.09	24.92	2.05	0.54
Manufacturing industries/ Construction	15,020.36	1.47	0.20	33.90	42.37	2.81
Transportation	11,886.00	1.41	0.10	125.08	472.82	90.11
Commercial/ Institutional	2,957.56	0.22	0.03	2.23	30.51	3.07
Residential	2,314.27	64.70	0.84	21.95	1,047.43	125.30
Agriculture/Forestry /Aquaculture	1,373.03	0.40	0.01	14.15	13.99	2.57
Others	1,174.63	0	0	0	0	0
Total	**45,900.00**	**68.35**	**1.27**	**222.23**	**1,609.17**	**224.40**

Note: Small differences between the total GHG emissions from fuel combustion by sector and by fuel type are due to the "bottom-up" and "top-down" approaches used in calculating these numbers.

Table 2.2 shows GHG emissions from energy by sub-sector. CO_2 emissions from manufacturing industries/construction were the largest single emission source with 15,020 thousand tonnes, followed by transportation with 11,886 thousand tonnes and energy industries with 11,174 thousand tonnes. GHG emissions from fuel combustion are shown in Table 2.3.

Table 2.3. GHG emissions from fuel combustion by GHG type

Gas	GHG emissions *(thousand tonnes)*	CO_2e *(thousand tonnes)*	Percentage
CO_2	45,900.00	45,900.00	96.2
CH_4	68.35	1,435.35	3.0
N_2O	1.27	393.70	0.8
Total		**47,729.05**	**100**

The total GHG emission from fuel combustion is about 47,729 thousand tonnes of CO_2e.

CO_2 made up the bulk of GHG emitted from fuel combustion, comprising 96.2% of total GHG emissions while CH_4 constituted 3% and N_2O accounted for the remaining 0.8% (Table 2.3).

2.2.1.2. GHG fugitive emissions

Fugitive emissions mainly result from the extraction of coal, oil, gas and gas leakage. CH_4 emitted from coal mining (surface and underground) amounted to 89.26 thousand tonnes while emissions from oil and gas activities reached 150.95 thousand tonnes. Total CH_4 fugitive emissions in 2000 was 240.21 thousand tonnes, equivalent to 5,044.41 thousand tonnes of CO_2 (Table 2.4).

Table 2.4. CH_4 fugitive emissions from coal mining, and oil and gas exploitation in 2000

Unit: thousand tonnes

Activity	CH_4	Percentage
Underground mining	88.28	36.8
Surface mining	0.98	0.4
Oil and gas	150.95	62.8
Total	**240.21**	**100**

Energy sector GHG inventory results for the year 2000 are presented in Tables 2.5, 2.6, and Figure 2.2.

Table 2.5. GHG emissions in energy by GHG type

Unit: thousand tonnes of CO_2e

Greenhouse gas	2000	
	Emissions	Percentage
CO_2	45,900.00	87.0
CH_4	6,479.76	12.3
N_2O	393.70	0.7
Total	**52,773.46**	**100**

Table 2.6. GHG emissions by sub- sector in energy

Unit: thousand tonnes of CO_2e

Emission source	2000	
	Emission	Percentage
Fuel combustion		
- Energy industries	11,205.20	21.2
- Manufacturing industries and construction	15,113.23	28.6
- Transportation	11,946.61	22.6
- Commercial/Institutional sector	2,971.48	5.6
- Residential sector	3,933.37	7.5
- Agriculture/Forestry/Aquaculture	1,384.53	2.6
- Others	1,174.63	2.2
Fugitive emissions		
- Solid fuel	1,874.46	3.6
- Gasoline and Oil	3,169.95	6.1
Total	**52,773.46**	**100**

Total GHG emissions from the energy sector in 2000 were 52.8 million tonnes of CO_2e, of which manufacturing industries and construction accounted for 28.6%, followed by transportation with 22.6%, while 2.6% came from agriculture/forestry/aquaculture (Table 2.6).

Emissions from energy consist mainly of CO_2, with 87% of total emissions, followed by CH_4 with 12.3% while N_2O accounted for 0.7% of the total (Table 2.5).

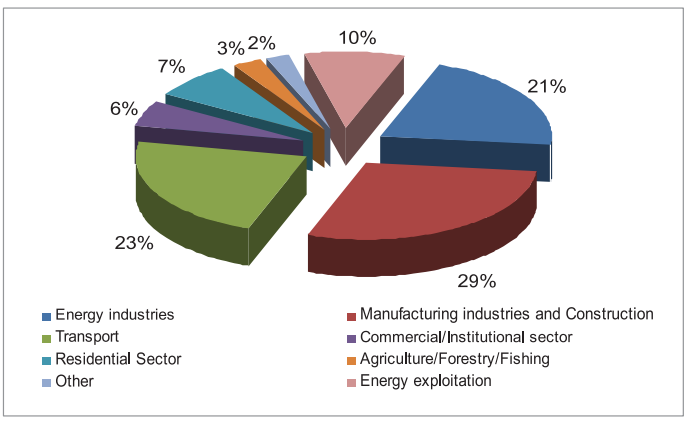


Figure 2.2. GHG emissions from energy

2.2.2. Industrial processes

GHG emissions from industrial processes are produced during the physical and chemical transformation processes of materials/substances. They are therefore unrelated to energy consumption.

Total GHG emissions from industrial processes in 2000 were 10,006 thousand tonnes of CO_2e, coming primarily from cement production with 6,629 thousand tonnes of CO_2e and steel production with 2,536 thousand tonnes of CO_2e.

The results of GHG emissions from industrial processes are presented in Table 2.7 and Figure 2.3.

Table 2.7. GHG emissions from industrial processes

Unit: thousand tonnes of CO_2e

Industrial production	2000	Percentage
Cement	6,629.05	66.3
Lime	821.99	8.2
Ammonia	10.40	0.1
Carbide	8.60	0.1
Steel	2,535.56	25.3
Total	**10,005.8**	**100**

Regarding other greenhouse gases, NO_x and CO emissions in 2000 totalled 0.79 and 4.4 thousand tonnes respectively, emitted mainly by steel, pulp and paper production processes. SO_2 emissions accounted for 9.7 thousand tonnes, originating mainly from cement, steel and paper and pulp production processes. Total NMVOC emissions of 140 thousand tonnes are mainly from the use of asphalt for road paving, and the production of food and drinks.

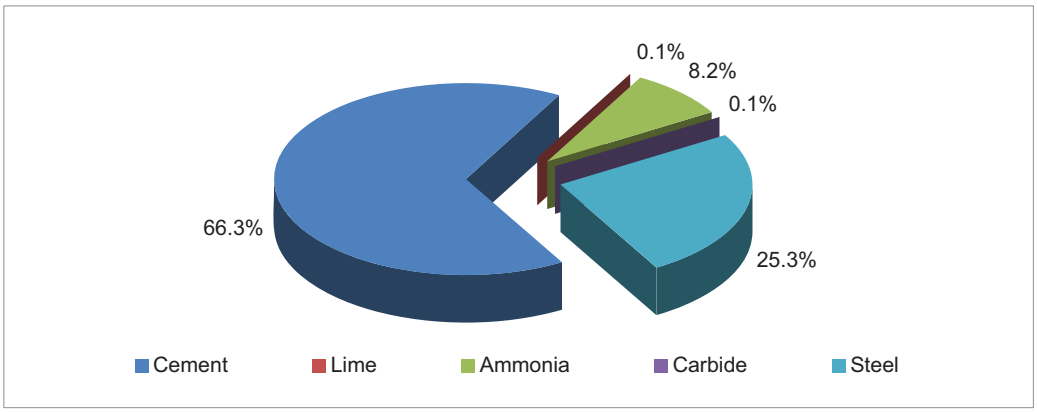


Figure 2.3. GHG emissions from industrial processes in 2000

2.2.3. Agriculture

The principal sources of GHG emissions in the agriculture sector are rice cultivation, livestock, agricultural soils, and burning of agricultural residues.

The areas of rice cultivation and irrigated land are shown in Table 2.8. Livestock populations are shown in Table 2.9.

Table 2.8. Rice cultivation and irrigated land areas in 2000

Unit: thousand ha

Area	Winter-spring crop	Autumn crop	Summer crop	Total
Rice cultivation land	3,013.2	2,292.8	2,360.3	**7,666.3**
Irrigated land	2,570.5	1,821.6	2,003.1	**6,395.2**

Source: Department of Water Resources Management, MARD, 2001

Table 2.9. Number of livestock in 2000

Unit: thousand heads

Classification	Number
Dairy cattle	35
Beef cattle	4,128
Buffalo	2,897
Sheep	4
Goat	540
Horse	126
Swine	20,194
Poultry	196,188

Source: Statistical Yearbook 2001, General Statistics Office of Viet Nam, 2002

The amounts of chemical and organic fertilizer used per hectare in 1998, 1999 and 2000 are presented in Table 2.10.

Table 2.10. Chemical and organic fertilizer amount used per hectare in 1998, 1999 and 2000

Unit: kg/ha

	Chemical fertilizer			Organic fertilizer		
Year	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
N	107.9	106.3	113.6	42.9	40.8	39.2
P_2O_5	49.5	59.9	54.7	49.2	47.1	46.1
K_2O	24.7	43.9	22.6	104.2	98.7	94.0

Source: PRISE and National Institute of Animal Husbandry, MARD, 2006

GHG emissions from agriculture are presented in Table 2.11 and Figure 2.4.

Table 2.11. GHG emissions from agriculture

Unit: thousand tonnes

Sub-sector	CH_4	N_2O	CO	NOx	CO_2e	Percentage
Enteric fermentation	368.12				7,730.52	11.9
Manure management	164.16				3,447.36	5.3
Rice cultivation		1,782.37			37,429.77	57.5
Agricultural soils		45.87			14,219.70	21.8
Burning of savannas	9.97	1.23	261.71	4.46	590.67	0.9
Burning of agricultural residues	59.13	1.39	1,214.68	50.28	1,672.63	2.6
Total	**2,383.75**	**48.49**	**1,476.39**	**54.74**	**65,090.65**	**100**

The total amount of GHG emissions from agriculture was 65,090.7 thousand tonnes of CO_2e. Rice cultivation emitted 37,430 thousand tonnes of CO_2e, equal to 57.5%,

agricultural soils mitted 14,220 thousand tonnes of CO_2e, or 21.8%, enteric fermentation produced 7,731 thousand tonnes of CO_2e, or 11.9%, and fertilizer management emitted 3,447 thousand tonnes of CO_2e, or 5.3% of the total amount.

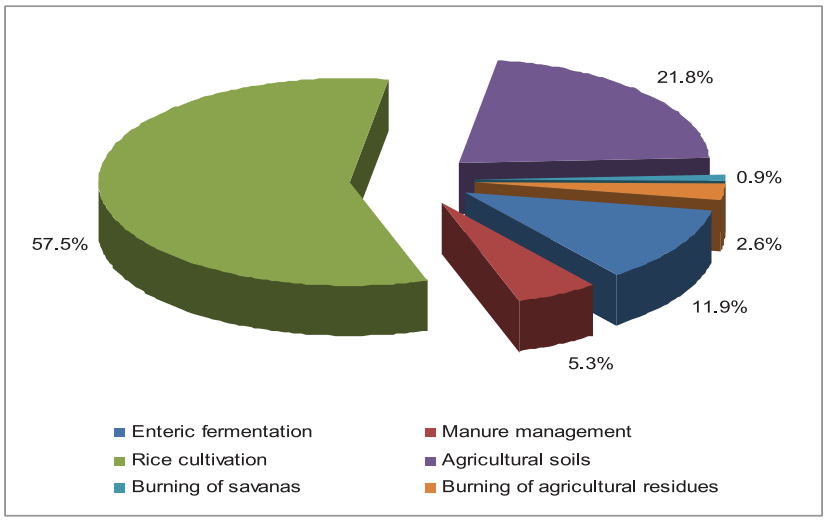


Figure 2.4. GHG emissions from agriculture in 2000

2.2.4. Land use, land-use change and forestry

GHG emissions/removals in LULUCF are the results of changes in forest and biomass stocks, land use, land-use change and CO_2 emissions from soils.

Forest area and forest soil types used for the 2000 GHG inventory are presented in Table 2.12.

Table 2.12. Forest areas and forest land types in 2000

Type of forest	Area (kha) A	Annual average biomass growth rate (tdm/ha/year) B
I. Forest area (= A+B)	**11,516**	
A. Natural forest (= 1+2+3+4+5)	**9,677**	
1. Woody	7,925	4.00
2. Bamboo	721	2.00
3. Mixed	514	3.00
4. Mangrove	80	3.60
5. Rocky	437	1.50
B. Planted forest (= 1+ 2+ 3+4+5+6+7)	**1,839**	
1. Eucalyptus	348	6.75
2. Acacia	228	8.45
3. Indigo	114	3.50
4. Mangrove	80	4.00
5. Pine	218	5.00
6. Others	778	5.00
7. Bamboo	73	2.00
II. Savannah (= 1+2+3+4)	**7,898**	
1. Grassland	590	1.25
2. Shrub	5,056	1.25
3. Regenerated timber	1,822	1.50
4. Rocky	430	0.05
III. Scattered plants (million trees)	**352**	

Source: Statistical Yearbook 2000, General Statistics Office of Viet Nam, 2001

Statistical Yearbook 2005, General Statistics Office of Viet Nam, 2006

Natural forests comprised 84% of the total 11.5 million ha of national forested area, while planted forests accounted for 16% equivalent to a 33.2% coverage.

Currently, Viet Nam's forests are under pressure from:

- Degradation due to inefficient logging and timber production technologies.
- Illegal logging.
- Competition between agricultural and forestry production, resulting in the degradation of forest quality and conversion of forest land to agricultural purposes.
- Forest fires.

Land-use change data for 2000 are given in Table 2.13.

Table 2.13. Land- use change - CO_2 emissions from biomass in 2000

Forest and forest soil	Area (thousand hectares)	Biomass before conversion (tdm/ha)	Biomass after conversion (tdm/ha)
Total (A+B)	**200**		
A. Natural forest	**55**		
Woody	5	500	15
Bamboo	20	100	5
Mixed	10	200	10
Mangrove	20		
B. Savannah	**145**		
Grassland	20	35	2
Shrub	100	50	5
Regenerated timber	25		

Sources: - National Monitoring and Assessment of Forest Resources Change 2000-2005, Forest Inventory and Planning Institute, MARD, 2006
- Forest Protection Department, MARD, 2002
- Report on the Growth of Several Natural Forest Plant Species, Forest Inventory and Planning Institute, MARD, 1998

The results of GHG emissions from LULUCF are presented in Table 2.14.

Table 2.14. GHG emissions from LULUCF in 2000

Unit: thousand tonnes

Source/sink	Emissions of CO_2	Removals of CO_2	CH_4	N_2O	CO_2e
Changes in forest and other woody biomass stocks	0	- 49,830.18			-49,830.18
Forest and grassland conversion	40,665.17		140.3	0.96	43,909.70
Abandonment of Managed Lands	0	- 7,330.33			-7,330.33
CO_2 uptake/ emission from soils	46,943.75	-18,588.22			28,355.53
Total	**87,608.92**	**-75,748.73**	**140.3**	**0.96**	**15,104.72**

Total GHG emissions from LULUCF in 2000 were 15,104.7 thousand tonnes of CO_2e, including 11,860.2 thousand tonnes of CO_2, 140.3 thousand tonnes of CH_4 and 0.96 thousand tonnes of N_2O.

2.2.5. Waste

Each year, Viet Nam produces over 15 million tonnes of waste from various sources with urban areas and businesses contributing approximately 80% of the total mass. Industry, the second largest source, generates over 2.6 million tones of waste annually, accounting for 17% of the yearly total.

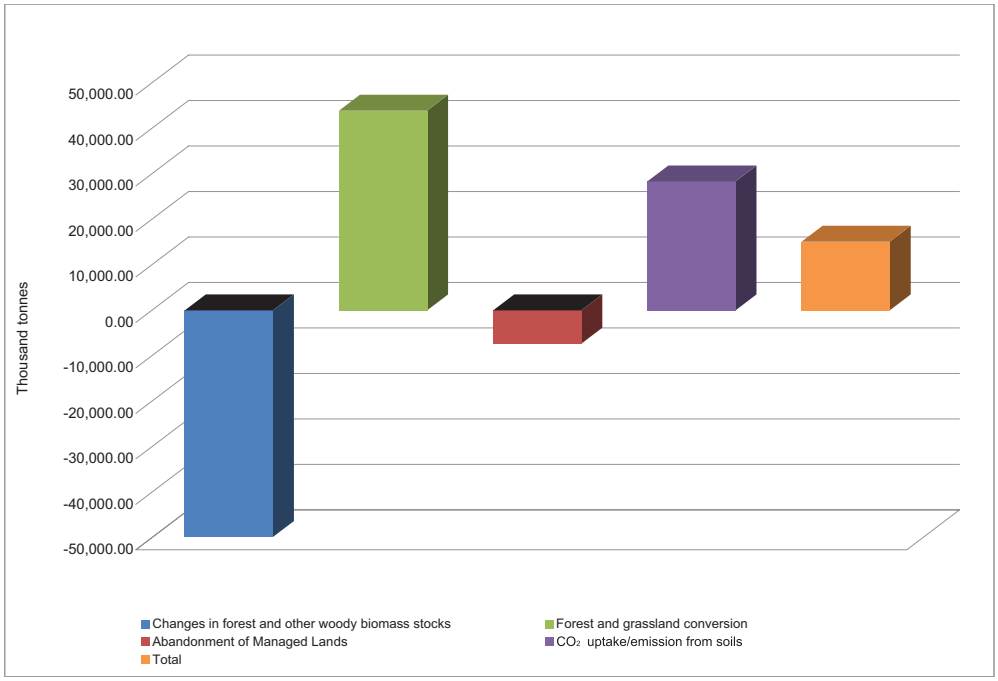


Figure 2.5. GHG emissions from LULUCF in 2000

Waste collection has been improving in the cities. On average, 71% of waste is collected in urban areas whereas the corresponding figure is no more than 20% in rural areas.

An overview of solid waste management during the period 2000-2004 is shown in Table 2.15.

Table 2.15. Overview of solid waste management in Viet Nam

Residential waste (tonnes/year)	
Nationwide	12,800,000
Municipal	6,400,000
Rural	6,400,000
Hazardous waste generated from industrial sites (tonnes/year)	128,400
Non-hazardous waste generated from industrial sites (tonnes/year)	2,510,000
Hazardous medical waste (tonnes/year)	21,000
Hazardous agricultural waste (tonnes/year)	8,600
Amount of stored agricultural chemical (tonnes)	37,000
Waste generation per capita (kg/cap/day)	
Nationwide	0.4
Municipal	0.7
Rural	0.3
Waste collection (percentage of the total waste generation)	
Urban	71%
Rural	<20%
Other	10 - 20%
Medical waste management capacity (percentage of the total)	50%

Source: Viet Nam Environmental Change Report 2000-2004, Ministry of Natural Resources and Environment, 2004

Estimations for GHG emissions from waste are presented in Table 2.16.

Table 2.16. GHG emissions from waste in 2000

Unit: thousand tonnes

Sub-sector	CH_4	N_2O	CO_2e	Percentage
Solid waste	266.52		5,596.92	70.6
Wastewater	1.35		28.35	0.4
Industrial wastewater	63.61		1,335.81	16.8
Human waste		3.11	964.10	12.2
Total	**331.48**	**3.11**	**7,925.18**	**100**

Total GHG emissions from waste in 2000 is 7,925.18 thousand tonnes of CO_2e, consisting of 331.48 thousand tonnes of CH_4 and 3.11 thousand tonnes of N_2O.

With 5,597 thousand tonnes of CO_2e, solid waste was the largest source of GHG emission from waste, accounting for 70.6% of the total. Industrial wastewater was the second largest contributing source at 16.8% with 1,336 thousand tonnes of CO_2e. Finally, human waste and wastewater contributed 964 thousand tonnes of CO_2e and 28.4 thousand tonnes of CO_2e, respectively.

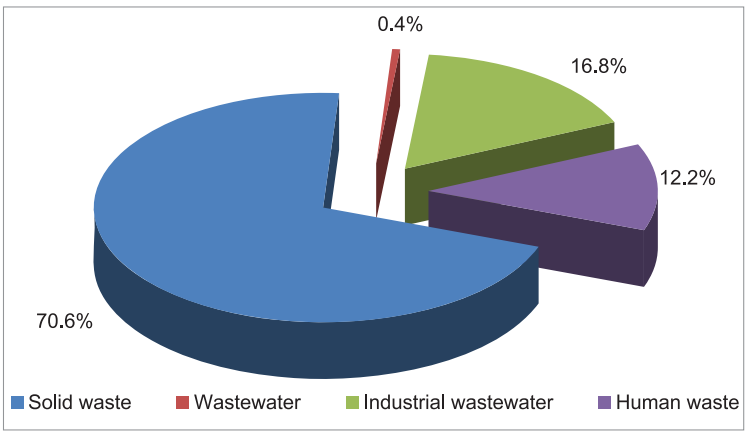


Figure 2.6. GHG emissions from waste in 2000

2.2.6. Summary of the national GHG inventory for the year 2000

2.2.6.1. GHG emissions by sector

The overall GHG emission estimates for the year 2000 totalled 150,899.7 thousand tonnes of CO_2e. Agriculture was the largest source of emissions with 65,090.7 thousand tonnes of CO_2e, accounting for 43.1%, followed by energy with 52,773.5 thousand tonnes of CO_2e or 35%, and LULUCF with 10% at 15,104.7 thousand tonnes of CO_2e. Industrial processes and waste produced 10,005.7 thousand tonnes of CO_2e (6.6%) and 7,925.2 thousand tonnes of CO_2e (5.3%), respectively.

The results of national GHG inventory by sector are summarized in Table 2.17 and Figure 2.7.

Table 2.17. National GHG inventory by sector in 2000

Unit: thousand tonnes

Sector	CO_2	CH_4	N_2O	CO_2e	Percentage
Energy	45,900.00	308.56	1.27	52,773.46	35.0
Industrial processes	10,005.72	0	0	10,005.72	6.6
Agriculture	0	2,383.75	48.49	65,090.65	43.1
LULUCF	11,860.19	140.33	0.96	15,104.72	10.0
Waste	0	331.48	3.11	7,925.18	5.3
Total	67,765.91	3,164.12	53.83	150,899.73	100

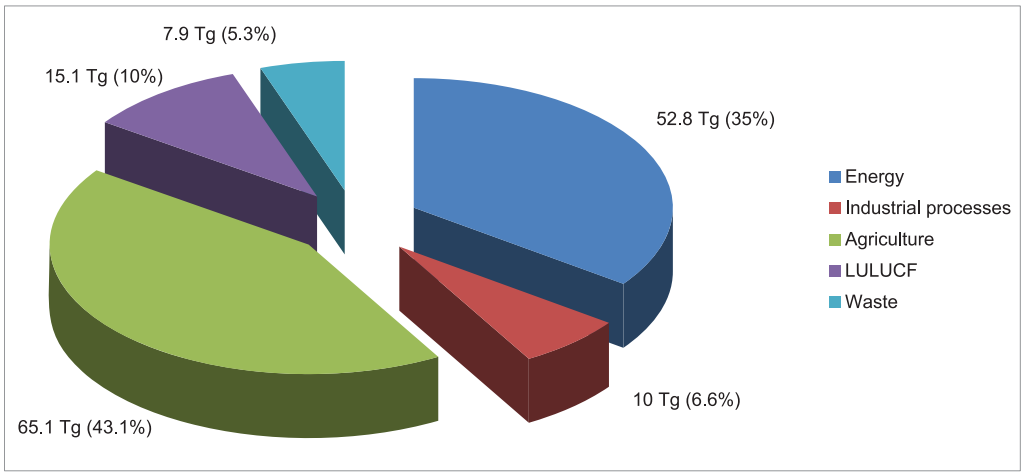


Figure 2.7. GHG emissions by sector in 2000 in CO_2e

2.2.6.2. GHG emissions by gas

Table 2.18 and Figure 2.8 summarize the results of the national GHG inventory. Estimated emission for CO_2 is 67,765.9 thousand tonnes, CH_4 is 66,446.1 thousand tonnes of CO_2e, and N_2O is 16,687 thousand tonnes of CO_2e. The respective shares of total emission for each type of greenhouse gas are 44.9%, 44% and 11.1%. 75-80% of the combined emissions of CH_4 and N_2O were from agriculture, while 70% of CO_2 were emitted from energy.

Table 2.18. Emissions by GHG type in 2000

GHG	Emissions (thousand tonnes)	GWP	Thousand tonnes	Percentage of CO_2e
CO_2	67,765.91	1	67,765.91	44.9
CH_4	3,164.12	21	66,446.52	44.0
N_2O	53.83	310	16,687.30	11.1
Total	**70,983.86**		**150,899.73**	**100**

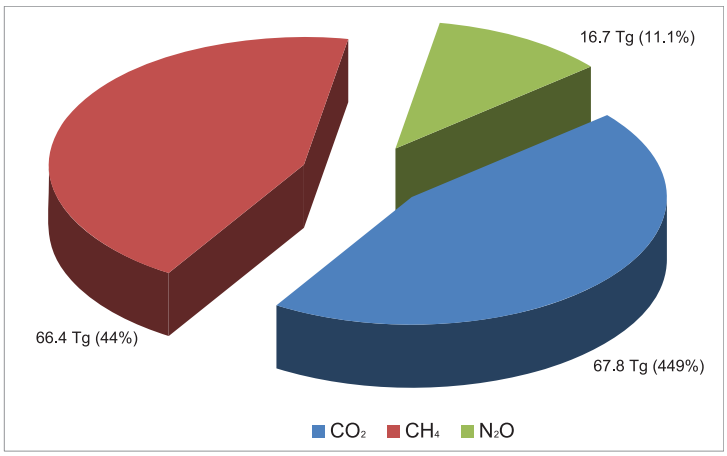


Figure 2.8. GHG emissions by gas in CO_2e

Table 2.19. GHG emissions by sector, in 1994 and 2000

Unit: thousand tonnes of CO_2e

Year	1994		2000	
Sector	Emissions	Percentage	Emissions	Percentage
Energy	25,637.09	24.7	52,773.46	35.0
Industrial processes	3,807.19	3.7	10,005.72	6.6
Agriculture	52,450.00	50.5	65,090.65	43.1
LULUCF	19,380.00	18.6	15,104.72	10.0
Waste	2,565.02	2.5	7,925.18	5.3
Total	**103,839.30**	**100**	**150,899.73**	**100**

Source: Viet Nam Initial National Communication, 2003

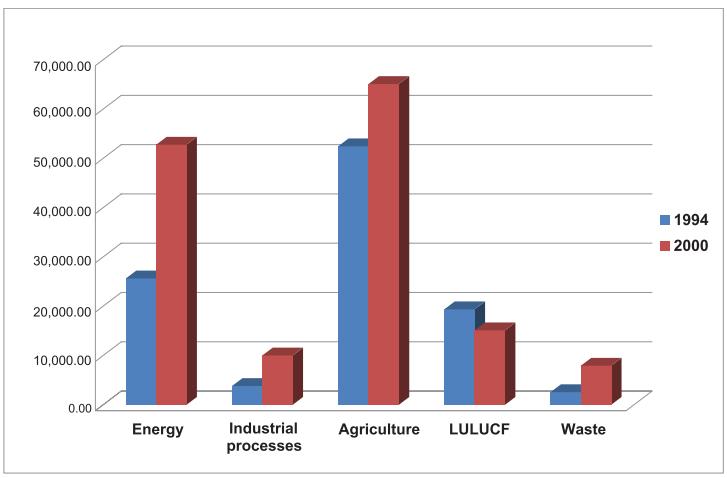


Figure 2.9. GHG emissions by sector, in 1994 and 2000

The results of national GHG inventory in 2000 show that the total GHG emissions at about 150.9 million tonnes of CO_2e was an increase of nearly 1.5 times over 1994 levels. Emission from energy increased two-fold from 25.6 million tonnes of CO_2e to 52.8 million tonnes of CO_2e. However, emissions from LULUCF declined from 19.4 million tonnes of CO_2e to 15.1 million tonnes of CO_2e (Table 2.19)

Per capita GHG emission in 2000 was 1.94 tonnes of CO_2e and constitutes a 0.47 tonnes of CO_2e increase from 1994 levels.

The national GHG inventory was conducted in accordance with the guidelines on GHG inventories of IPCC.

Activity data is the basic input for GHG emission estimations. The process of collecting data for emission sources remains challenging and poses limitations on data quality, particularly in agriculture and LULUCF.

2.2.7. Uncertainty

Methodology: The methodology provided in 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used to calculate uncertainty levels in the national GHG inventory. Tier 1 approach was chosen in consultation with experts.

Table 2.20. Results of uncertainty assessment of 1994 and 2000 national GHG inventories and emission trends

	1994	2000
Total emissions (thousand tonnes of CO_2e)	103,839	150,900
Contribution to uncertainty variance by category	396.5	221.6
Emissions variance (thousand tonnes of CO_2e)	± 20,672	± 22,465
Uncertainty (%)	19.9	14.9
Total emissions with uncertainty (thousand tonnes of CO_2e)	103,839 ± 20,672	150,900 ± 22,465
Emission trends uncertainty for 1994-2000 (%)	**19.5** (2000: ± 9,162 thousand tonnes of CO_2e)	

Source: Viet Nam Initial National Communication, 2003

The uncertainty level for national GHG inventory for 2000 was estimated at 14.9%, while it was 19.9% in 1994. Emission variance for 2000 was about ±22.5 thousand tonnes of CO_2e. Emission trends uncertainty for 1994-2000 period was 19.5%.

2.2.8. Analysis of main GHG emission sources and sinks

The GPG Tier-1 approach analyzes the impacts of the main sources and sinks of emissions on GHG levels and trends. Based on GHG inventory results from 1994 and 2000, emission levels and trends were assessed. Subsequently, the 14 main sources and sinks of emissions in Viet Nam's National GHG inventory in 2000 were determined as follows:

- Energy: manufacturing industries and construction, transportation, energy industries, oil and natural gas extraction.

- Industrial processes: cement production, steel production.

- Agriculture: wet rice cultivation, enteric fermentation, agricultural soils.

- LULUCF: changes in forest and other woody biomass stocks, land conversion, abandonment of managed land.

- Waste: solid waste.

2.3. Projected emissions from main sources for 2010, 2020 and 2030

Based on the results of the 2000 national GHG inventory, the primary GHG sources and sinks for Viet Nam are: energy, agriculture and LULUCF. Thus GHG emission projections for 2010, 2020 and 2030 were made for the above-mentioned three sectors.

2.3.1. Data

Based on the medium economic development scenario, projections of energy demand, sectoral GDP growth rate, GDP contribution by sector, population growth rate, forest coverage and forest land, population of cattle and agricultural land area in 2010, 2020 and 2030 are shown in Tables 2.21 to 2.27.

Table 2.21. End- use energy demand projections for 2010, 2020 and 2030

Unit: KTOE

Sector	2010	2020	2030
Industry	14,176	27,846	48,556
Transportation	9,404	16,317	29,088
Agriculture	738	905	1,112
Residential	16,874	23,648	37,175
Commercial/institutional	2,346	5,416	9,895
Total	**43,538**	**74,131**	**125,825**

Source: LEAP model output

Table 2.22. Sectoral GDP growth projections

Unit: %

Sector	2011 - 2020	2021 - 2030
GDP growth	**7.2**	**7.0**
Of which		
Industry	8.2	7.5
Agriculture	3.0	2.5

Source: Ministry of Planning and Investment, 2005

Table 2.23. Projected structure of GDP by sector

Unit: %

Sector	2010	2020	2030
GDP	**100**	**100**	**100**
Of which			
Industry	44.7	47.8	48.7
Agriculture	17.3	12.5	8.7

Source: Ministry of Planning and Investment, 2005

Table 2.24. Population growth projections

Unit: %

Period	Growth rate
2010 - 2020	1.0
2020 - 2030	0.7

Source: National Committee for Population and Family Planning, 2005

Table 2.25. Projected forest coverage and forest land area

Unit: million ha

Forest type	2010	2020	2030
Natural forest	9.7	9.7	9.7
Planted forest	1.9	4.4	4.8
Savannah	3.4	1.0	0.2
Total	11.6	14.1	14.5

Source: Forest Inventory and Planning Institute, MARD, 2009

Table 2.26. Livestock number projections

Unit: million heads

Breed	2010	2020	2030
Beef cattle	7.8	12.5	13.5
Dairy cattle	0.2	0.5	0.7
Buffalo	2.9	2.9	2.9
Pig	29.9	34.8	49.0

Source: Ministry of Agriculture and Rural Development, 2006

Table 2.27. Projected agricultural land areas

Unit: million ha

Crop type	2010	2020	2030
Rice	7.1	6.8	6.6
Maize	1.2	1.5	1.6
Sweet potato	0.3	0.3	0.3
Cassava	0.3	0.3	0.3

Source: Ministry of Agriculture and Rural Development, 2006

2.3.2. Greenhouse gas emission projections for 2010, 2020 and 2030

Total emissions from the three principle emitting sectors are projected at 169.2 million tonnes of CO_2e in 2010, increasing to 300.4 million tonnes of CO_2e in 2020 to reach 515.8 million tCO_2e in 2030. Energy is projected to be the largest source, with 470.8 million tonnes of CO_2e, comprising 91.3% of total emissions in 2030 (Table 2.28 and Figure 2.10).

Table 2.28. GHG emission projections for 2010, 2020 and 2030

Unit: million tonnes of CO_2e

Sector	2010	2020	2030
Energy	113.1	251.0	470.8
Agriculture	65.8	69.5	72.9
LULUCF	-9.7	-20.1	-27.9
Total	169.2	300.4	515.8

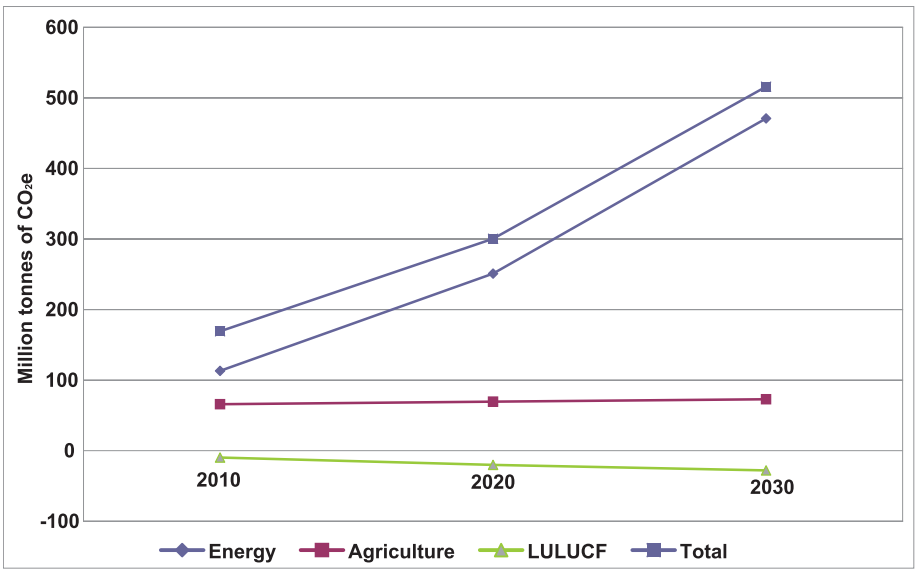


Figure 2.10. GHG emission projections 2010-2030

CHAPTER 3
CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

3.1. Climate change manifestation and climate change scenarios for Viet Nam

3.1.1. Climate change manifestation

Temperature: Over the past 50 years, (1958-2007), annual average temperatures increased by about 0.5 to 0.7^{o}C. Temperatures for winters and northern climate zones increased at faster rates compared to summers and southern climate zones, respectively (Figure 3.1)

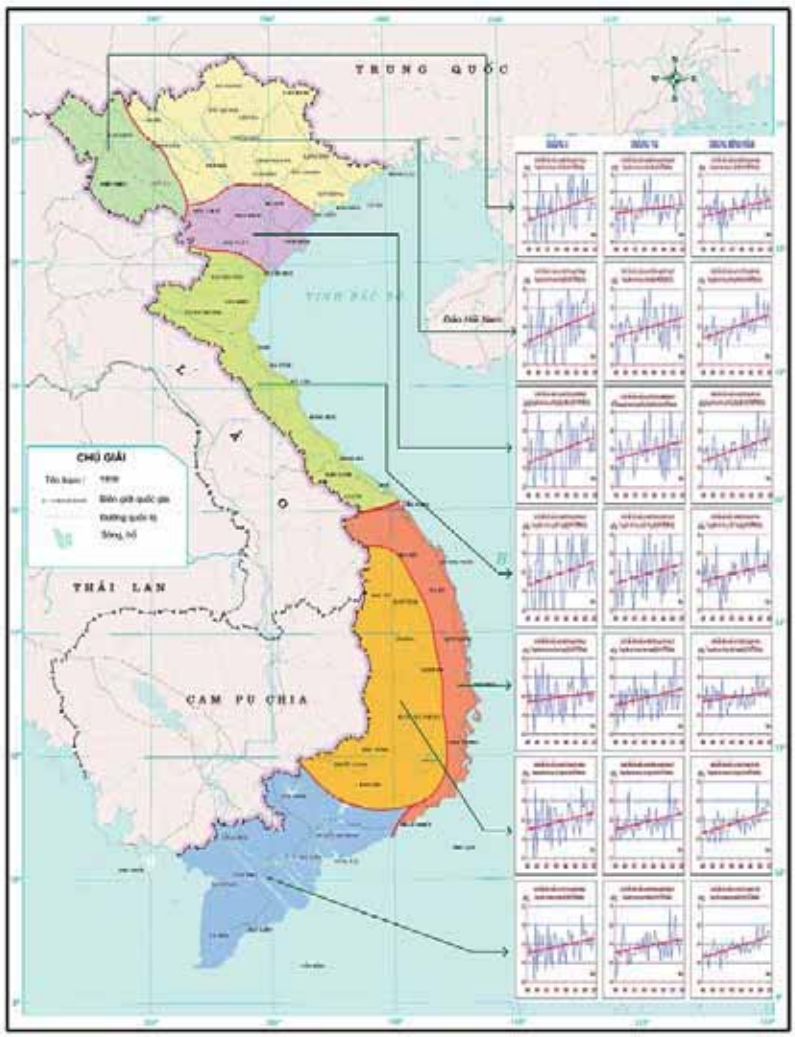


Figure 3.1. Temperature trends

Rainfall: Annual average precipitation over the last nine decades (1911-2000) does not show a clear trend across regions and time periods. Instead, both upward and downward trends can be seen. Northern climate zones have seen a decrease in annual rainfall, in contrast to southern zones (Figure 3.2). On a country-wide basis, average precipitation fell by 2% during the last fifty-year period (1958-2007).

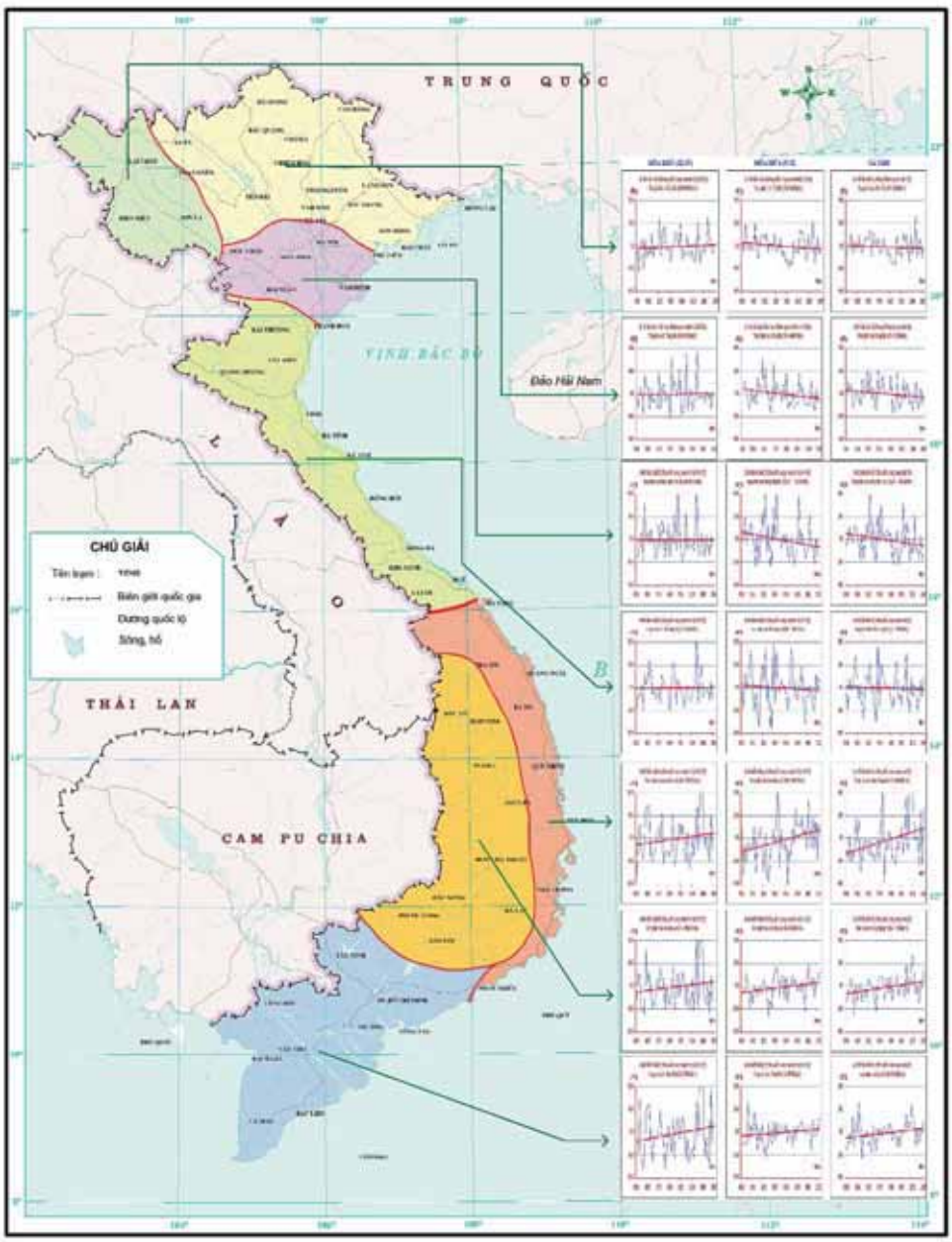


Figure 3.2. Rainfall trends

Cold fronts: The number of cold fronts affecting Viet Nam has decreased significantly over the last two decades. However, anomalous events have occurred more frequently recently, with most notably the damaging cold surge which lasted for 38 days in the North of Viet Nam during January and February 2008.

Typhoons: In recent years, typhoons with higher intensity tend to occur more frequently. Typhoon tracks show signs of moving southwards, with abnormal movements while storm seasons tend to end later (Figure 3.3).

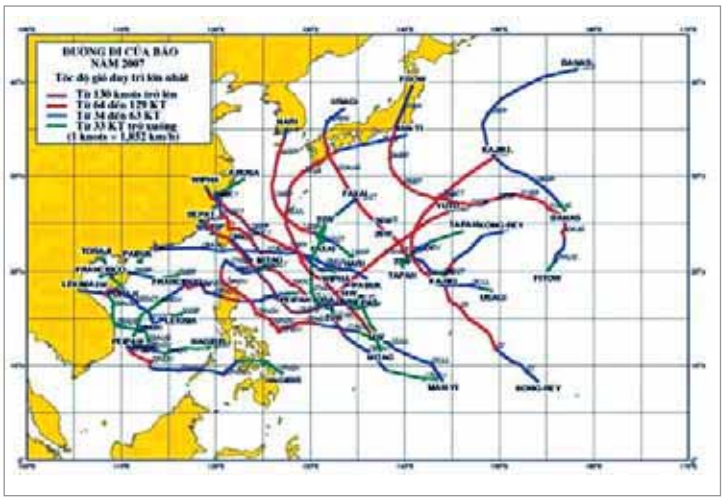


Figure 3.3. West Pacific Ocean typhoon tracks in 2007

Sea level: Observations by tidal gauges along the coastline of Viet Nam show that the mean sea level rose at a rate of 3 mm per year (during 1993-2008). Over the past fifty years, sea level at Hon Dau Oceanographical station has increased by about 20 cm (Figure 3.4).

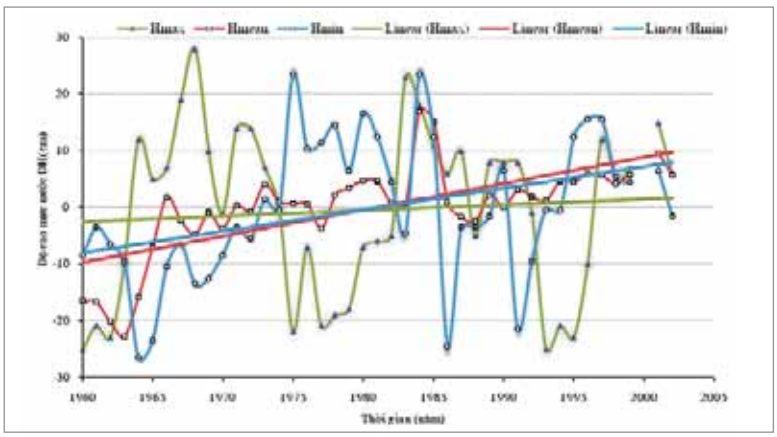


Figure 3.4. Sea level changes at Hon Dau Oceanographical station

3.1.2. Climate change scenarios

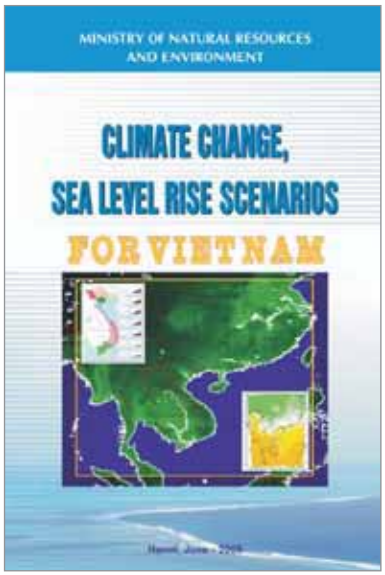
Climate change scenarios for Viet Nam were developed using the coupled method (MAGICC/SCENGEN 5.3) as well as the statistical downscaling method, and are based on emission scenarios in IPCC's Fourth Assessment Report, namely the high emission scenario (A2[1]), the low emission scenario (B1[2]) and the medium emission scenario (B2[3]).

(1) A2 family scenario: A very heterogeneous world; self-reliance and preservation of nations; continuously increasing population in the 21st century; regionally-oriented economic development; technological change and per capita economic growth are more fragmented and slow (high emission scenario).

(2) B1 family scenario: Rapid economic growth, but with rapid changes towards a service and information economy; global population reaches the peak in 2050 and declines thereafter; reductions in material intensity and the introduction of clean and resource-efficient technologies; the emphasis on global solutions to economic, social and environmental sustainability (low emission scenario).

(3) B2 family scenario: Continuously increasing population, but at a rate lower than A2; the emphasis is on local rather global solutions to economic, social and environmental sustainability; intermediate levels of economic development; less rapid and more diverse technological change than in B1 family (medium emission scenario).

The scenarios, which focus on temperature and rainfall changes, were developed for Viet Nam's seven climate zones: Northwest, Northeast, North Delta (Red River Delta), North Central Coast, South Central Coast, Central Highlands and the South Delta (Mekong River Delta). The baseline period is 1980-1999. However, the application of the MAGICC/SCENGEN 5.3 model in the development of climate change scenarios, which produces low-resolution grid maps (300 by 300 km), has a number of limitations as it is unable to accurately reflect the local specificities of climate change in Viet Nam. "Climate Change, Sea-Level Rise Scenarios for Viet Nam" with temperature, rainfall and sea level projections for the 21st century, was published in 2009.



Increases in temperature, rainfall and sea-level rise relative to the 1980-1999 baselines for the three climate change scenarios are presented in Table 3.1.

3.1.2.1. Temperature

Winter temperatures are likely to increase faster than summer temperatures in all climate zones. Temperatures in northern zones are projected to rise at a faster rate than southern ones.

By 2020, according to the three low, medium and high climate change scenarios, annual mean temperatures for four northern climate zones are projected to increase by 0.5°C relative to the 1980-1999 level by 2020. The remaining three southern climate zones are set to experience a smaller increase of 0.3 to 0.4°C.

By 2050, annual mean temperatures for northern climate zones are projected to increase by 1.2 to 1.3°C, with the exception of the North Central zone where temperatures may rise by 1.4-1.5°C. In contrast, southern climate zones are likely to experience a smaller increase in temperature of about 0.8-1.0°C.

By the end of the 21st century, differences in temperatures between climate zones and scenarios are set to be much more pronounced (Table 3.1). Indeed, in northern climate zones, according to the low scenario, annual mean temperatures are projected to be 1.6 to 1.9°C higher than in 1980-1999. In the medium scenario, temperatures are likely to increase by 2.4 to 2.6°C, except for the North Central zone with more than 2.8°C. In the high scenario, temperature increases are between 3.1 and 3.3°C in most zones, but up to 3.6°C for the North Central zone (Table 3.1).

From the South Central zone and southwards, the low scenario estimates that the increase in annual mean temperatures will be 1.2 to 1.4°C over 1980-1999 levels. The medium scenario projects a rise of 1.9 to 2.0°C while, for the high scenario, the increase is from 2.4 to 2.6°C (Table 3.1).

3.1.2.2. Rainfall

By 2020, all three scenarios project increases in total annual rainfall of 1.4 to 1.8% for

northern climate zones and 0.3 to 0.7% for southern climate zones over 1980-1999 levels.

By 2050, rainfall will have increased by 3.6 to 4.1% in northern climate zones, but only by 0.7 to 1.7% in the South Central zone and further south.

By 2100, annual rainfall in northern climate zones is projected to increase by 4.8 to 5.2% in the low scenario, 7.3 to 7.9% in the medium scenario and 9.3 to 10.1% in the high scenario. From the South Central zone and southwards, the increase will be smaller, averaging 1.0 to 3.2% in the low and medium scenarios and 1.8 to 4.1% in the high scenario (Table 3.1).

Rainfall is projected to decrease during the dry season in almost every zone, most markedly in the south. In the rainy season, rainfall is likely to increase in all zones. Overall, total annual rainfall is set to increase throughout the country.

3.1.2.3. Sea-level rise

According to the B1, B2 and A1F1[4] scenarios, sea level may rise 28 to 33 cm by the mid-21st century and 65 to 100 cm by the end of the 21st century above 1980-1999 levels (Table 3.1).

Table 3.1. Increases in temperature, rainfall and sea level according to the three climate change scenarios, compared to 1980- 1999

Element	Year / Climate zone	2020			2050			2100		
Temperature (°C)	Scenario	B1	B2	A2	B1	B2	A2	B1	B2	A2
	Northwest	0.5	0.5	0.5	1.2	1.3	1.3	1.7	2.6	3.3
	Northeast	0.5	0.5	0.5	1.2	1.2	1.3	1.7	2.5	3.2
	Red River Delta	0.5	0.5	0.5	1.2	1.2	1.3	1.6	2.4	3.1
	North Central Coast	0.5	0.5	0.6	1.4	1.5	1.5	1.9	2.8	3.6
	South Central Coast	0.4	0.4	0.4	0.9	0.9	1.0	1.2	1.9	2.4
	Central Highlands	0.3	0.3	0.3	0.8	0.8	0.8	1.1	1.6	2.1
	Mekong River Delta	0.4	0.4	0.4	1.0	1.0	1.0	1.4	2.0	2.6
Rainfall (%)	Northwest	1.4	1.4	1.6	3.6	3.8	3.7	4.8	7.4	9.3
	Northeast	1.4	1.4	1.7	3.6	3.8	3.8	4.8	7.3	9.3
	Red River Delta	1.6	1.6	1.6	3.9	4.1	3.8	5.2	7.9	10.1
	North Central Coast	1.5	1.5	1.8	3.8	4.0	3.7	5.0	7.7	9.7
	South Central Coast	0.7	0.7	0.7	1.6	1.7	1.7	2.2	3.2	4.1
	Central Highlands	0.3	0.3	0.3	0.7	0.7	0.7	1.0	1.4	1.8
	Mekong River Delta	0.3	0.3	0.3	0.7	0.8	0.7	1.0	1.5	1.9
Sea-level rise (cm)	Scenario	B1	B2	A1F1	B1	B2	A1F1	B1	B2	A1F1
	All climate zones	11	12	12	28	30	33	65	75	100

Source: Ministry of Natural Resources and Environment, 2009

(4) A1 family: Rapid economic growth; global population peaks at 9 billion in 2050 and declines thereafter; rapid introduction of new and more efficient technologies; a convergence of world-income and way of life, a convergence among regions and increased cultural and social interactions.
A1F1 group: Fossil-fuel intensive technological emphasis (high emission scenario).

3.2. Impacts on water resources

Impacts of climate change on river flow regimes

Climate change will impact river stream flow volumes and temporal and spatial distribution. The impacts of climate change on annual flows, flood flows and low flows in the future were assessed based on the rainfall-flow model and the above-mentioned climate change scenarios.

Annual flows

Climate change impacts on annual flows vary from one region/river system to another across Viet Nam's territory. According to the medium climate change scenario B2, annual stream flows in the Red River Delta and northern North Central region will trend towards increases under 2% for 2040-2059 and between 2 and 4% for 2080-2099.

By contrast, annual flows for regions south of the North Central region to the northern South Central region and the Southeast (Dong Nai River system) will trend towards varying decreases, slightly below 2% for the Thu Bon and Ngan Sau Rivers, but significantly higher at 4 to 7% for the Dong Nai and Be River systems for 2040-2059 and 7 to 9% for 2080-2099 (Table 3.2).

Studies conducted by the Mekong River Commission project the annual flows for the Mekong River at Kratie, which is the main water supply for the Mekong River Delta, to rise by 4 to 6% between 2010-2050, relative to 1985-2000, for scenario B2.

Table 3.2. Average annual flow variations for major rivers under the medium scenario B2

Station	River	Annual flows period 1980 - 1999	Annual flows period 2040 - 2059		Annual flows period 2080 - 2099	
		m^3/s	m^3/s	Increase (%) above the 1980 -1999 level	m^3/s	Increase (%) above the 1980 -1999 level
Ta Bu	Da	1,539.00	1,550.00	0.79	1,579.00	2.81
Yen Bai	Thao	711.00	717.00	0.74	728.00	2.07
Vu Quang	Lo	1,076.00	1,089.00	1.36	1,108.00	3.21
Chiem Hoa	Gam	384.00	391.00	1.75	396.00	3.03
Son Tay	Hong	3,315.00	3,483.00	0.68	3,559.00	2.95
Gia Bay	Cau	54.40	55.00	0.94	56.00	2.49
Dua	Ca	423.11	430.61	1.77	439.32	3.83
Nghia Khanh	Hieu	132.16	134.67	1.90	136.93	3.61
Hoa Duyet	Ngan Sau	112.84	111.97	-0.77	111.64	-1.06
Nong Son	Thu Bon	276.63	273.33	-1.73	267.86	-1.19
Cung Son	Ba	279.71	292.11	4.43	294.11	5.15
Ta Lai	Dong Nai	349.00	335.00	-4.01	323.30	-7.36
Ta Pao	La Nga	77.23	74.13	-4.01	71.93	-6.86
Phuoc Hoa	Be	227.58	210.78	-6.94	206.98	-9.05

Source: Institute of Meteorology, Hydrology and Environment, MONRE, 2010

Flood flows

Flood flows for most rivers are generally projected to rise by 2 to 4% for 2040-2059 and 5 to 7% for 2080-2099, albeit with a wide degree of variations between rivers.

Flood flows for Thu Bon and Ngan Sau Rivers are likely to rise by less than 2% for 2040-2059 and below 3% for 2080-2099 (Table 3.3).

Dong Nai and Be River systems are projected to see decreasing flood flows by 2.5 to 6% and 4 to 8% for the same periods, respectively.

Relative to 1985-2000 levels, flood flows of the Mekong River at Kratie are projected to increase by 5 to 7% on average during 2010-2050.

Table 3.3. Flood flow variations for major rivers under the medium scenario B2

Station	River	Annual flows period 1980 - 1999	Annual flows period 2040 - 2059		Annual flows period 2080 - 2099	
		m^3/s	m^3/s	Increase (%) above the 1980 -1999 level	m^3/s	Increase (%) above the 1980 -1999 level
Ta Bu	Da	2,849.00	2,919.00	2.48	2,995.00	5.15
Yen Bai	Thao	1,203.00	1,247.00	3.65	1,289.00	7.15
Vu Quang	Lo	1,806.00	1,849.00	2.40	1,901.00	5.31
Chiem Hoa	Gam	676.00	695.00	2.72	712.00	5.22
Son Tay	Hong	6,041.00	6,191.00	2.48	6,408.00	6.07
Gia Bay	Cau	81.90	85.00	3.58	88.00	7.51
Dua	Ca	740.73	771.05	4.09	797.88	7.72
Nghia Khanh	Hieu	215.60	222.90	3.39	228.99	6.21
Hoa Duyet	Ngan Sau	192.68	195.81	1.63	198.49	3.01
Nong Son	Thu Bon	770.14	780.18	1.30	786.08	2.07
Cung Son	Ba	609.40	656.70	7.76	674.00	10.60
Ta Lai	Dong Nai	655.80	637.30	-2.82	617.00	-5.92
Ta Pao	La Nga	145.74	142.54	-2.20	139.84	-4.05
Phuoc Hoa	Be	433.52	406.72	-6.18	398.52	-8.07

Source: Institute of Meteorology, Hydrology and Environment, MONRE, 2010

Low flows

Climate change tends to reduce low flows with projected decreases of 2 to 9% for the dry season during 2040-2059 and 4 to 12% during 2080-2099 (Table 3.4)

However, the low flows for sections of the Mekong River at Kratie and Tan Chau do not show any clear trends.

Table 3.4. Low flow variations for major rivers under the medium scenario B2

Station	River	Annual flows period 1980 - 1999	Annual flows period 2040 - 2059		Annual flows period 2080 - 2099	
		m^3/s	m^3/s	Increase (%) above the 1980 -1999 level	m^3/s	Increase (%) above the 1980 -1999 level
Ta Bu	Da	604.00	572.00	-5.19	567.00	-5.98
Yen Bai	Thao	360.00	339.00	-5.76	328.00	-8.76
Vu Quang	Lo	556.00	547.00	-1.58	540.00	-2.74
Chiem Hoa	Gam	175.00	173.00	-0.81	170.00	-2.61
Son Tay	Hong	1,617.00	1,549.00	-4.24	1,523.00	-5.79
Gia Bay	Cau	23.00	22.00	-4.33	22.00	-6.68
Dua	Ca	196.24	187.45	-4.48	183.21	-6.64
Nghia Khanh	Hieu	72.56	71.64	-1.26	71.17	-1.91
Hoa Duyet	Ngan Sau	55.81	52.20	-6.67	49.61	-11.11
Nong Son	Thu Bon	112.13	104.39	-6.90	100.44	-10.42
Cung Son	Ba	114.72	109.62	-4.45	103.92	-9.41
Ta Lai	Dong Nai	129.93	120.93	-6.83	116.03	-10.70
Ta Pao	La Nga	28.30	23.20	-18.02	24.30	-14.13
Phuoc Hoa	Be	80.45	73.25	-8.95	71.15	-11.56

Source: Institute of Meteorology, Hydrology and Environment, MONRE, 2010

Impacts on evapotranspiration

According to the medium climate change scenario B2, annual levels of potential evapotranspiration are projected to increase by 7 to 10% for 2040-2059 and 12 to 16% for 2080-2099 over present levels. The South Central Coast and Mekong River Delta will see the highest potential evapotranspiration increase over the same periods at 10 to 13% and 18 to 22%, respectively (Table 3.5).

Table 3.5. Annual potential evapotranspiration under the medium scenario B2

Region	Potential evapotranspiration 1980 - 1999	Potential evapotranspiration 2040 - 2059		Potential evapotranspiration 2080 - 2099	
	mm	mm	Increase (%) above the 1980 -1999 level	mm	Increase (%) above the 1980 -1999 level
Northwest	1,292	1,379	6.75	1,440	11.49
Northeast	1,215	1,317	8.38	1,389	14.28
Red River Delta	1,204	1,306	8.53	1,378	14.52
Northe Central Coast	1,344	1,477	9.92	1,571	16.69
South Central Coast	1,536	1,732	12.89	1,870	21.96
Central Highlands	1,590	1,726	8.50	1,821	14.47
Mekong River Delta	1,418	1,552	10.62	1,646	18.09

Source: Institute of Meteorology, Hydrology and Environment, MoNRE, 2010

Impacts on groundwater table

Post-2020, groundwater table may decrease significantly due to overexploitation and decrease in groundwater recharge during the dry season. In the South, if river flow decreases by 15 to 20% in the dry season, the corresponding groundwater level may drop by 11 meters below current levels. The groundwater level may drop even lower in areas not subjected to tidal activities.

Adaptation measures

a) Formulate plans for sustainable water resources development of all river basins and regions based on the national social and economic development planning. Review the existing and build new hydrologic and hydropower reservoirs, dams, and dykes, taking into account the impacts of climate change.

b) Reinforce, upgrade, complete the existing structures and add new water resource infrastructure, including dams, reservoirs, drainage channel networks, irrigation systems, groundwater wells, and water tanks, etc., to improve operational efficiency and safety.

c) Reinforce and upgrade the existing system of river and sea dykes, flood diversion areas, flash flood relief channels, embankments for flood protection, and saltwater

intrusion barriers. Begin construction of new dykes and introduce new artificial drainage structures (pump stations) into low-lying plains and coastal flood-prone areas.

d) Promote water efficiency and conservation, and widely practice water-saving irrigation methods in agriculture, such as spray, and drip irrigation.

e) Upgrade and modernize the observation and long-range water resources forecasting network, seasonal and yearly forecasting for water resources and natural disasters (e.g. flooding, drought, salinity intrusion). Develop warning systems for flash floods and debris floods, with priority for mountainous areas in Northern and Central regions).

f) Raise public awareness on climate change impacts on water resources, improve water use efficiency and promote the protection of water resources.

Box 1:

A study on community-based adaptation measure to drought in the context of climate change in Ninh Thuan province, 2007.

The study provides an in-depth assessment of drought impacts on production and life in the driest areas of Ninh Thuan province (particularly An Hai village, Ninh Phuoc District, and Phuoc Thanh village, Bac Ai District) in the South Central Coast by analyzing the impact of drought on cultivation, stock breeding and aquaculture.

The main causes of the severe droughts in the region are the wide fluctuations in rainfall and increases in demand for water for crops, livestock and fish.

Several adaptation measures have been proposed:

- Develop drought-resistant crop seeds,

- Long-term adaptation measure: Set up groundwater irrigation systems with high-efficiency, water-conserving equipment. Provide new breeds, seed varieties and vaccines at preferential prices, and increase finance to communities to support their livelihood and support the natural resources that the communities rely on. Offer low-interest loans for drought control.

- Analyze and assign drought control responsibilities and missions at both central and provincial levels (including civil society organizations and NGOs).

- Strengthen community organizations by establishing or building upon social institutions like village Self-Help Groups (SHGs), women's groups, and village water sub-committees, set up commune seed banks/food credit coupon system, and promote better forest management and the prevention of forest fires.

Source: Drought-Management Considerations for Climate-Change Adaptation: Focus on the Mekong Region (Report Viet Nam) - Oxfarm in Viet Nam and Graduate School of Global Environmental Studies of Kyoto University, Japan, 2008

3.3. Impacts on coastal zones

Coastal zones damage assessment methodologies include the Geographical Information System (GIS), Flooding and Flood Risk (FFR) analysis, and Geographical Management System (GMS).

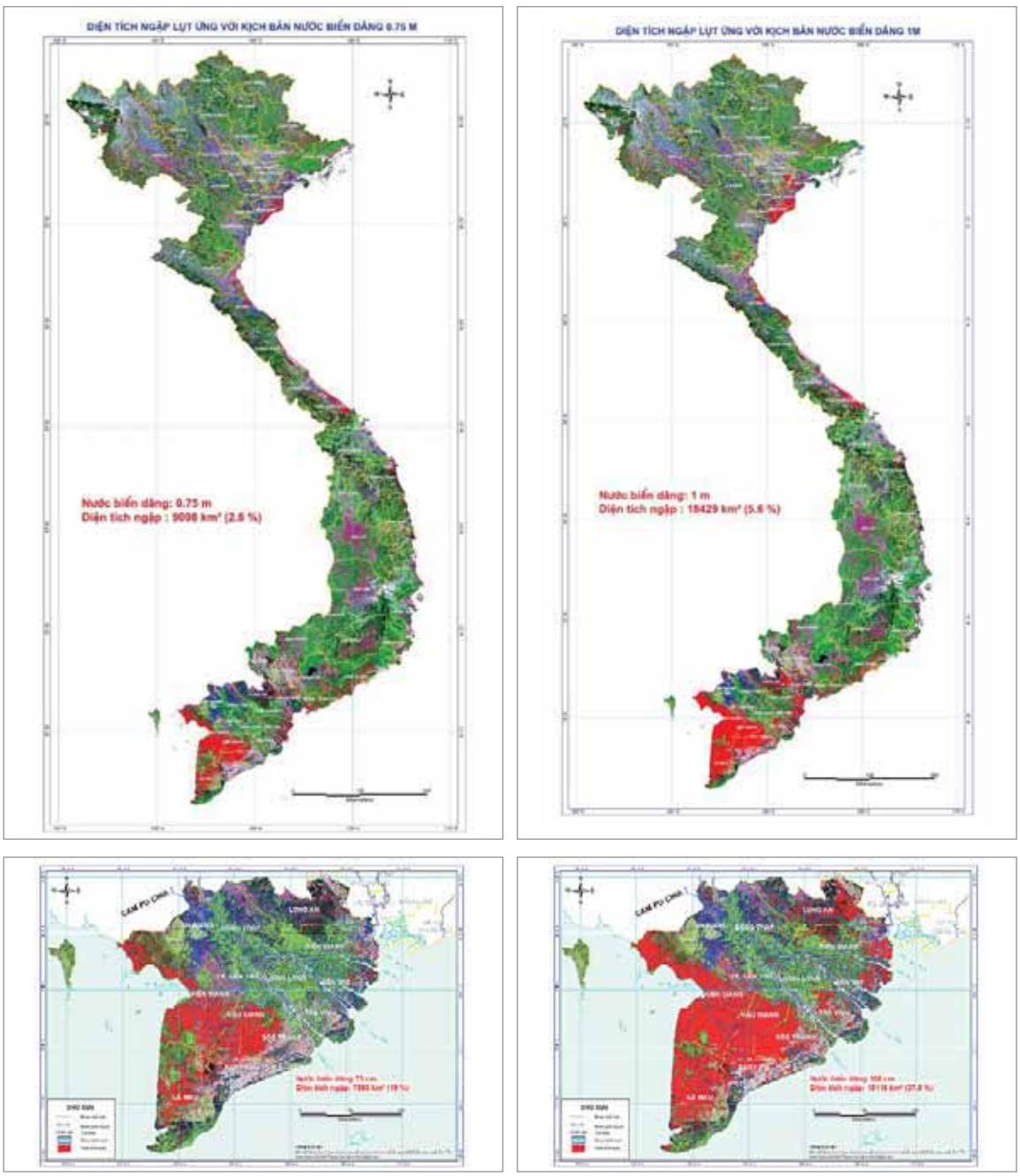


Figure 3.5. Flood area corresponding to 75 cm and 100 cm sea-level rise

Sea-level rise will increase flood area, intensity and duration

Recent research has indicated that a 45 cm rise in sea level would increase the annual flooded area to 18,346 km^2, affecting 44,210 km^2. A 100 cm rise in sea level would increase these figures to 40,000 km^2 and 56,000 km^2, respectively, with the worst affected area being the Mekong River Delta which would account for 90% of the national flooded area.

Rising sea levels may also lead to higher risks of salinization for freshwater rivers and aquifers, causing serious socio-economic damage. Coupled with increased storm intensity, the sea-level rise would additionally exacerbate coastal erosion.

Coastal ecosystems may be destroyed

Coral reef ecosystems are in danger of destruction. Reefs in shallow waters are most vulnerable to destruction by the concurrence of rising sea levels and strong storm waves.

Seagrass: Large disturbances to the living conditions of seagrass caused by storms and sea-level rise threaten the reproduction and development of seagrass ecosystems. In 1997, typhoon Linda swept away 20 to 30% of the Con Dao seagrass bed.

Lagoons: Lagoon environments are very vulnerable to severe floods and rising sea level. Rising lagoon water salinity causes damage to aquaculture infrastructure, and the disappearance of rivulets in lagoons with adverse impacts on local aquaculture and fishing activities.

Conservation areas: Viet Nam has 68 major wetlands and 15 marine conservation areas, 36 of which are set to be frequently flooded, 13 of these 36 will be severely inundated when sea level rises by 100 cm. Conservation areas such as U Minh Thuong National Park and Bac Lieu Natural Reserve will be completely submerged, thus affecting the conservation of endangered species in the area.

Impacts on mangrove forests

Sea-level rise will speed up mangrove-fringed shoreline and estuarine erosion and wash away mangrove swamps. Such was the case with mangrove forests east of Ca Mau, where many species lost their natural habitat.

Table 3.6. Forest flood areas for 100 cm sea-level rise

Unit: km^2

Region	Mangrove forest	Others forests
Mekong River Delta	207.5	25.7
Southeast	114.2	3.0
Total	321.7	28.7
Percentage of national mangrove forest cover	15.8	15.0

Source: Institute of Environmental Technology, Viet Nam Academy of Science and Environment, 2009

Table 3.6 shows the mangrove forest flooded area for a 100 cm rise in sea level in southern regions. A total of 300 km^2 would be inundated, corresponding to 15.8% of the total mangrove forest area.

Intertidal zones (or foreshores) will be more deeply submerged at high tide as a result of sea-level rise. This will consequently hinder the growth of mangrove trees, notably for species such as *Avicenna, Sonneratia alba* which can trap sediment and help increase sediment retention along the shorelines.

Sea-level rise damage assessment

By 2100, potential damages caused by the 65, 75, and 100 cm sea-level rises respectively have been assessed for the Central and Southern regions. The assessment used the (1) statistical synthesis and analysis, (2) GIS spatial analysis and (3) market and non-market economic losses quantification methods.

The assessment included economic losses to households, agricultural production, aquafarming, forestry, and infrastructure in directly affected coastal zones.

Average household loss due to flooding

By 2100, the percentages of the total population directly affected by coastal flooding are 3.2, 4.4, and 8.1% for the respective above-mentioned scenarios (out of a projected total population of 278 million inhabitants).

Average household loss would be above VND62 million at current prices (Table 3.7).

Table 3.7. Average household loss due to flooding

Unit: VND

Damage and Reconstruction	Cost
Home repairs	23,499,188
Property damage (gardens, poultries, fishing ponds...)	30,280,730
Land restoration for agriculture or salt production	5,990,599
Clean-up	2,385,169
Total	**62,155,686**

Source: Institute of Environmental Technology, Viet Nam Academy of Science and Environment, 2009

According to the medium scenario in which sea level would rise by 75 cm, about 2 million households will be affected, with total damage estimated at VND124,000 billion.

Damage to agricultural production and rural development

By 2100, arable land lost to sea-level rise is estimated at 3,620, 5,469 and 11,188 km^2 for the corresponding three scenarios. The corresponding values of agricultural production loss are VND236,601 billion, 354,901 billion and 1,423,481 billion.

Damage to aquaculture production

The loss of aquafarming area is estimated at about 127, 168 and 345 km^2 by 2100, resulting in losses of about VND1,443,160 billion, 1,922,696 billion and 4,048,826 billion, respectively, for the three scenarios. In addition to production losses, aquaculture businesses may also suffer fixed-capital losses.

Damage to forestry

Potential flooded forest areas by 2100 for the three scenarios are 204, 320 and 778 km^2 with estimated losses of about VND266.6 billion, 430.5 billion and 1,096.9 billion.

Sea-level rise will likely reduce the productivity and area of cultivable land and thus increasing the need to convert forest lands to agricultural and aquacultural purposes. Additionally, as populations migrate to higher altitudes, further deforestation would reduce the forest coverage.

Damage to infrastructure

For a 100 cm rise in sea levels, 8,732 km representing 10.1% of total embankment, and 1,117 or 12.2% of the total number of industrial facilities in the studied area may be submerged. Sea-level rise will also threaten sea ports, oil rigs, and dykes, erode infrastructural foundations and increase maintenance costs.

Adaptation measures

Adaptive strategies to impacts of sea-level rise can be categorized into the three following groups:

- *Full protection,* which involves strengthening and elevating embankments nationwide, intensifying security services along the coastline, preventing saltwater intrusion, installing water pumps and elevating foundations for industrial, transportation and residential infrastructure.

- *Adaptation,* which accepts a certain level of climate change-induced losses, adopts damage cost-sharing, invests in the construction of "adaptive" infrastructure, focusing on developing new agricultural techniques and elevating houses above flood levels.

- *Withdrawal,* which "averts" sea-level rise impacts by relocating inhabitants, enterprises and services towards safer areas.

Each locality can carry out 2 or 3 adaptive strategies at the same time depending on their particular situations. At the national level, it is necessary to implement all three adaptive strategies, with the following specifications:

a) Upgrade 2,700 km of the existing sea and river dykes in accordance with new standards corresponding to rising sea levels. Construct an additional 585 km of dykes to protect key economic areas. The total cost of this plan is estimated at VND7,600 billion.

b) Elevate land and residential infrastructure

The elevation of 1,800 ha of land designated for special industrial zones, will cost an estimated VND1,368 billion.

Raising land by another 100 cm above the highest recorded flood peak will increase the safety of residential zones, especially in the Mekong River Delta. Approximately 128,550 ha of land (1.3 million households) in the Mekong River Delta will be prioritized in this plan, which has an estimated cost of VND70,300 billion.

c) Pump and dewater

Water will be pumped and drained out of low-lying lands or areas behind dykes to reduce flood risks. The Red River Delta will require a large pump station, while the Mekong River Delta will need a large number of smaller pump stations.

d) Protect coastal environments

A number of coastal tourist spots will undergo maintenance. An estimated 14 km of coastline would be maintained at a cost of VND418 billion.

e) Establish community-based adaptation funds

f) Develop flooding-risk maps

Detailed flood maps corresponding to sea-level rise scenarios at the provincial level will be developed, primarily for the Mekong River Delta, to ensure the socio-economic development.

Box 2:

Climate change adaptation in Ho Chi Minh City in 2009

The goal is to support Ho Chi Minh City develop efficient methodologies to build climate change response capacity.

Five main groups of activities include:

1. Basic assessment of the environment, society and economy, past experiences in disaster response and forecast of socio-economic conditions and other relevant sectors.

2. Climate change modeling to determine its impacts on Ho Chi Minh City's meteorological and hydrological conditions in 2050.

3. Impact and vulnerability assessment based on the results of risk and impact assessments of climate change on the society, economy and environment.

4. Identification of priority adaptation measures.

5. Recommendation to mainstream climate change adaptation measures into the municipal development strategy.

Proposed comprehensive adaptation measures for Ho Chi Minh City include:

- Construction of riverside embankments, including dykes which are part of the flood control projects.

- Management and restoration of Can Gio mangrove ecosystems.

- Reforestation of upstream forests and implementation of flow control measures for the Dong Nai River basin.

- Restoration of canals and streams, protection and restoration of urban wetlands.

- Selection of suitable crops and growing seasons in areas that are at high risk of saltwater intrusion.

- Development of early warning system for floods, droughts and improvement of the communication system.

- Development of adaptation measures targeting vulnerable groups (poor communities and residents of flood-prone areas).

The study recommends the development of a climate change adaptation plan for Ho Chi Minh City. The plan would set up a legal framework, orientation and responsibility assignments for sectors, agencies in accordance with the NTP, based on findings and suggestions of the study. Many of the above-mentioned measures have been chosen and are under implementation in municipal pilot projects.

Source: adb.org.vn

3.4. Impacts on agriculture

Methodologies used in the assessment of impacts on production include the dynamic ecosystem simulation model and statistical analysis of agrometeorological data.

Impacts on agrometeorological factors

Climate change is set to raise aggregated temperature, with a declining number of days below 20°C, and an increasing number of days above 25°C (Table 3.8).

Table 3.8. Aggregated temperature and number of days above 25°C

	Aggregated temperature (°C)				Number of days above 25°C			
Region	Base year	2020	2050	2100	Base year	2020	2050	2100
Northwest	8,136	8,285	8,636	9,036	124	143	176	207
Northeast	8,360	8,550	8,845	9,310	164	173	190	212
Red River Delta	8,525	8,686	8,943	9,410	166	172	189	209
North Central Coast	9,101	9,274	9,605	10,040	192	203	223	251
South Central Coast	9,704	9,820	10,085	10,417	275	290	337	365
Central Highlands	8,664	8,774	8,985	9,266	79	94	134	230
Mekong River Delta	9,737	9,864	10,123	10,424	365	365	365	365

Source: Viet Nam Seed Trade Association, 2008

Annual aggregated temperature of all regions is projected to increase by 1 to 2% by 2020, 4 to 5% by 2050 and 8 to 11% by 2100. In terms of geographical distribution, the area with aggregated temperature above 10,000°C will extend northwards by 2020, 2050 and 2100. The northernmost point of the area, situated at latitude 14°C in 2000, may be displaced to latitude 18.5°C by 2100 (Figure 3.6).

The number of days where average daily temperature falls below 20°C in the Red River Delta could drop to 90 by 2050 and 40 by 2100. These numbers are expected to be 86 and 46 days in the Northeast, and 74 and 30 days in the Northwest, in the respective years.

By 2050 and 2100, the number of days where average daily temperature exceeds 25°C will have markedly increased in the Red River Delta. In the Northwest, this number may rise from 124 days (2000) to 176 days (2050) and 207 days (2100). For the South Central Coast, this number would increase from 275 days (2000) to 337 days in 2050 and 365 days in 2100 (Table 3.8).

As the number of days with average temperatures below 20°C decreases, winter crop patterns in northern regions may have to change in terms of growing season, crop types and varieties. On the other hand, the extension of warmer days above 25°C will benefit tropical crops. To take advantage of this condition, it is necessary to make cropping pattern adjustments and begin developing a suitable crop-rotation system for heat-tolerant crops.

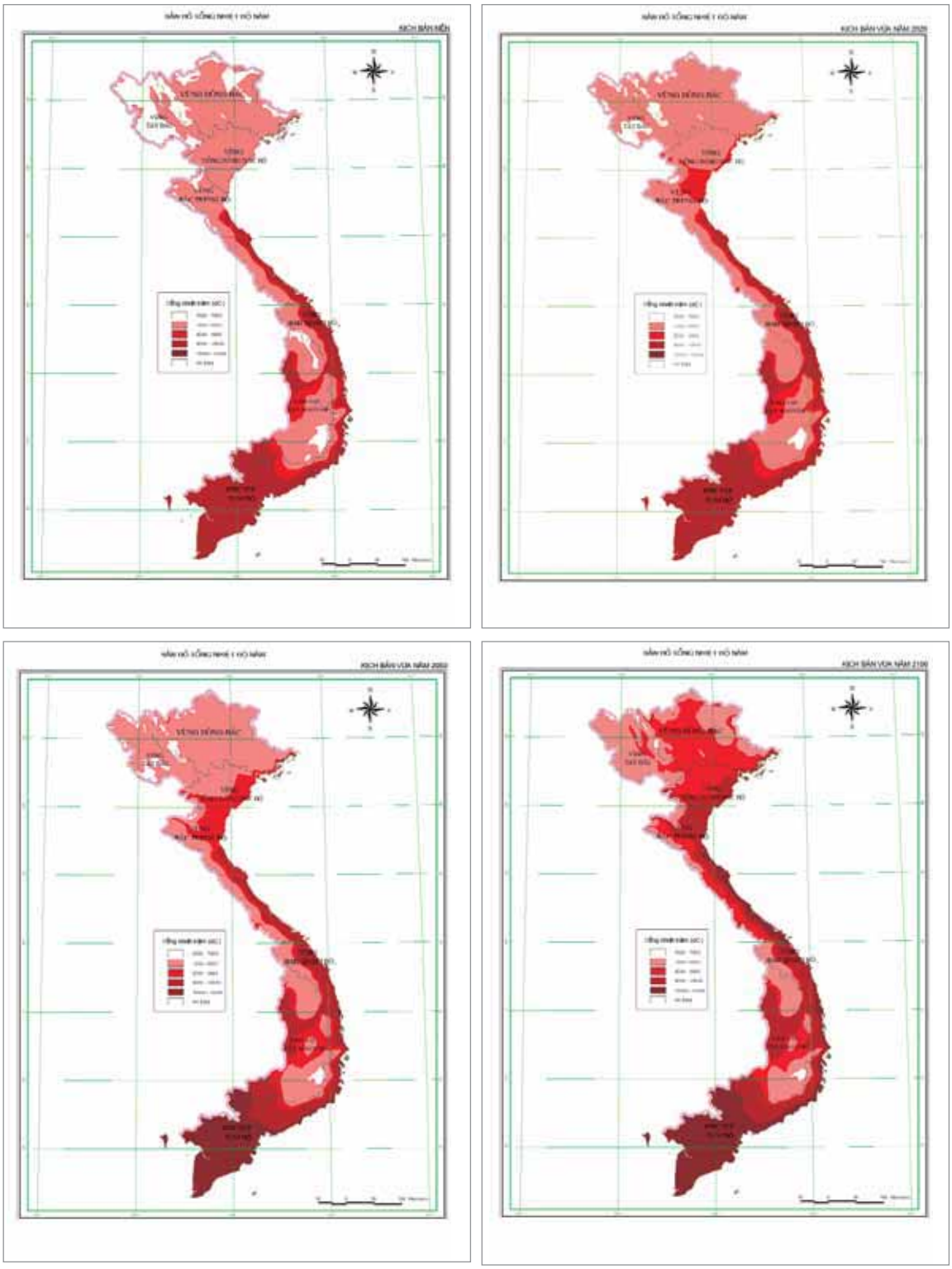


Figure 3.6. Aggregated temperatures for the base year, 2020, 2050 and 2100

Impacts on crop growth rate

Rising temperatures would increase the crop growth rate, and thereby shorten plants' growth cycle. A 1^{o}C increase in temperature would correspond to a shortening of the growth cycle by 5 to 8 days for rice, and 3 to 5 days for potatoes and soybean.

Impacts on crop water demand

Water demand for agriculture may double or triple 2100 as against 2000. At the same time, there are constantly growing risks of severe droughts and water shortage for irrigation.

Impacts on growth and spread of detrimental pests

There is a risk of sharp increases in the reproduction and spread of harmful pests such as the rice-feeding ear-cutting caterpillars, black cutworms, bark-boring beetles, fungi, amongst others, which thrive at higher temperatures and in changing rainfall patterns.

Impacts on growing seasons

According to the medium climate change scenario, spring rice crops in the Red River Delta may be sown earlier by 5 to 20 days on average. For summer rice crops, however, the sowing season may be delayed by 20 to 25 days.

Impacts on crop geographic distribution

Regions where tropical crops grow will tend to shift to higher elevations in the mountains and northwards. By 2100, tropical crops may be found at elevations of 100 to 550 m and move 100 to 200 km northward. In contrast, subtropical crops' cultivation area may decline.

The distribution of hygrophytes may be altered by changes in rainfall, rainfall intensity and more frequent floods and droughts.

The potential intensification of water shortage for agriculture and increased evapotranspiration would decrease the cover area of hygrophytes.

Impacts of sea-level rise

Due to rising sea levels, arable land across the country will be significantly reduced. Annual rice output may drop by dozens of millions of tonnes. In addition, millions of people living in low-lying areas would be forced to either elevate or abandon their homes, causing significant damage to the local and national economies.

Impacts on rice and maize output

Climate change impact assessments for rice and maize outputs in Ha Noi (representing the Red River Delta), Da Nang (for the Central region) and Ho Chi Minh City (for the South) shows that (Table 3.9):

Outputs for both spring and summer crops tend to fall, most noticeably in the Red River Delta. Spring crop output for the region may drop by 12.5% by 2050 and 16.5% by 2070, while in the Central and Southern regions, output may fall by 10 and 8% by the respective years. Across the country, summer crop output may decrease albeit at a lower rate of around 2 to 4% by 2050, and 3 to 6% by 2070.

Winter maize output is affected differently by climate change between the Northern, Central and Southern regions. In the Northern region, winter maize output may increase by 7% by 2050 and 2070, while declining by 3 to 6% by 2050 and 4 to 8% by 2070 in the Central and Southern regions.

Table 3.9. Percentage difference in output of spring, summer rice crops and maize relative to base year

Unit: %

Location/ Year	2020	2050	2070
Spring rice crop			
Hanoi	-3.71	-12.48	-16.53
Da Nang	-2.40	-6.84	-10.32
Ho Chi Minh City	-1.11	-5.96	-8.11
Summer rice crop			
Hanoi	-1.04	-3.74	-5.04
Da Nang	-1.22	-4.25	-5.69
Ho Chi Minh City	-0.25	-1.71	-2.79
Maize			
Hanoi	+0.69	+7.24	+7.11
Da Nang	-0.74	-3.07	-4.25
Ho Chi Minh City	-1.64	-6.40	-8.54

Source: Viet Nam Seed Trade Association, 2008

Impacts on animal husbandry

Reductions in feed sources will affect livestock growth and reproduction. Many livestock breeds will have difficulties adapting to new, warmer conditions. In addition, global warming and the associated increase in extreme weather events such as typhoons, floods, storm-induced high waters, strong winds and rainfall will greatly threaten the animals' life cycles. Climate change also raises the risk of epidemic break-outs.

Adaptation measures

Short-term measures:

a) Prevent soil erosion, implement soil protection, preserve soil moisture and fertility levels, plant trees and form terraced fields on steep slopes to increase vegetation cover.

b) Provide proactive crop irrigation by constructing water resevoirs and adopt more efficient methods such as spray and drip irrigation.

c) Select crops adaptable to climate change (e.g. short-term crops with short maturity, crops with enhanced resistance to harsh conditions of drought, high acidity, high salinity, pests and diseases).

d) Adjust the growing seasons and sowing times to meet the changing climate conditions.

e) Adopt new, more suitable cultivation practices (e.g. planting distances, fertilizer application, weed control, plowing, post-harvest straw mulching, pest control, crop rotation).

f) Expand fodder production and enhance storage, processing and utilization of animal feeds.

g) Build stables with adequate designs, proper manure and wastewater treatment systems.

Long-term measures:

a) Adopt climate change-suited cropping patterns.

b) Crossbreed to create new species more adaptable to the changing climate with increased tolerance for arid conditions, high salinity, flooding and pests.

c) Modernize cultivation and stockbreeding techniques.

d) Adopt scientific, efficient water management methods.

e) Improve land management capacity to enhance land conservation.

Management and planning:

a) Replan regional patterns of crop and livestock production to better fit the changing climate conditions.

b) Provide additional incentives for agriculture, forestry and aquafarming.

c) Forecast crop output, develop disaster and pest warning systems in agriculture, and improve information and communication systems.

d) Encourage agricultural technology research and development.

e) Provide crop and livestock insurance.

f) Develop and implement climate change adaptation mechanisms and policies.

On the basis of the NTP, the Ministry of Agriculture and Rural Development has formulated and adopted the Action Plan Framework for Adaptation and Mitigation of Climate Change in the Agriculture and Rural Development Sector Period 2008-2020. The Plan seeks to enhance capacity in mitigation and adaptation for ensuring sustainable agricultural and rural development to stabilize agricultural production and food security by reserving 3.8 million ha of land for bi-annual crop harvests, guarantee safety of the dike system, public, economic and technical infrastructure, and to prevent and mitigate natural disasters.

3.5. Impacts on forestry

Forest vegetation cover and ecosystems are likely to be impacted in a variety of ways by climate change.

Shifts in forest ecosystems borderlines

Based on the medium climate change scenario B2, the Viet Nam Climatic Mapping Program model - VCMP (Trevor H.Booth, 1996) was used to assess climate zones suitable for several natural forest ecosystems.

The results show that natural forest ecosystems, such as those found in deciduous dipterocarp forests, closed evergreen and closed semi-deciduous forests, all tend to shrink in coverage, a trend clearly visible in 2100 (Tables 3.10 and 3.11).

Table 3.10. Changes in natural forest areas under the medium scenario B2

Forest type	2000		2020		2050		2100	
	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%
Deciduous dipterocarp	375	1.2	1,544	4.6	504	1.5	302	0.9
Closed evergreen	1,211	3.6	1,492	4.4	1,492	4.4	651	1.9
Closed semi-deciduous	3,827	11.4	2,251	6.7	1,307	3.9	1,179	3.5

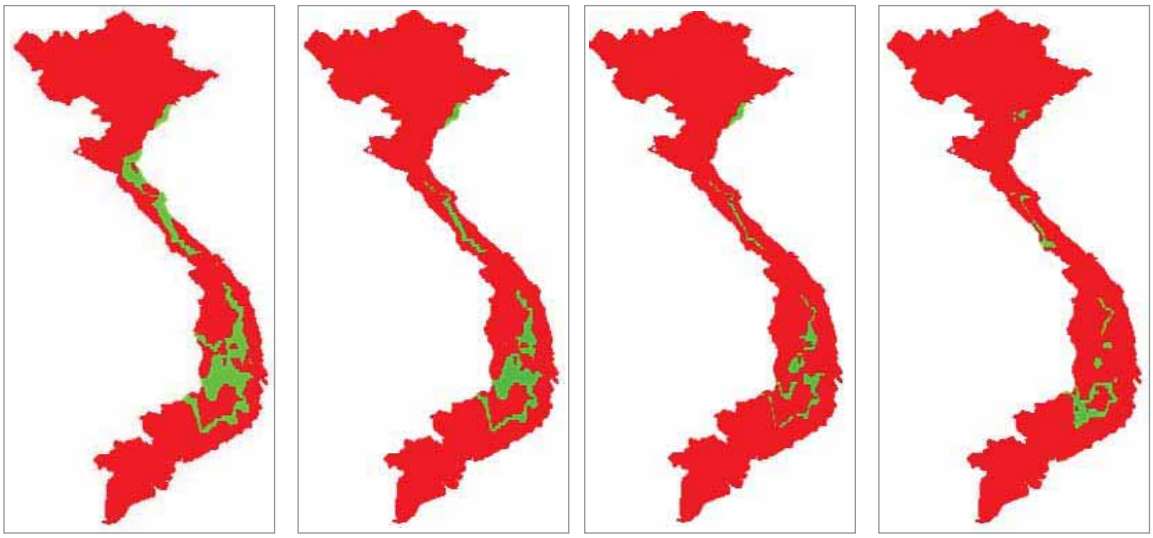
Source: Research Centre for Forest Ecology and Environment, Forest Science Institute of Viet Nam, 2008

Table 3.11. Changes in planted forest areas under the medium scenario B2

Forest type	2000		2020		2050		2100	
	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%
Churkasia tabularis	1,000	3.1	1,214	3.6	686	1.1	245	0.7
Pinus merkusii	5,360	15.9	5,757	17.1	4,237	12.6	2,338	7.0

Source: Research Centre for Forest Ecology and Environment, Forest Science Institute of Viet Nam, 2008

The closed tropical moist semi-deciduous forest ecosystem may be the most vulnerable ecosystem to climate change. In 2000, these forests covered approximately 3.8 million ha, forming 11.4% of the total forest area, and stretching from the North Central Coast to the Southeast. By 2020, 2050 and 2100, under the impact of climate change, this area may decrease to 2.3 million, 1.3 million and 1.2 million ha, respectively, corresponding to coverage of 6.7, 3.9 and 3.5%. The coverage area will remain mostly concentrated in the Central Highlands and South Central Coast (Figure 3.7).



Note: Green areas indicate closed semi-deciduous deciduous rainforests

Figure 3.7. Closed tropical moist semi-deciduous forests distribution changes, climate change scenario B2

The geographical distribution of the typical ecosystems of *Churkasia tabularis* or *Pinus merkusii* forests are also affected by climate change with their cover contracting most markedly in 2100 (Table 3.11).

Churkasia tabularis forests, which cover about 1.0 million ha of northern mountains, may decrease to 0.7 million ha by 2050 and 0.3 million ha by 2100.

Pinus merkusii forests, with a current 5.4 million ha cover area in the low coastal hills of the North Central Coast, may be reduced to only 4.2 million ha in 2050 and 2.3 million ha in 2100.

Impacts on forest fire risk

a) Forest fire risk was calculated using V.G Nesterov's forecasting formula:

$$P = k\sum_{1}^{n} ti_{13}di_{13}$$

Where ti_{13} is the air temperature at 1PM;

di_{13} is the difference from saturation of humidity (mb) at 1PM;

P is the integrated index indicating fire risk. Higher values for P indicate higher risks of fire

b) The results of calculations for climate change-induced forest fire risk based on the medium climate change scenario B2 are shown in Figures 3.8 and 3.9

The Northwest and North Central Coast have rapidly increasing risks of forest fires which peak in 2100. The value of P for March in the Northwest in 2000 was 3,400, and is projected to rise to 4,800 by 2100. June values of P for the North Central Coast exhibit the same trend, increasing from 5,400 in 2000 to 9,100 by 2100 (Figures 3.8 and 3.9).

Climate change increases the risk of forest fires in all regions, particularly during the hot-dry season.

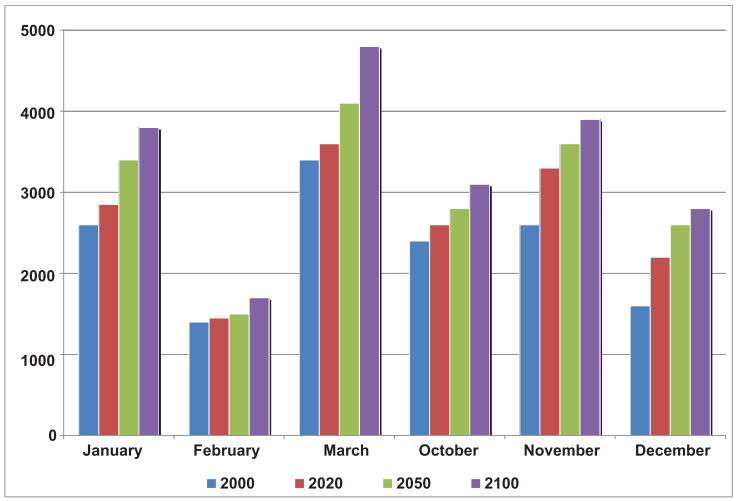


Figure 3.8. January, February, March, October, November, December values of P for 2000, 2020, 2050 and 2100 for the Northwest under the medium scenario B2

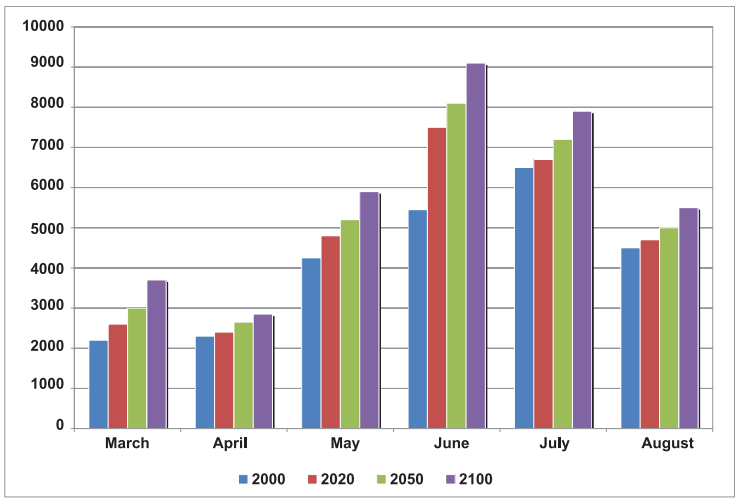


Figure 3.9. March, April, May, June, July, August values of P for 2000, 2020, 2050 and 2100 for the North Central Coast under the medium scenario B2

Impacts on growth and dispersion of harmful forest pests

In the context of rising temperatures and increasing rainfall, damaging pests such as the pine processionary caterpillar, beet armyworm, inchworm, or grasshopper, and diseases, such as eucalyptus leaf blight, pine needle brown-spot blight, may thrive, spread and hinder the growth of forest ecosystems.

Impacts on forest land

The loss of agricultural land caused by climate change-induced flooding, drought and salinization may lead to the loss of forest land by accelerating conversion of the latter for agricultural purposes.

Adaptation measures

a) Strengthen sustainable forest management and development, emphasize

afforestation and reforestation, prevent deforestation to reduce forest ecosystem vunerability and increase forest coverage.

b) Conduct research to select and diversify plant species resistant to droughts, floods, pests and less prone to causing forest fires. Establish genetic conservation plans and gene banks.

c) Develop a forest fire control and management program, and strengthen infrastructure for fire forecasting, warning and control.

d) Enhance timber-use efficiency, and develop timber and non-timber product processing technologies.

e) Implement coastal mangrove forest system restoration and development projects, plant protective dune forests (soft dykes) and implement other forest development components of sea dyke projects.

f) Support livelihood and improve living conditions for people living near forests.

Box 3: Mangrove forest reforestation and disaster preparedness projects in six provinces: Quang Ninh, Hai Phong, Ninh Binh, Thanh Hoa, Nghe An and Ha Tinh, 1997-2005

Goals:

- Reduce typhoon damage to and vulnerability of coastal communities in six provinces.

- Increase income and provide jobs for poor households residing in mangrove forest areas, and raise community awareness in mangrove forest management.

2 year-old mangrove forest

Results:

- Over 8,600 ha of mangrove forest, comprising of jungle flames, mangrove apples, white and grey mangroves, planted along the coastal and estuarine dykes in 53 communes belonging to 18 districts in six provinces.

- Improved coastal ecosystems, increased sedimentation in Hai Phong and Thanh Hoa.

- Increased income for tens of thousands of households through forest planting and aquaculture.

- Published and distributed thousands of publications on disaster management. Trained over 1,800 Red Cross staff members in disaster control. Introduced 8,000 instructors and 300,000 students to disaster response. Trained the general population in these six provinces in health, humanitarian work and mangrove tree planting techniques and storm surge-wave prevention.

Source: Vietnam Red Cross Community-based Mangrove Reforestation/Disaster Preparedness Programme, 1994-2010, funded by the Japan Red Cross Society and Viet Nam Red Cross, http://chuthapdo.org.vn/

3.6. Impacts on aquaculture

Impacts on ecosystems

Coral reef ecosystem: typhoons, floods and sea-level rise will alter the deposition of sediment, speed up erosion rates, affect coastal formations, degrade and destroy shallow-water coral reefs through coral bleaching. In addition, rising temperatures will foster the development of coral diseases and cause widespread damage to reefs and their ecosystem.

A recent survey in several coral reef colonies off the coasts of Hai Phong and Quang Ninh reveal a significantly deteriorating coral coverage, most severely at Ang Tham (86.7%) and Cong Do (96.5%), while the level of degradation at Cong La and Ba Trai Dao reefs approach 50%. Surviving reefs are few, with dead coral rocks and mud replacing corals (Table 3.12).

Table 3.12. Coral coverage in offshore coral colonies near Hai Phong and Quang Ninh

Unit: %

Reef	Pre-1998 coverage	2003 coverage	Reduction rate
Cong La	29.3	17	42.0
Ang Tham	55.7	7.4	86.7
Ba Trai Dao	85.7	44.6	48.0
Cong Do	28.3	1	96.5
Tung Ngon	64.7	48	25.8
Coc Cheo	68.4	55.9	18.3

Source: Research Institute for Aquaculture, 2009

Seagrass ecosystem: Increased rainfall will lead to increases in turbidity of the surrounding environment, slowing the growth and killing many varieties of seagrasses. This phenomenon, coupled with the physical impacts of typhoons and global warming, will have destructive impacts on seagrass ecosystems.

Estuarine ecosystem: Sea-level rise and global warming will speed up the annual sedimentation rate and restricting the habitat for many estuarine species and have far-reaching implications on the estuarine topography, fauna and flora, causing rapidly decreasing aquacultural production.

Impact on aquaculture

Rising temperatures affect the metabolism, growth and seasonal reproduction of aquatic organisms and make them more vulnerable to diseases and toxins. Dissolved oxygen in water will drop rapidly at night, impeding the growth and killing fishes and shrimps.

Floods and storms can destroy fish ponds, fish cages, and reduce estuarine water salinity, severely affecting aquacultural production.

Sea-level rise will exacerbate saltwater intrusion in coastal zones. The possible

disappearance of mangrove swamps would result in habitat loss for many species while saltwater intrusion into estuaries and lagoons would replace freshwater species with marine or estuarine species.

Impacts on pest and disease growth and spread in aquafarming

Rising temperatures foster the growth and development of harmful micro-organisms at the expense of the fish stock.

Red tides (colloquially called "semolina" in Viet Nam) is the rapid over-blooming and accumulation of red, blue, green and brown micro-algae due to rising temperatures, which decolor water. Dissolved oxygen decreases as a consequence of the increasing algae density, killing fishes and invertebrates. Recently, red tides have appeared frequently in July and August in the South Central Coast, most noticeably in Khanh Hoa, Ninh Than, Binh Thuan, and caused significant damage to the local aquacultural production.

Adaptation measures

a) Design aquacultural plans for different ecological zones on the basis of the assessments of climate change impacts on aquaculture and marine resources.

b) Develop plans to preserve marine biodiversity and ecologies, particularly coral reefs and coral islands.

c) Introduce heat-tolerant varieties in aquafarming.

d) Improve capacity in the management of aquafarming infrastructure, including fish ponds, ships and ports, in response to disasters caused by climate change.

e) Construct more storm shelters for fishing ships.

f) Upgrade the existing and develop new aquaculture logistic services sites, with focus on island routes.

g) Study and forecast fish school movements, provide fishermen with fish tracking equipment such as fish finders, fishery locators, and offer them better access to weather forecast bulletins.

h) Establish insurance funds to mitigate climate change and natural disaster risks in aquaculture.

3.7. Impacts on energy and transportation

Impacts on energy demand

As temperatures rise, energy consumption in climate-sensitive sectors will also increase as more power is needed for electric fans, air conditioners, industrial cooling processes, and agricultural irrigation and drainage pumps.

Recent research by the Institute of Energy under the Ministry of Industry and Trade shows that for every 1^{o}C increase in summer temperatures, energy demand increases by almost 1%, particularly in residential, commercial/institutional sectors. The percentage increase is the highest between 9AM and 4PM, rising 2.2% above power consumption for other times of day each year.

Impacts on energy industries

Unpredictable extreme weather events and rising sea levels will adversely impact electricity transmission and distribution systems, as well as oil rigs, pipelines, and shipping. Furthermore, changing river flows and unpredictable floods will affect hydropower stations, reservoirs, and flood control regimes, augmenting flood risks and threatening downstream communities.

Rising temperatures reduce the efficiency of steam turbine heat cycles resulting in fuel wastage. For a thermal power plant condenser with a 300 MW capacity and 25^{o}C cooling water temperature, the design and operational efficiency of the turbine heat cycle is 46.5%. If cooling water temperature were to rise by 1^{o}C, the efficiency would drop to 46.3%, and the annual consumption of coal for a 300 MW generator would increase by 0.5%, or 4,500 tonnes per year.

For a natural gas power plant, a temperature increase of 1^{o}C reduces total power output by 0.5%. For a 250MW gas turbine facility the loss would be 7.5 million kWh per year.

Impacts on power infrastructure

Sea-level rise will inundate facilities, stations, and transmission lines in coastal areas. Unpredictable storms are capable of eroding and destroying embankments and hydropower plants, thereby increasing energy infrastructure maintenance and repair costs. Constructions in progress and completed may need to be elevated, further increasing costs.

Impacts on transportation infrastructure

Direct damage

Transportation infrastructure is damaged or destroyed as storms and floods grow in both frequency and intensity. Between 2001 and 2005, extreme weather events cost the transportation sector VND2,571 billion in damages. If sea level rises by 100 cm, 11,000 km of roads would be submerged.

Indirect damage

Transportation paralysis affects socio-economic activities and induces further economic losses.

Adaptation measures

a) Mainstream climate change issues into energy and transportation development strategies and plans. Guarantee energy security, transportation safety and sustainable development.

The Ministry of Industry and Trade has formulated the Action Plan to respond to climate change for 2010-2015. On the basis of the NTP, the Action Plan is divided into three stages and focuses on: Raising awareness of climate change impacts on industrial and commercial activities, controlling greenhouse gas emissions in industrial manufacturing processes and trade activities, and implementing pilot projects in green, environmentally sound technology transfers for energy intensive products.

b) Promote efficient energy use and energy conservation.

c) Improve energy efficiency in the exploitation, production, distribution and consumption of energy.

d) Elevate and renovate structures in the energy and transportation sectors in areas vulnerable to sea-level rise and flooding.

e) Reinforce transportation infrastructure, power transmission towers in flood-prone areas, strengthen roads and rail networks in the mountains and areas with sloping terrain. Construct bridges to replace submerged intersections and spillways to guarantee an uninterrupted transportation network.

3.8. Impacts on human health

Climate change impacts on human health can be categorized into direct and indirect impacts. The impact assessment was made using statistics.

Direct impacts

Direct impacts on health include the direct physical effects of climate, and the environment on human life leading to rapid or gradual changes in customs and lifestyle.

Impact of changing climate patterns

According to climate change scenarios, temperatures may rise by 2 to 3^{o}C by the end of the 21st century, with the annual and monthly Human Balance Index (HBI) values increasing by 7 to 14 watt/m^2 in 2081-2100 against those of 1991-2000 (Figure 3.10). Seasons will also change, eminently in northern regions as summers are extended while winters are truncated by 1 to 2 months, and affect the population's circadian rhythm, health, customs and habits, especially for the elderly and children.

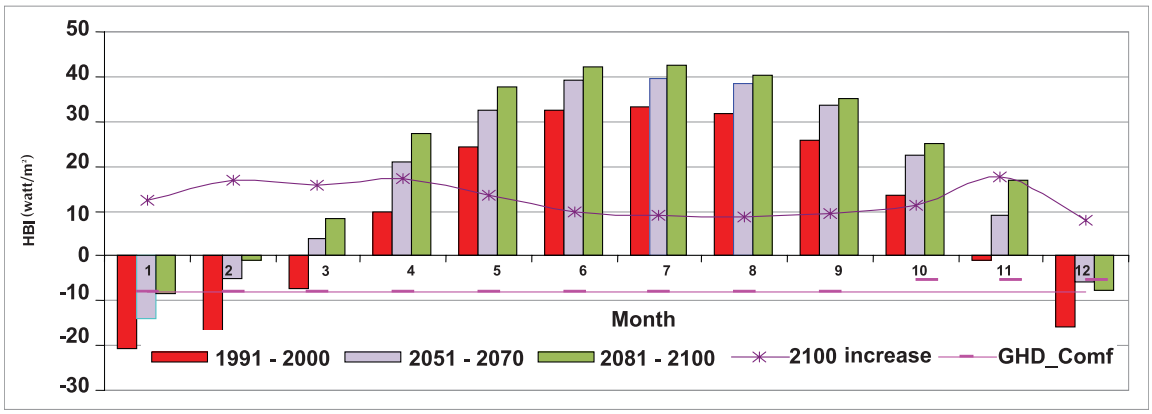


Figure 3.10. Yearly HBI fluctuations, Hanoi

Impact of anomalous heat waves on health

Recent researches show that if temperature rises by 1^{o}C, the number of heat waves increases by 100 to 180%, while the number of cold surges decrease by 20 to 40%. In the Red River Delta, as summer temperatures for 2100 are projected to increase by 2.4^{o}C in the high scenario, and 1.6^{o}C in the medium scenario, the number of heat waves would correspondingly increase by 302% and 204%. The consequences are detrimental to health particularly for the young and elderly. In addition, heat waves will increase the incidence of epidemic outbreaks, such as malaria, dengue fever, and diarrhea.

Impact of natural disasters on human health

Storms, floods, droughts, tornadoes and landslides are set to increase in frequency and intensity, causing significant damage to human life and property.

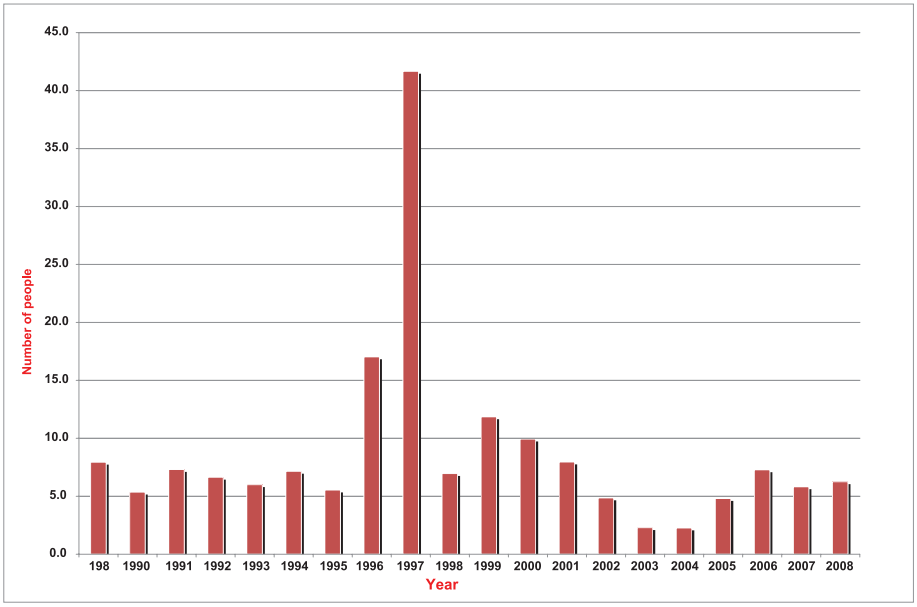


Figure 3.11. Number of dead and missing in natural disasters per million inhabitants (1989-2008)

Statistics from the Natural Disaster Mitigation Partnership show that, between 1989 and 2008, the number of dead and missing during natural weather disasters in Viet Nam reached 13,097, which translates into 655 per year, or 8.7 per million inhabitants. Figure 3.11 illustrates annual number of dead and missing per million inhabitants due to meteorological disasters. Total loss of property for the period reached US$4,858 million, averaging US$240 million a year. It is worth noticing that the value of losses have increased in recent years (Figure 3.12)

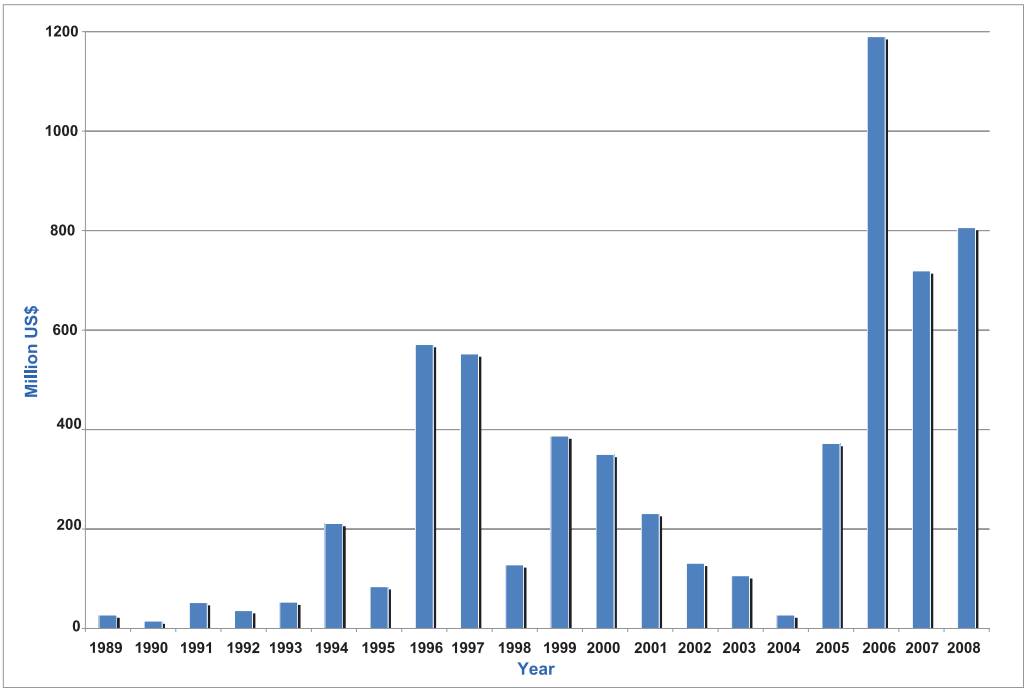


Figure 3.12. Property loss (in US$) in natural disasters (1989-2008)

Indirect impacts

Rising sea levels will lead to the inundation of arable land, affecting food security and increasing the risk of famine. Saltwater intrusion and inundation will degrade the quality and hygiene of water and food. Consequently, diseases and epidemics may spread more easily.

Climate change will lead to changes in ecosystems, increase pathogenic bacteria and parasites, resulting in the outbreak of diseases such as malaria, dengue fever, Japanese encephalitis, and diarrhea.

Recent research results show that number of diarrhea cases in the 90s stood at about 500 cases/100,000 persons. The medium climate change scenario projects a doubling of this figure by 2020 and an 11.6-fold increase by 2100 (Table 3.13)

Table 3.13. Number of diarrhea cases and percentage increase relative to 1990 under the medium scenario B2

Year	Number of cases /10,000 persons	Increase above 1990 figure
2020	1,086	2.0
2050	3,313	6.1
2100	6,301	11.6

Source: Light Center for Public Health Development, Viet Nam Union of Science and Technology Associations, 2008

Adaptation measures

a) Review construction standards and regulations to take into account meteorological loading such as wind load (related to storms, tornadoes, whirlwinds), heat load (caused by heat waves) and urban sewage standards.

b) Strengthen residential planning, taking into account natural disasters impacts for vulnerable areas such as coastal zones, steep hills and mountains and fluvial low-lying areas. Urban planning must mitigate the "urban heat island" effect by replacing concentrated metropolises with satellite cities.

c) Build capacity for rural healthcare institutions in disaster-prone areas.

d) Decrease outdoor activities, hard labor in particular, around the peak of the hot seasons during heat waves.

e) Enhance hydro-meteorological forecasting, information dissemination and utilization for disaster forecasting and warning. Develop disease, epidemic, and air pollution outbreak forecasting capacity. Integrate disease forecasting into the national weather forecast.

f) Control diseases through the following measures

- For vectors-borne diseases:

+ Establish a national program to track and monitor vectors and epidemic potential.

+ Organize vaccination campaigns and encourage the use of repellent-treated mosquito nets.

+ Develop human resources, infrastructure and techniques in disease prevention and treatment, including medication, medical equipment, and transportation in disease-prone areas.

- For water-borne diseases:

+ Promote techniques to ensure sanitation and water safety such as treating and filtering water, drinking boiled water, hygienic lavatories.

+ Enhance information dissemination and awareness-raising for disease prevention, particularly in areas susceptible to dengue fever, malaria, and diarrhea.

g) Promote climate change and epidemics research and information dissemination.

- Establish a network to monitor and survey diseases nationwide. Establish a database to help assess and monitor public health.

- Launch studies on climate change-related disease transmission mechanisms. Establish a scientific base to determine the relationships between climate change and human health, as well as epidemic outbreaks.

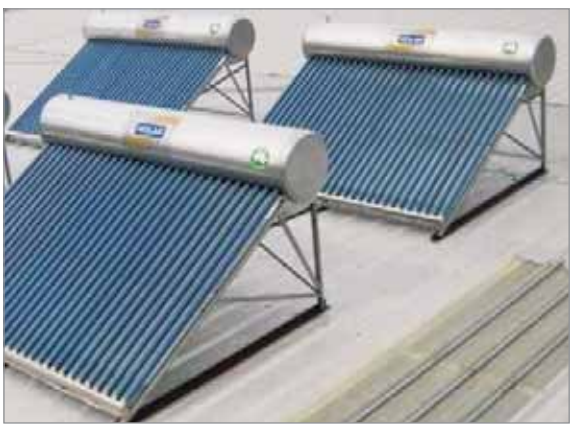
- Raise public awareness on climate change and diseases to protect human health and to respond to climate change.

Table 3.14. Time horizon of adaptation measures

Sector	Measures	Short term	Long term
Water resources	Formulate plans for sustainable water resources development of all river basins and regions based on the national social and economic development planning.	x	
	Reinforce, upgrade and complete the existing structures and add new water resource exploitation and utilization infrastructure	x	x
	Reinforce and upgrade the existing system of river and sea dykes and build a water-pump and drainage system in low-lying areas and coastal flood-prone areas	x	x
	Promote water use efficiency and conservation		x
	Upgrade and modernize the observation and long-range water resources forecasting network and develop flood warning systems	x	x
	Raise public awareness	x	
Coastal zone	Upgrade 2,700 km of the existing sea and estuarine dykes		x
	Elevate land and residential infrastructure		x
	Pump and dewater	x	x
	Protect coastal environments		x
	Establish community-based adaptation funds	x	x
	Develop flood maps	x	
Agriculture	Prevent soil erosion, implement soil protection, preserve soil moisture and fertility levels	x	x
	Provide proactive irrigation to crops by constructing water resevoirs and adopt more efficient irrigation methods	x	
	Select crops adaptable to climate change	x	
	Adjust the growing seasons and sowing times as appropriate	x	
	Adopt new, more suitable cultivation practices	x	
	Expand fodder production and enhance storage, processing and utilization of animal feeds	x	x
	Build stables with adequate designs, proper manure and wastewater treatment systems	x	
	Adopt climate change-suited cropping patterns		x
	Crossbreed to create new species more adaptable to the changing climate with increased tolerance for arid conditions, high salinity, flooding and pests	x	x
	Modernize cultivation and stockbreeding techniques	x	x
	Adopt scientific, efficient water management methods	x	x
	Improve land management capacity		x
	Replan regional patterns of crop and livestock production	x	x
	Provide additional incentives for agriculture, forestry and aquafarming	x	
	Forecast crop output, develop disaster and pest warning systems in agriculture, and improve information and communication systems	x	x
	Provide crop and livestock insurance	x	x

	Develop and implement climate change adaptation mechanisms and policies	x	
Forestry	Strengthen sustainable forest management and development	x	x
	Conduct research to select and diversify plant species resistant to droughts, floods, pests and less prone to causing forest fires. Establish genetic conservation plans and gene banks	x	x
	Develop a forest fire control and management program, and strengthen infrastructure for fire forecasting, warning and control	x	
	Enhance timber-use efficiency, and develop timber and non-timber product processing technologies	x	
	Implement coastal mangrove forest system restoration and development projects, plant protective dune forests	x	x
	Support livelihood and improve living conditions for people living near forests	x	
Aquaculture	Design aquacultural plans for different ecological zones	x	
	Develop plans to preserve marine biodiversity and ecologies	x	
	Introduce heat-tolerant varieties in aquafarming	x	
	Improve capacity in the management of aquafarming infrastructure	x	
	Construct more storm shelters for fishing ships	x	
	Upgrade the existing and develop new aquaculture logistic services sites	x	
	Study and forecast fish school movements, improve the capacity in weather forecast information accessibility for fishermen	x	x
	Establish aquaculture insurance funds	x	x
Energy and transportation	Mainstream climate change issues into energy and transportation development strategies and plans	x	
	Promote efficient energy use and energy conservation	x	x
	Improve energy efficiency	x	x
	Elevate and renovate structures in the energy and transportation sectors in areas vulnerable to sea-level rise and flooding	x	x
	Reinforce transportation infrastructure, power transmission structures in high flood-prone, mountainous and sloping areas	x	
Health	Review construction standards and regulations to take into account meteorological loading and urban sewage	x	
	Strengthen residential planning with respect to natural disasters impacts for vulnerable areas	x	
	Build capacity for rural healthcare institutions in disaster-prone areas	x	x
	Develop disease, epidemic, and air pollution outbreak forecasting capacity. Integrate disease forecasting into the national weather forecast	x	x
	Control vector-borne, water-borne and food-borne diseases	x	
	Promote climate change and epidemics research and information dissemination	x	

CHAPTER 4
GREENHOUSE GAS EMISSION MITIGATION OPTIONS



4.1. Policy instruments for mitigation of greenhouse gas emissions

Being a Party to the UNFCCC and the Kyoto Protocol, Viet Nam has developed and issued a number of legal documents with the aim of attaining the UNFCCC's objective: "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

4.1.1. Legal documents

The National Assembly of Viet Nam has issued a number of environmental protection laws and regulations directly related to mitigation of GHG emissions as follows:

- Law on Environmental Protection No. 52/2005/QH11 dated 29th November 2005 (replaces the 1993 Law on Environmental Protection).
- Water Resources Law No. 08/1998/QH10 dated 20th May 1998.
- Petroleum Law (1993) No. 10/2008/QH12 dated 6th July 1993 (amended twice on 9th June 2000 and 3rd June 2008).
- Law on Minerals No. 2/1996/QH9 dated 1st September 1996 (amended on 27th June 2005).
- Law on Forest Protection and Development No. 29/2004/QH11 dated 3rd December 2004 (replaces the 1991 Law on Forest Protection and Development).
- Law of Electricity No. 28/2004/QH11 dated 3rd December 2004.
- Law on Safe and Efficient Use of Energy No. 50/2010/QH12 dated 28th June 2010.

4.1.2. Government-issued legal documents

In 2003, the National Environment Protection Strategy by 2010 and vision until 2020 was approved by the Prime Minister. The strategy aims to promote the application of clean technologies, cleaner production processes and the use of less polluting, more environmentally sound fuels and materials.

In 2006, the Government established the National Target Program on Energy Efficiency to raise public awareness, promote research and development of science and technology, and enforce regulations on energy conservation and efficiency. The Program sets a three to five percent conservation rate for national energy consumption for 2006-2010 and five to eight percent for 2011-2015.

In 2008, the Government approved the National Target Program to Respond to Climate Change. The main objective of the Program is to determine sectoral and regional impacts for each time period, so as to develop feasible action plans to effectively respond to climate change, in the short and long term, in order to achieve sustainable development, to seize opportunities to develop towards a low-carbon economy and to join the international community's efforts in mitigating climate change and protecting the climate system. The development and implementation of GHG mitigation options, such as CDM projects, have made substantial contribution to achieving the national sustainable development goals.

The NTP lays out nine targets and their means for 2009-2015, including the

formulation and implementation of GHG mitigation options.

In addition, the Government has also issued many other legal documents related to climate change response.

4.2. GHG mitigation options

Results of the national GHG inventory show that Viet Nam's total GHG emissions for the year 2000 were 150.9 million tonnes of CO_2e, emanating from three main sources including agriculture with 43.1%, energy (including transportation) with 35%, and LULUCF with 10%. Based on the development plan of each of the sectors identified as the main GHG sources and sinks, mitigation options focus on:

- ❑ Energy
- ❑ Agriculture
- ❑ LULUCF

4.2.1. Mitigation options in energy

The Long-range Energy Alternatives Planning system (LEAP) model was used to forecast energy demand for both baseline and mitigation scenarios in the course of GHG mitigation options development and evaluation. LEAP is a modelling tool used to systematically analyze energy-environment interdependence, from primary energy development (i.e. extraction, production, transformation, distribution) to end-use energy consumption based on the assumed inputs. LEAP's main strengths reside in its flexibility, ease of use, and the capacity to analyze, assess GHG emissions from energy and choose appropriate policies. The model was therefore picked for the development and evaluation of energy emission mitigation options.

4.2.1.1. Baseline scenario

GDP: Economic growth will lead to increased energy consumption. According to the predictions of the Ministry of Planning and Investment, baseline scenario GDP growth rates are projected at 7.6, 7.2 and 7.0% for 2005-2010, 2010-2020 and 2020-2030, respectively

GDP growth projections in the baseline scenario serve to orient and forecast Viet Nam's energy demand. Growth rates and structure of GDP by sector are shown in Tables 2.22 and 2.23.

Population: Viet Nam's population is projected to reach 104 million in 2030, with 45.2 million living in urban areas. Population growth until 2030 is shown in Table 2.24.

Based on LEAP model inputs, outputs such as GDP, population, past trends of energy consumption, and end-use energy demand by sector are summarized in Table 2.21 and Figure 4.1.

GHG emissions by sector and source are shown in Table 4.1.

Table 4.1. GHG emission estimates by source

Unit: thousand tonnes of CO_2e

Source	2010	2020	2030	Growth rate of 2010 - 2030 (%)
1. Energy industries	31,841	110,946	238,039	10.58
2. Energy use	81,280	140,062	232,748	5.40
- Industry	31,340	52,992	76,544	4.57
- Transportation	28,236	48,601	86,037	5.73
- Agriculture	2,066	2,444	2,901	1.71
- Residential sector	13,994	25,313	49,373	6.32
- Commercial /Institutional sector	5,644	10,712	17,893	5.94
Total (1 + 2)	**113,121**	**251,008**	**470,787**	**7.39**

Source: LEAP model outputs

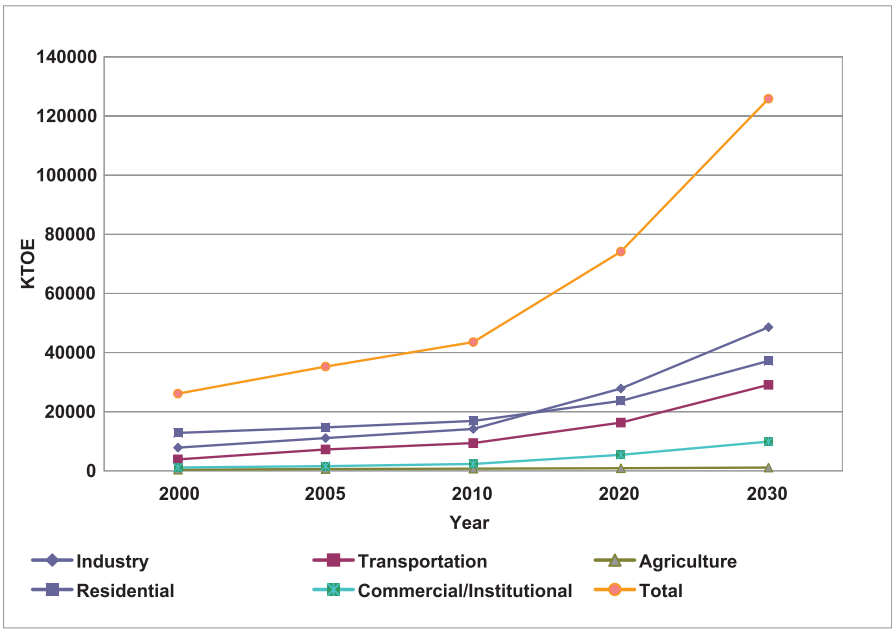


Figure 4.1. Energy demand projections by sector

4.2.1.2. Greenhouse gas emission mitigation options

Fifteen GHG mitigation options were developed and evaluated for the energy sector using the LEAP model, including six options in energy efficiency and alternatives for the residential sector, two options in energy efficiency for industry, two options in energy efficiency and alternatives for transportation, one option in energy efficiency for the commercial/institutional sector and four options in renewable energy for energy industries. The GHG mitigation options in energy sector are as follows:

❑ *Option E1: Innovative coal stoves*

Scenario assumptions: Innovative coal stoves with 30% efficiency rate will replace conventional coal-fired stoves with 22% efficiency in three million households by 2030.

Each household formerly consuming 0.48 TOE/year would only consume 0.35 TOE/year using innovative stoves, leading to an aggregate 0.39 million TOE/year saving for three million households.

The CO_2 mitigation potential of this option is approximately 25.3 million tCO_2, at an abatement cost of US$-17.4/$tCO_2$.

❑ *Option E2: Replacing coal with LPG in household cooking*

Scenario assumptions: 0.9 million households switch from coal to LPG for cooking activities by 2030.

Each household formerly consuming 0.48 TOE/year using coal-fired stoves would only consume 0.14 TOE/year using LPG, leading to 432 thousand TOE/year decrease in demand for coal and a 126 thousand TOE/year increase in demand for LPG.

The CO_2 mitigation potential of this option is approximately 22 million tCO_2, at an abatement cost of US$23.8/$tCO_2$.

❑ *Option E3: High-efficiency refrigerators*

Scenario assumptions: High-efficiency refrigerators will replace conventional models in six million homes by 2030.

High-efficiency 102W fridges consuming 521 kWh/year replacing 120W models which consume 613 kWh/year would lead to a total reduction in electricity consumption of 552 million kWh/year (47.47 thousand TOE/year) by 2030.

The CO_2 mitigation potential of this option is approximately 7.3 million tCO_2, at an abatement cost of US$12.3/$tCO_2$.

❑ *Option E4: Energy-saving compact fluorescent light bulbs*

Scenario assumptions: 30 million 16W compact fluorescent bulbs will be used for lighting instead of 75W incandescent bulbs by 2030.

Compact fluorescent bulbs each consuming 16 kWh/year replace incandescent bulbs which consume 75 kWh/year. Total electricity consumption would fall by 1,770 million kWh/year (152.2 thousand TOE/year).

The CO_2 mitigation potential of this option is approximately 23.4 million tCO_2 at an abatement cost of US$-8.2/$tCO_2$.

❑ *Option E5: High-efficiency air conditioner*

Scenario assumptions: Three million conventional air conditioning units are replaced by high-efficiency air conditioners by 2030.

Functioning 1,500 hours/year at 10,000 BTU, a conventional unit consumes 1,530 kWh whereas a high-efficiency model consumes 1,280 kWh. Aggregate electricity consumption for three million units would fall by 750 million kWh/year (64.5 thousand TOE/year).

The CO_2 mitigation potential of this option is 9.9 million tCO_2 at an abatement cost of US$-4.4/$tCO_2$.

❑ *Option E6: Solar water-heating appliances*

Scenario assumptions: 1.5 million households use solar water-heating appliances (such as solar boilers) by 2030.

The use of solar water-heating appliances can save 700 kWh/household/year. Thus, by 2030, if 1.5 million families were to use solar-powered devices to heat water, electricity consumption would decrease by 1,050 million kWh/year (90.3 thousand TOE/year).

The CO_2 mitigation potential of this option is 13.9 million tCO_2 at an abatement cost of US$-6.2/$tCO_2$.

❑ *Option E7: High-efficiency electric motors*

Scenario assumption: 0.5 million conventional 15kW, 86% efficiency electric motors are replaced by more efficient (91%) electric motors by 2030.

An average conventional motor consumes 61,047 kWh/year while a high-efficiency one consumes only 57,692 kWh/year. By 2030, the replacement of 0.5 million conventional electric motors with more efficient models would decrease electricity demand by 1,174.3 million kWh/year (101 thousand TOE/year).

The CO2 mitigation potential of this option is approximately 15.5 million tCO_2 at an abatement cost of US$-24.9/$tCO_2$.

❑ *Option E8: Innovative brick kilns*

Scenario assumption: Six thousand conventional kilns are replaced by vertical shaft continuous kilns, at constant output of one million bricks per year, by 2030.

While a traditional kiln requires 0.16 kg of coal to produce one brick, an improved kiln only requires 0.08 kg per brick. The use of innovative brick kilns can save 235.2 thousand TOE/year by 2030.

The CO_2 mitigation potential of this option is approximately 14.2 million tCO_2 at an abatement cost of US$-5.1/$tCO_2$.

❑ *Option E9: Switching from DO to CNG in transportation*

Scenario assumption: By 2030, 30 thousand public buses will run on compressed natural gases (CNG) instead of diesel oil (DO).

On average, a conventional diesel bus consumes 28.2 kg of diesel oil per 100 km, while a CNG-powered bus consumes 30.4 kg of CNG per 100 km. By 2030, with the shift from DO to CNG, demand for DO will drop by 350.3 thousand TOE/year, and demand for CNG will increase by 375.0 thousand TOE/year.

The CO_2 mitigation potential of this option is approximately 2.1 million tCO_2 at an abatement cost of US$-14.1/$tCO_2$.

❑ *Option E10: LPG-fuelled cabs*

Scenario assumptions: 200 thousand cabs run on LPG instead of normal gasoline by 2030.

On average, a gasoline-powered cab consumes 6.5 kg of gasoline per 100 km while an LPG-powered one consumes 6.5 kg of LPG per 100 km. With 200 thousand taxi cars switching from petrol to LPG, demand for petrol will decrease by 707.0 thousand TOE/year and demand for LPG will increase by 679.3 thousand TOE/year.

The CO_2 mitigation potential of this option is approximately 3.3 million tCO_2 at an abatement cost of US$-11/$tCO_2$.

❑ *Option E11: Using high-press sodium lamps in public lighting*

Scenario assumptions: By 2030, there will be 1.2 million 15W high-press sodium lamps used in public lighting, instead of conventional 200W mercury vapor lamps.

A mercury vapor lamp consumes 720 kWh/year, while a high-pressure sodium lamp only consumes 540 kWh/year. By 2030, with 1.2 million high-press sodium lamps in use, electricity consumption will decrease by 216 million kWh/year (18.576 thousand TOE/year).

The CO_2 mitigation potential of this option is approximately 2.9 million tCO_2 at an abatement cost of US$-22.8/$tCO_2$.

❑ *Option E12: Switching from coal-fired to LNG thermal power*

Scenario assumptions: By 2030, 500 MW of electricity produced by thermal power plants will be generated by LNG instead of coal.

A LNG power plant has a 35% efficiency, US$920/kW capital cost and US$0.5/MWh operating cost. A coal power plant has a 25% efficiency, US$1,230/kW capital cost and US$3.0/MWh operating cost.

The CO_2 mitigation potential of this option is approximately 16 million tCO_2 at an abatement cost of US$15.1/$tCO_2$.

❑ *Option E13: Small-scale hydropower replacing coal thermal power*

Scenario assumptions: By 2030, 150 MW of coal-fired electricity will instead be produced by small-scale hydropower.

A coal power plant has a 25% efficiency, US$1,230/kW capital cost and US$3.0/MWh operating cost. A small-scale hydroelectric power plant has a 100% efficiency, US$1,700/kW capital cost and US$1.0/MWh operating cost. Because the amount of electricity generated by a small-scale hydropower plant is relatively small-50% of its power, the generation of 150MW of electricity, a hydropower plant needs a capacity equivalent to 240 MW.

The CO_2 mitigation potential of this option is approximately 15.3 million tCO_2 at an abatement cost of US$-7.2/$tCO_2$.

❑ *Option E14: Wind power replacing coal-fired thermal power*

Scenario assumptions: By 2030, 200 MW of coal-fired thermal power will instead be produced by wind power.

A coal power plant has a 25% efficiency, US$1,230/kW capital cost and US$3.0/MWh operating cost. A wind power station has a 100% efficiency, US$1,200/kW capital cost and US$0.5/MWh operating cost. Since a wind power station only generates electricity

equal to about 25% of its power, the generation of 200MW of electricity requires a wind power station with a capacity of 640 MW.

The CO_2 mitigation potential of this option is approximately 14.2 million tCO_2 at an abatement cost of US$16.2/$tCO_2$.

❑ *Option E15: Rice husk power replacing coal thermal power*

Scenario assumptions: By 2030, 100MW of electricity generated by coal will be replaced by rice husk-fuelled thermal power plants.

A coal power plant has a 25% efficiency, US$1,230/kW capital cost and US$3.0/MWh operating cost. A rice husk power plant has a 33-80% efficiency, US$1,750/kW capital cost and US$6.0/MWh operating cost.

The CO_2 mitigation potential of this option is approximately 6.9 million tCO_2 at an abatement cost of US$6.6/$tCO_2$.

LEAP model outputs are summarized in Table 4.2.

Table 4.2. Mitigation potential and cost in energy

Option	Mitigation potential (million CO_2)	Incremental cost (million US$)	Mitigation cost (US$/$tCO_2$)
E1	25.3	-81.8	-17.4
E2	22.0	97.5	23.8
E3	7.3	16.5	12.3
E4	23.4	-35.6	-8.2
E5	9.9	-8.1	-4.4
E6	13.9	-16.0	-6.2
E7	15.5	-71.5	-24.9
E8	14.2	-13.4	-5.1
E9	2.1	-3.6	-14.1
E10	3.3	-4.5	-11.0
E11	2.9	-12.0	-22.8
E12	16.0	48.5	15.1
E13	15.3	-21.1	-7.2
E14	14.2	28.4	16.2
E15	6.9	5.7	6.6
Total	**192.2**		

Cost of emission reduction initiatives (CERI) curve for the 15 options is shown in Figure 4.2. Over 30 years, GHG mitigation potentials for the 15 options total 192.2 million tCO_2.

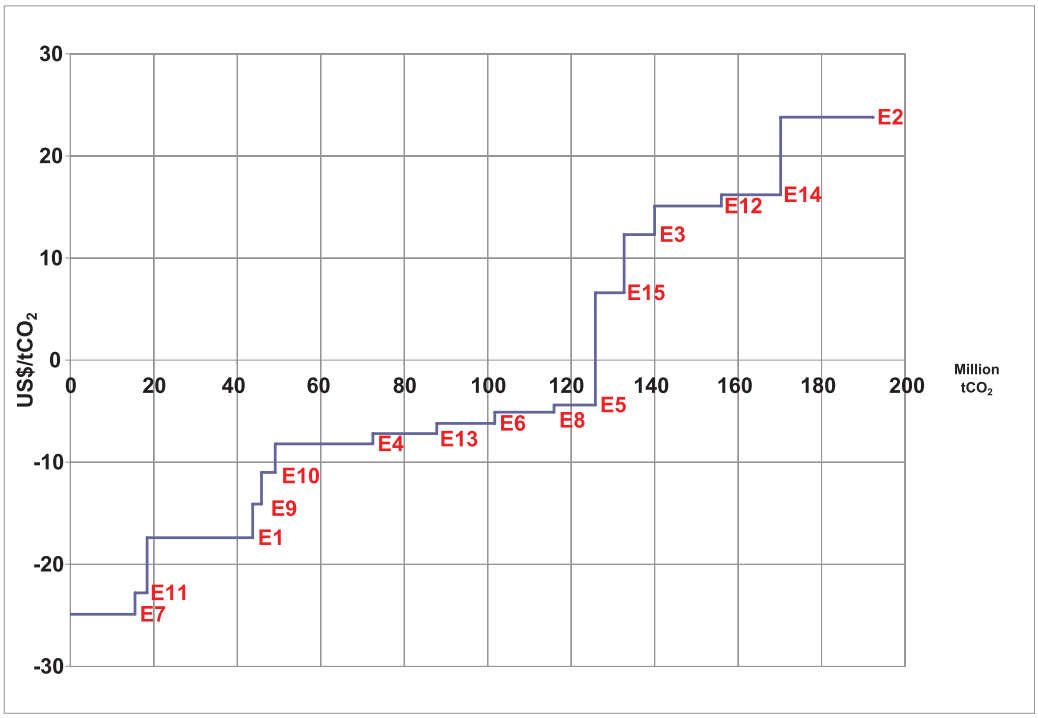


Figure 4.2. Cost of emission reduction initiatives curve for 15 mitigation options in energy

4.2.2. Mitigation options in agriculture

The national greenhouse gas inventory for the year 2000 reveals that the largest sources of emission in agriculture are rice cultivation, agricultural soils and animal husbandry, predominantly through the emission of methane. The development of GHG mitigation options for the sector has therefore focused on reducing emissions from these sources.

The development and evaluation of GHG mitigation options in agriculture are in compliance with the Greenhouse Gas Mitigation Assessment guidebook by Dr. J.Sathaye (1995), which provides guidance for the development of baseline and mitigation scenarios, and the assessment of mitigation potential, mitigation options cost-effectiveness and benefits.

GHG mitigation options for this sector are built upon the "business as usual" scenario, driven by Viet Nam's agricultural development policy linking GHG mitigation objectives with national agricultural development targets to avoid any adverse impact on agricultural productivity targets and product quality.

4.2.2.1. Baseline scenario

The baseline scenario for agriculture is based on the sector's developmental orientation for the early decades of the 21st century, which aims to build the foundations for a diversified and sustainable commodity agriculture applying scientific knowledge, techniques and new technologies. Table 4.3 summarizes some of the sector's set targets for the coming years.

Table 4.3. Several agricultural targets

Target	2010	2020	2030
Agricultural soils (%)	26.6	26.6	26.6
Wet-seeded rice area (million ha)	7.1	6.8	6.6
Maize area (million ha)	1.2	1.5	1.6
Dairy cattle (thousand head)	200.0	490.0	735.0
Buffalo and beef cattle (million head)	9.5	12.9	16.4
Contribution to GDP (%)	17.0	13.0	

Source: Decision 150/2005/QÑ-TTg dated 20th June 2005 by Prime Minister-Government, and Statistical Yearbook 2002

4.2.2.2. GHG mitigation options

❑ *Option A1: Biogas replacing cooking coal in lowlands*

Scenario assumptions: Coal is to be gradually replaced by gas for cooking as lowland households are equipped with 336,000 biogas tanks. The increase will be from 3,000 tanks in 2010 to 168,000 tanks in 2020 and finally 336,000 tanks in 2030.

The GHG mitigation potential for this option is 17.4 million tCO_2 at an abatement cost of US$4.1/$tCO_2$.

❑ *Option A2: Biogas replacing cooking coal in mountain areas*

Scenario assumptions: Coal is to be gradually replaced by gas for cooking as mountain areas households are equipped with 224,000 biogas tanks. The increase will be from 2,000 tanks in 2010 to 112,000 tanks in 2020 and finally 224,000 tanks in 2030.

The GHG mitigation potential of this option is 5.2 million tCO_2 at an abatement cost of US$9.7/$tCO_2$.

❑ *Option A3: Rice paddy field water drainage in the Red River Delta*

Scenario assumptions: An active irrigation and drainage system ensuring adequate water supply has been used for one million ha of rice paddies in the Red River Delta, with 50,000 ha in 2010, 700,000 ha by 2020 and finally 1,000,000 ha by 2030.

The GHG mitigation potential of this option is 21.9 million tCO_2, at an abatement cost of US$5.2/$tCO_2$.

❑ *Option A4: Rice paddy field water drainage in the South Central Coast*

Scenario assumptions: An active irrigation and drainage system ensuring adequate water supply has been applied to 200,000 ha of rice paddies in the South Central Coast with 30,000 ha in 2010, 150,000 ha by 2020 and finally 200,000 ha by 2030.

The GHG mitigation potential of this option is 4.1 million tCO_2, at an abatement cost of US$6.99/$tCO_2$.

❑ *Option A5: MUB cattle feeds*

Scenario assumptions: 292,000 dairy cattle will be fed Molasses Urea Block (MUB) by

2030. The number of MUB-fed cattle will be 73,000 heads in 2010, 182,000 by 2020 and 292,000 by 2030.

The GHG mitigation potential of this option is 7.9 million tCO_2, at an abatement cost of US$-10.9/$tCO_2$.

Mitigation potential and cost of the five options in agriculture are presented in Table 4.4. The cost of emission reduction initiatives curve is shown in Figure 4.3.

Table 4.4. Mitigation options potential and cost in agriculture

Option	Methane reduction (in CO_2e) (million tonnes)	Incremental cost (million US$)	Mitigation cost (US$/tonne of CO_2)
A1	17.4	0.122	4.1
A2	5.2	0.086	9.7
A3	21.9	0.128	5.2
A4	4.1	0.032	7.0
A5	7.9	-0.196	-10.9
Total	**56.5**		

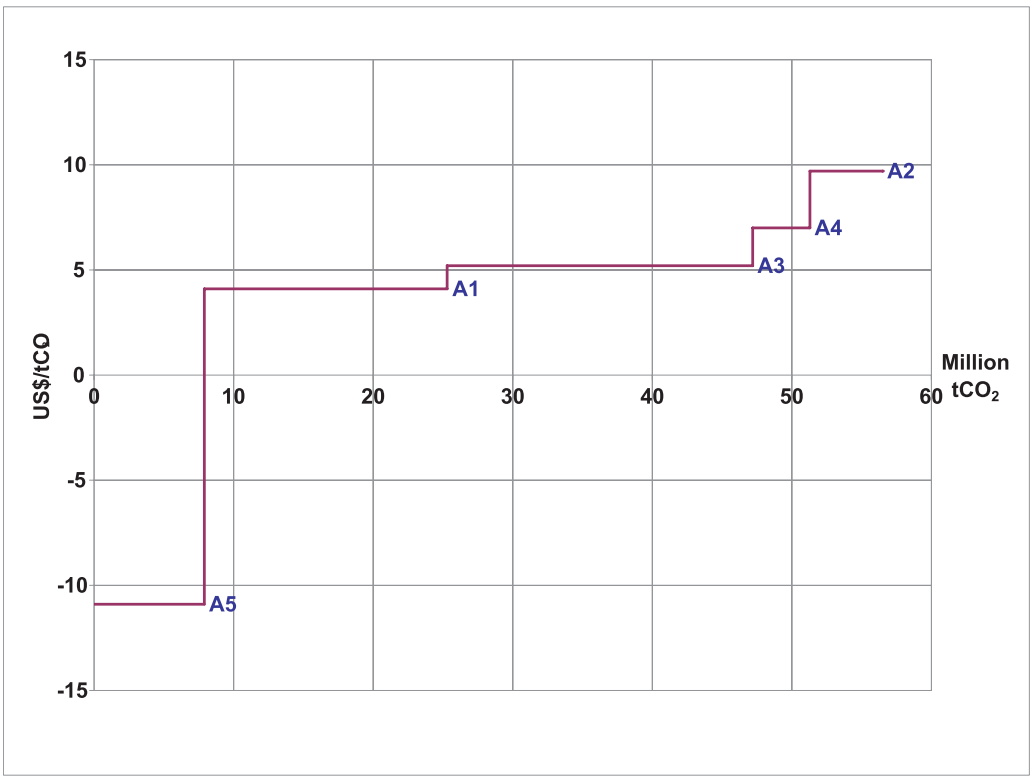


Figure 4.3. Cost of emission reduction initiatives curve for mitigation options in agriculture

4.2.3. GHG mitigation options in LULUCF

The Comprehensive Mitigation Analysis Process (COMAP) model was used in the development and evaluation of LULUCF mitigation options. COMAP supports forestry sector policy and development strategy analysis, and provides basic information on changes to carbon sinks, mitigation potential, mitigation costs and cost-efficiency.

4.2.3.1. Baseline scenario

The baseline GHG emission scenario for LULUCF was built upon the Viet Nam's Forestry Development Strategy for 2006-2020. The strategy sets specific goals to be reached between 2001 and 2020, consisting of the sustainable management of 8.4 million ha of production forests including 4.15 million ha of planted forests and 3.63 million ha of natural forests, quality control, planning and utilization for 5.68 million ha of protection forests and 2.16 million ha of special forests, reforestation of 0.8 million ha in depleted woodlands, and afforestation for 2.5 million ha of land.

4.2.3.2. GHG mitigation options

Mitigation options were developed, assessed and adopted for LULUCF on the following criteria:

- The ability to support the implementation of the National Forestry Development Strategy 2006-2020;

- The ability to reduce GHG emissions and produce concrete positive effects on the environment;

- Feasible, economically and socially beneficial (easily integrated into other national target programmes such as poverty reduction and hunger eradication, or conservation of protection forests)

There are eight GHG mitigation options in LULUCF, developed and assessed by COMAP.

❑ *Option F1: Protection and sustainable management of existing production forest areas*

Scenario assumption: Over a 40-year period, two million ha of existing timber forest will be protected.

The carbon sink enhancement potential for this option is 904 million tCO_2, at an abatement cost of US$1.36/$tCO_2$.

❑ *Option F2: Conservation of existing protection forests*

Scenario assumptions: Over a 40-year period, 2.5 million ha of existing protection forests will be preserved.

The carbon sink enhancement potential of this option is 1,153 million tCO_2, at an abatement cost of US$0.77/$tCO_2$.

❑ *Option F3: Reforestation of large timber forests in conjunction with natural regeneration*

Scenario assumptions: Over a 40-year period 100,000 ha of large timber forests will be planted and surrounded for natural regeneration. Between 2001 and 2010, 5,000 ha of forests will be grown each year, 3,000 ha/year between 2011 and 2020, 1,500 ha/year between 2021 and 2030 and 500 ha/year from 2031 to 2040.

The carbon sink enhancement potential of this option is 80.5 million tCO_2, at an abatement cost of US$0.38/$tCO_2$.

❑ *Option F4: Planting long-rotation large timber trees*

Scenario assumptions: Over a 40-year period, 400.000 ha of timber forests will be planted, at a rate of 6,500 ha/year from 2001 to 2010, 14,500 ha/year between 2011 and 2020, 14,200 ha/year between 2021 and 2030, and 4,800 ha/year from 2031 to 2040.

The carbon sink enhancement potential of this option is 271 million tCO_2, at an abatement cost of US$0.55/$tCO_2$.

❑ *Option F5: Planting fast-growing trees for lumber*

Scenario assumptions: Over a 15-year period, 600,000 ha of timber forests, such as acacia or eucalyptus, will be planted, at a rate of 90,000 ha/year for the first 5 years, 33,330 ha/year for the following 3 years and 10,000 ha/year for the next 5 years.

The carbon sink enhancement potential of this option is 297 million tCO_2, at an abatement cost of US$0.81/$tCO_2$.

❑ *Option F6: Planting short-rotation pulpwood forest*

Scenario assumptions: Over a 15-year period, 600,000 ha of pulpwood forests, such as acacia, eucalyptus, etc., will be planted, at a rate of 86,000 ha/year for the first 5 years, 33,330 ha/year for the following 3 years and 17,500 ha/year for the next 4 years.

The carbon sink enhancement potential of this option is 176.8 million tCO_2, at an abatement cost of US$1.38/$tCO_2$.

❑ *Option F7: Growing long-rotation non-timber product forest*

Scenario assumptions: Over a 40-year period, 200.000 ha of long-rotation non-timber forests (e.g. Sumatran pine or three-needled pine) will be grown at a rate of 10,000 ha/year for the first 10 years, 8,000 ha/year for the following 10 years and 2,000 ha/year for the next 10 years.

The carbon sink enhancement potential of this option is 118.9 million tCO_2, at an abatement cost of US$0.48/$tCO_2$.

❑ *Option F8: Planting melaleuca forest on alkaline wetlands*

Scenario assumptions: Over a 15-year period, 50,000 ha of melaleuca forests will be planted on alkaline wetlands at an average rate of 5,000 ha/year.

The carbon sink enhancement potential of this option is 25 million tCO_2, at an abatement cost of US$0.59/$tCO_2$.

The results for the eight LULUCF mitigation options, developed and assessed using COMAP, are presented in the following Table 4.5 and Figure 4.4.

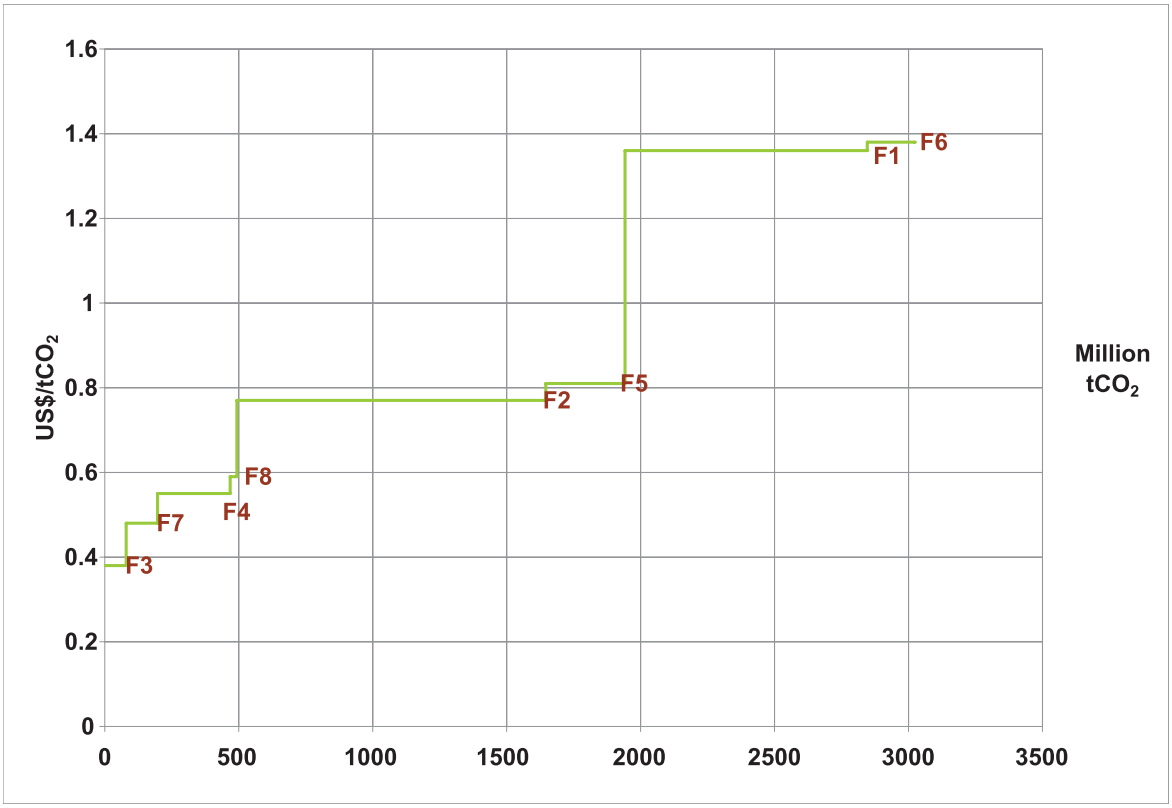


Figure 4.4. Cost of emission reduction initiatives curve for mitigation options in LULUCF

Table 4.5. Mitigation options potential and cost in LULUCF

Measure	F1	F2	F3	F4	F5	F6	F7	F8
Period (years)	40	40	40	40	15	15	40	15
Mitigation potential (million tonnes of CO_2)	904	1,153	80	271	296	176	117	25
Mitigation cost (US$/tonne of CO_2)	1.36	0.77	0.38	0.55	0.81	1.38	0.48	0.59

4.3. Conclusions

Viet Nam has developed and assessed 28 mitigation options for GHG sources and sinks. Of these 28 options, 15 are in the energy sector (including transportation), and 5 are in agriculture and 8 are in LULUCF.

Sectoral development plans for 2001-2020 with the vision until 2030 are the ground for designing the baseline scenarios necessary for the subsequent development and assessment of GHG mitigation options.

The LEAP model was used for energy and COMAP applied for LULUCF. In agriculture, mitigation options were assessed using statistical methods and methodologies consistent with Dr. J. Sathaye's mitigation option assessment guidebook.

The aggregated potential GHG mitigation of all 28 options in three sectors is 3,270.7 million tonnes of CO_2e, to which energy contributes 192.2 million tonnes, agriculture 56.5 million tonnes and LULUCF 3,022 million tonnes. Mitigation potential uncertainty levels are placed in order of increasing magnitudes, from energy to agriculture to LULUCF.

GHG abatement and sink enhancement costs vary greatly. These vary between US$-24.9 and US$23.8/tCO_2 for energy, between US$-10.9 and US$9.7/tCO_2 for agriculture and between US$0.4 and US$1.4/tCO_2 in LULUCF. Out of the 28 options, 11 have negative costs for reducing GHG emissions (signifying high economic returns). However, several options, for instance E8, E9, E10, and A5, demand high investment costs and therefore require government subsidies.

E2, E13, E14, E15, F4, F5, F7, and A1 can potentially be developed as CDM projects while F1, F2, and F3 are potential UN-REDD projects. E6, E8, E9, E11, E13, F2, and F4 are high-potential options which may quickly be adopted for implementation in Viet Nam.

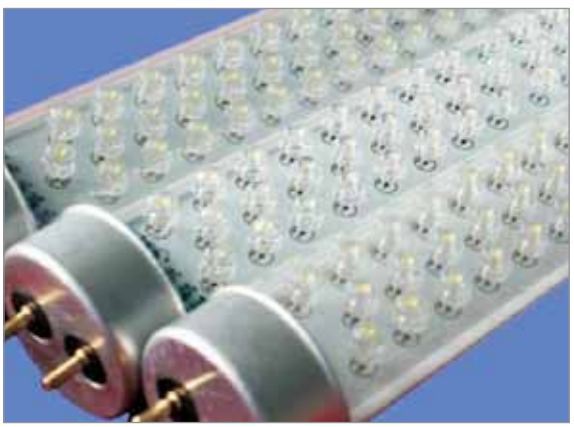
Potential GHG mitigation projects are listed and summarized in Annex 3. Small-scale hydropower projects have very high returns on investment while wind power and methane-recovery electricity generation projects have high investment costs and need support from the Government. The total emission reduction potential of these projects is over 15 million tonnes of CO_2e over 10 years.

Mitigation potential and cost of the 28 options across the three sectors are shown in Table 4.6.

Table 4.6. Mitigation potential and cost of 28 options in energy, agriculture and LULUCF

Option	Abbreviation	Mitigation potential (million tCO_2)	Mitigation cost (US$/$tCO_2$)
Replacing coal with LPG in household cooking	E2	22.0	23.80
Wind power replacing coal-fired thermal power	E14	14.2	16.20
Switching from coal-fired to LNG thermal power	E12	16.0	15.10
High-efficiency refrigerators	E3	7.3	12.30
Biogas replacing cooking coal in mountain areas	A2	5.2	9.70
Rice paddy field water drainage in South Central Coast	A4	4.1	7.00
Rice husk power replacing coal thermal power	E15	6.9	6.60
Rice paddy field water drainage in the Red River delta	A3	21.9	5.20
Biogas replacing cooking coal in lowlands	A1	17.4	4.10
Planting short-rotation pulpwood forest	F6	176.0	1.38
Protection and sustainable management of existing production forest area	F1	904.0	1.36
Planting short-rotation trees for lumber	F5	296.0	0.81
Conservation of existing protection forests	F2	1,153.0	0.77
Planting melaleuca forest on alkaline wetlands	F8	25.0	0.59
Planting long-rotation large timber trees	F4	271.0	0.55
Growing long-rotation non-timber-product forest	F7	117.0	0.48
Reforestation of large timber forests in conjunction with natural regeneration	F3	80.0	0.38
High-efficiency air conditioner	E5	9.9	-4.40
Innovative brick kilns	E8	14.2	-5.10
Solar water-heating appliances	E6	13.9	-6.20
Small-scale hydropower replacing coal thermal power	E13	15.3	-7.20
Energy-saving compact fluorescent light bulbs	E4	23.4	-8.20
MUB cattle feeds	A5	7.9	-10.90
LPG-fuelled cabs	E10	3.3	-11.00
Switching from DO to CNG in transportation	E9	2.1	-14.10
Innovative coal stoves	E1	25.3	-17.40
Using high-press sodium lamps in public lighting	E11	2.9	-22.80
High-efficiency electric motors	E7	15.5	-24.90
Total		**3,270.7**	

CHAPTER 5
ENVIRONMENTALLY SOUND TECHNOLOGIES APPLICATION



The Vietnamese economy has a low efficiency in the use of raw materials, fuel and energy. This is due to the use of old and outdated equipment and technology, and the inadequate management of energy development and utilization, which lead to growing energy consumption and increasing GHG emission.

5.1. Application of environmentally sound technologies

In recent years, new, modern and environmentally sound technologies have been transferred and applied in manufacturing industries, such as:

- Dense medium separation in coal preparation.

- Thermal power generation technologies such as coal-fired steam generators (boilers), fluidized beds, combined gas and steam (COGAS); or the 500 KV super high voltage transmission technology in electricity generation and distribution.

- Dry process technology in cement production (comprising 71% of the total production).

- Tunnel kilns and vertical-shaft continuous kiln technologies in brick production, LPG-powered kilns in ceramic production.

However, outdated technologies continue to be in widespread use, causing the level of environmental pollution, including the emission of greenhouse gases, to rise:

- Blast mining, manual loading and open-container transportation in surface mining.

- Wet and semi-dry process technologies in cement production, with 29 percent share of the total production.

- Conventional coal-powered kilns, with low energy efficiency and high emissions, in brick and ceramic production.

- Outdated and/or incompatible technologies used by small and medium private businesses in pulp and paper production, especially in packaging, tissues and low-quality writing paper production, without wastewater and toxic gas treatment systems.

- Inefficient use of energy in food processing such as brewing industry, soft drink production and fish processing, especially in the absence of an adequate wastewater treatment system, leading to high GHG emissions.

5.2. Study and application of new environmentally sound technologies

The transfer of environmentally sound technologies in the energy sector plays a key role in the national GHG emission reduction.

In energy supply, high efficiency coal mining and electricity generation technologies should be promoted, in conjunction with the development and application of renewable energies.

In energy consumption, energy efficiency and conservation should be given high priority.

There is a need for the deployment of additional environmentally sound technologies in order to develop a low-carbon economy.

5.2.1. Coal mining and oil and gas production

- Aerial photography, seismic exploration and advanced drilling techniques which enable both sampling and sample analysis in natural resources exploration (mineral mining) and reserves enhancement.

- Technologies permitting exploration to depths of 200 m and 300 m underground and high capacity machinery for surface mining.

- Underground coal gasification and uniform mechanization technologies in underground mining.

- Production diversification through coal gasification and liquefaction, coal preparation process mechanization, coal recovery enhancement and coal-induced pollution reduction.

- Advanced explosive techniques in underground mining.

- New tunnel methane recovery, storage and utilization techniques.

- Advanced oil spill prevention techniques.

- Techniques of associated gas recovery and utilization.

5.2.2. Electricity generation, transmission and distribution

- Clean coal technology.

- Thermal power technologies such as superheaters, supercriticial steam generators powered by crushed coal, circulating fluidized bed combustion, and integrated gasification combined cycle.

- Thermal power co-generation.

- Renewable energies (wind, solar, geothermal power and biogas, etc.)

- Energy loss and heat waste reduction.

5.2.3. Energy use

Cement production:

- Switch from vertical to rotary kilns.

- Waste heat recovery (WHR) technology to enhance energy saving.

Brick production:

Continued use of tunnel kilns and thorough conversion from conventional to vertical continuous kilns.

Steel manufacturing:

- Cleaner technology, with clean coke sintering and fractionation.

- Blast furnace with injection.

- Direct-current electric arc ovens using cold water to cool the inner walls of the oven and/or high-frequency furnaces.

Transportation:

- Switch from DO to CNG.
- Switch from petrol to LPG.

Civil area:

- Lighting technology.
- Advanced, high efficiency air-conditioning and refrigeration technologies.
- Innovative electric engine systems

In order to accommodate and deploy those advanced, environmentally sound technologies, Viet Nam needs more investment and technical experts.

The high capital costs of renewable energies, such as wind or solar power, pose real challenges to the extent of their development and deployment, particularly in the highlands or offshore territories.

5.3. Application of new technologies through CDM projects in Viet Nam

With the implementation of CDM projects as outlined in Article 12 of Kyoto Protocol, Viet Nam has received and applied a number of new technologies to mitigate GHG emissions.

As of October 2010, Viet Nam has had 34 CDM projects registered by the EB, generating total GHG emission reductions of 17.5 million tCO_2e. Viet Nam currently ranks 11th globally in registered CDM project quantity and 8th in issued Certified Emission Reduction (CERs) amount (Annex 2).

The CDM projects have used the following technologies:

- Recovery and utilization of associated gases from oil extraction as fuels for gas turbines in thermal power plants, such as Phu My, Ca Mau, Nhon Trach.
- Recovery and utilization of methane in solid waste and/or wastewater treatment for electricity generation.
- Recovery of waste heat in cement production for electricity generation.
- Utilization of wind, solar power and small-scale hydropower.

These technologies have made substantial contributions to GHG emission mitigation and the sustainable development of the country. However, any expansions in scale and scope of applications for CDM-transferred technologies are limited by insufficient capacity and resources.

CHAPTER 6
SYSTEMATIC OBSERVATION AND CLIMATE CHANGE RESEARCH

6.1. Hydro-meteorological and environmental observation system

Viet Nam's hydrological, meteorological and environmental observing system dates back to over 100 years. In the early days, this system consisted of 38 meteorological stations and 13 hydrological stations whose primary task was to gauge water levels in several main rivers. Today, this observation network has expanded to 174 meteorological surface stations, 248 hydrological stations, 17 oceanographic stations and 393 independent rain gauge stations across the country. However, the stations are distributed unevenly between regions, with varied station densities. In 1976, the system of air and water quality management was established.

Of the 174 surface-based meteorological stations, 145 stations have observation time-series data for over 30 years, 16 stations have data series for 20 to 30 years, and the rest have data records of less than 20 years. Observation data is archived in the Hydro-Meteorological Data Center of the National Hydro-Meteorological Service, Ministry of Natural Resources and Environment.

6.1.1. Surface-based station network

Surface-based stations are divided into three categories, on the basis of number of observed elements and transmission duties.

1st Category stations: Full observations of meteorological elements, continuous weather monitoring and data transmission eight times a day at 0100, 0400, 0700, 1000, 1300, 1600, 1900 and 2200. Stations in this category communicate both domestically and internationally.

2nd Category stations: Same observations as 1st Category stations excluding radiation and underground temperatures at greater depths. These stations transmit information four times a day at 0100, 0700, 1300 and 1900 or eight times a day like 1st Category stations upon request.

3rd Category stations: Same observations as 2nd Category stations, excluding atmospheric pressure. 3rd Category stations send information four times a day.

6.1.2. Upper-air meteorological network

The upper-air meteorological network consists of seven weather radar platforms, five radiosonde stations, seven pilot wind profilers, and three ozone-UV radiation stations.

Upper-air stations can observe temperature, humidity, and wind profile, or only wind at elevations of 30-35 km. Observations are done once or twice a day and information is distributed internationally and nationally.

Radar stations make observations on track, intensity and influence of important weather events such as storms, tropical cyclones, and downpours within 100-300 km, depending on radar active distance.

6.1.3. Agro-meteorological observation network

The network of agro-meteorological stations comprises 29 stations (15 principal stations, 12 ordinary stations and two specialised stations).

Observed elements usually include temperature, air humidity, or soil temperature at depths of 5, 10, 20, 50 and 100 cm below the surface and at other depths for case studies; soil humidity, water-related phenomena and other elements of field moisture balance, wind profile, radiation and other biological elements.

Figure 6.1. Meteorological station network

6.1.4. Hydrological observation network

The hydrological observation network is composed of 248 stations and thousands of observation points nationwide. On average, there is only one station for 4,140 km^2 in large river basins, and for 4,090 km^2 in smaller basins. The network is divided into three categories including 59 1st Category stations, 21 2nd Category stations and 168 3rd Category stations.

1st Category stations make observations on water level, water temperature, air temperature, rain, water discharge and suspended articles.

2nd Category stations make the same observations as 1st Category stations but exclude suspended articles.

3rd Category stations make the same observations as 2nd Category stations but exclude water discharge.

6.1.5. Marine hydro-meteorological station network

The sea-based hydro-meteorological network is composed of 17 stations, with 11 island-based stations, five coastal stations and one rig-based station. Because of the country's long coastline, complicated tidal activities and frequent typhoons and tropical cyclones, the current network is insufficient and not evenly distributed.

Observed elements include:

- Marine meteorology: winds, visibility, air temperature, rainfall, critical events, etc.
- Marine hydrology: wave, currents, sea surface, sea level, sea temperature, density and salinity, etc.

6.1.6. Network of air and water quality monitoring stations

The network of air and water quality monitoring stations includes 32 rainwater and dust sampling stations, two acidity control stations under the East Asian network of acidity control stations, ten automated atmosphere quality control stations, 51 river water quality management stations, 48 river salinity control stations, 11 reservoir environment management stations and six marine environment stations.

Observed elements include:

- Air quality: dust, rainwater chemical components, SO_2, NO_x, and CO.
- Ocean, river and lake water quality: temperature, conductivity, colour turbidity, pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, nitrogen concentration, phosphorous concentration and other solutes.

6.2. Hydro-meteorological forecasting system

Viet Nam's hydro-meteorological forecasting system consists of three levels: national (National Centre for Hydro-Meteorological Forecasting), regional (Regional Hydro-Meteorological Services) and provincial (Provincial Hydro-Meteorological Services). Serving hydro-meteorological forecasting are systems of observation, telecommunication and data processing.

The current telecommunication network includes the global telecommunication system, the Internet and the national information system.

6.3. International cooperation and information exchange in hydro-meteorology

As a member of the World Meteorology Organization (WMO) and Regional Association II - Asia (RAII), Viet Nam has been actively engaged in implementing the scientific and technological programs of both organizations, in particular the World

Figure 6.2. Hydrological station network

Weather Watch and Global Observing Systems. Viet Nam's international telecommunication stations are part of the WMO and RAII networks and operate normally on a regular basis. Viet Nam is also an active member of Typhoon Committee (UNESCAP, WMO) and the Mekong River Commission. The country has established bilateral cooperation with other countries in hydro-meteorology. Indeed, three international hydro-meteorological information channels - Hanoi-Moscow, Hanoi-Bangkok and Hanoi-Beijing - have been set up to promote global and regional hydro-meteorological communication.

6.4. Strengthening natural resources and environmental observation network

The current natural resources and environmental observations network has inadequate infrastructures and equipments. Experienced technical experts are limited.

In an effort to strengthen hydro-meteorological capacity, the Government issued Decision 16/2007/QÑ-TTg dated 29th January 2007 on approving the Master Plan of the National Natural Resources and Environmental Observation Network until 2020. This Master Plan includes, inter alia, hydro-meteorological observation networks, consiting of meteorological, hydrological, marine meteorological observations, air and water environment monitoring.

Both the expanse and quality of Viet Nam's hydro-meteorological networks are being gradually improved and upgraded with superior hydrology and meteorology forecasting capacity.

6.5. Climate change research

In recent years, climate change research has been carried out by governmental agencies, science academies, universities, institutes and NGOs with international assistance at different levels and in various forms. In general, research themes center on:

- Basic climate change knowledge, and vulnerability analysis and assessment of Viet Nam's coastal zones.

- Analysis of climate change impacts on the natural conditions and resources of Viet Nam and mitigation and adaptation strategy formulation to ensure Viet Nam's sustainable social and economic development.

- Agro-climate change impacts in seven ecoregions; adjustment strategies for agricultural planning and production, and rural sustainable development.

- Climate change impact assessment for water resources.

- Climate change and sea-level rise scenarios for Viet Nam.

- Development of electricity grid emission factor for the preparation of Viet Nam's CDM projects.

- Development of renewable energies and energy efficiency.

- Development and assessment of mitigation options for energy, agriculture, forestry and land-use change.

- Piloting adaptation measures in some provinces, such as Quang Nam, Ben Tre and Thua Thien Hue.

- National CDM strategy and CDM project formulation capacity-building.

- Technology needs assessment for adaptation and mitigation to climate change.

As part of the implementation of the National Target Program to Respond to Climate Change, Viet Nam is developing the Scientific and Technological Program on Climate Change, with the aim of establishing a scientific foundation to support policy making, strategy formulation and action plan development for climate change response. Furthermore, Viet Nam is part of UNEP's Global Technical Needs Assessment Project - Phase I (2010-2011), which assesses the country's technical needs with support from UNEP.

CHAPTER 7
EDUCATION, TRAINING AND PUBLIC AWARENESS-RAISING

7.1. Education and training on climate change

7.1.1. Formal education

Until recently, climate change was merely cursorily touched upon as part of environment studies programs and did not constitute an official domain of study in Viet Nam's formal educational system.

In recent years however, major educational and training institutions across the country including the Ha Noi National University, Ha Noi University of Technology, National Economics University, University of Forestry, Hue University, Ho Chi Minh City National University, Ho Chi Minh City University of Technology, University of Agriculture and Forestry, Can Tho University, have begun offering Climate Change Studies in their official curricula for students and researchers.

At Ha Noi University of Technology, climate change and CDM have been mainstreamed into the fourth-year curriculum for Environmental Management majors. Ha Noi National University has made climate change part of the compulsory core curriculum for Environmental Studies Master's degree and has plans to offer a Master's degree in Climate Change by early 2011.

In November 2008, Can Tho University, in collaboration with the US Geographical Survey and National Wetland Research Centre, established the Research Institute for Climate Change. One of the institute's goals is to provide graduate and doctorate-level training in climate change and climate change response.

Presently, Viet Nam has yet to establish a national climate change education and training program. However, in its effort to increase education and raise public awareness towards climate change within the scope of the NTP, the Government tasked the Ministry of Education and Training with developing climate change education and training programs at all levels for 2009-2015. Towards this goal, the Ministry of Education and Training has developed an Action Plan on Response to Climate Change and a project to mainstream climate change response into educational programs for 2011-2015.

7.1.2. Informal education

In 2008 and 2009, the Ministry of Natural Resources and Environment, in coordination with relevant agencies, developed a program framework and seminar documents for sector-wide climate change training workshops. A series of short courses for the natural resources and environment officials were held across the country at the national and local levels.

7.2. Climate change training and awareness-raising

Awareness raising activities have been broadened in both content scope and participant diversity. During preparation for the Second National Communication, MONRE organized numerous climate change workshops, seminars and forums with the participation of central and local policy makers, technical staff members as well as local communities. The Ministry of Agriculture and Rural Development and Germany's Federal

Ministry of Economic Cooperation and Development co-organized a regional conference on sustainable development in the context of climate change. In addition to imparting general knowledge of climate change causes and impacts, a range of in-depth technical issues were also introduced and discussed (Table 7.1)

Table 7.1. Main training and awareness- raising activities since 2000

Activities	Objectives	Content	Target participants
Workshops	Raise awareness on climate change and mainstream climate change issues into social and economic development strategies	- Climate change and measures to respond to climate change - Female members of parliament, members of the National Assembly's Science and Technology Committee - Climate change scenario publication - Introduction of the NTP	- Policy makers from the Party's Central Committee's Office, the National Assembly's Office, the President's Office and the Government Office - Members of parliament, female members of the National Assembly's Science and Technology Committee - Policy makers of relevant ministries and sectors
Seminars and technical workshops	- Raise awareness on climate change and the role of Viet Nam in international climate change efforts - Provide basic knowledge on identification and project development	- Basic knowledge on climate change - UNFCCC and KP implementation in Viet Nam - CDM project development and implementation	- News agencies - Research institutes, universities and colleges - Viet Nam Union of Science and Technology Associations; - Businesses - Experts in relevant fields
Thematic workshops	Provide basic knowledge on climate change and related issues	- Climate change and climate change response in energy and non-energy sectors - Carbon market and CDM	Experts from relevant ministries, sectors and localities

Specialized seminars	Develop climate change negotiation capacity and skill	- UNFCCC and Kyoto Protocol - Conference of Parties (COP) to UNFCCC	Experts from related ministries or sectors that have attended COP 14, 15, 16
Radio and television forums	Raise public awareness on climate change and CDM	- Climate change-related issues and its impacts on Viet Nam - CDM project development	Experts and scientists of climate change in various fields
Video clips, publications or documentaries	Rise public awareness on climate change and CDM	- Introduction to global climate change and climate change in Viet Nam - Capacity to respond to climate change - Benefits from CDM projects	- Mass-media organizations - Representatives of relevant ministries, sectors and research institutes - Representatives of relevant enterprises, companies
Awareness raising campaigns and competitions	Rise awareness on climate change for the targeted population	- Exploration of climate change and its impacts - Climate change response initiatives	Women, young people, students

Many climate change projects involving education, training and awareness raising activities, have been implemented (Annex 1).

However, the organization of public awareness raising activities for climate change has not been sufficiently coordinated, and lacks in inter-agency collaboration. In the NTP, the Government assigned the Ministry of Information and Communication the task of coordinating the development of specialized information programs (periodicals, radio, television, websites, etc.) to help raise public awareness on climate change. Similarly, MONRE was put in charge of coordinating with Viet Nam General Confederation of Labor and other social organizations, ministries and provinces to organize climate change awareness raising via information dissemination campaigns, educational games and competitions.

7.3. Information and communication network

Climate change information has been disseminated via the mass-media nationally and locally.

Reporters with a solid grasp of climate change issues through training, workshops and meetings, have been active and effective in relaying the information to the general public while also providing coverage of climate change-related news at both the domestic and international levels.

Climate change issues have been regularly mainstreamed into international events and national traditional festivals such as Tree-planting Festival, Earth Day, World Water Day, World Meteorology Day, Earth Hour as a topic of great interest particularly among the younger generations.

Several major climate change-related publications (books, periodicals, leaflets, video clips) have been translated, published and widely distributed (Table 7.2). The publication of these materials involved government agencies, such as MONRE, MARD, Viet Nam Television, Radio Voice of Viet Nam, as well as non-governmental organizations, such as the Viet Nam Association for Conservation of Natural Resources, and Center for Hydrology, Meteorology and Environment Science and Technology.

Table 7.2. Climate change publications

Materials	Publishing agency	Time
United Nation Framework Convention on Climate Change	MONRE	2003
Kyoto Protocol	MONRE	2003
Clean Development Mechanism	MONRE	2004
Introduction of CDM under the Kyoto Protocol and relevant information about CDM projects in Viet Nam	MONRE	2006
Kyoto Protocol and CDM - Questions and Answers	MONRE	2005
Guidelines on CDM Programme of Activities	MONRE	2009
Climate Change	Center for Hydrology, Meteorology and Environmnet Science and Technology	2008
Basic information on climate change	Viet Nam Assciation	2008
Climate change and sea-level rise scenarios for Viet Nam	MONRE	2009
Legal documents for the implementation of the UNFCCC and the KP in Viet Nam	Steering Committee for UNFCCC and KP Implementation	2007 - 2008
Viet Nam CDM projects list	MONRE	2007
Brief introduction of CDM	MONRE	2009
Summary leaflet of the 2000 national inventory with emission projections for	MONRE 2020-2030	2009
Video clips: Climate change response	Viet Nam Television	2010
Video clips: The Clean Development Mechanisms (CDM)	Voice of Viet Nam Television	2009
Video clip: Song Muc Hydropower - Double the Benefit	Voice of Viet Nam Television	2008
Video clip: Climate change - A year in retrospect	Voice of Viet Nam	2008

Every six months, the "Climate change" bulletin is published and distributed to ministries, departments and committees and other relevant experts and scholars. The bulletin contains general information on the UNFCCC and the KP, the implementation of the UNFCCC and the KP around the world and in Viet Nam, a climate change science and technology news as well as other relevant information.

Since 2009, as part of the climate change capacity-building project implementation for civil society organizations, a periodic news bulletin with news updates is published and distributed to relevant member agencies.

A number of specialized websites covering climate change issues, such as www.noccop.org.vn, www.vacne.org.vn and www.nea.gov.vn have been set up to provide timely global and national news updates.

www.noccop.org.vn

www.vacne.org.vn

7.4. The role of Non-governmental Organizations

Since the ratification of the Kyoto Protocol in 2002, the Government has issued a number of legal documents to guide the implementation of the UNFCCC and the KP. Accordingly, many NGOs have shown interest in climate change response activities as reflected by the organization of numerous workshops, training courses, educational games and competitions to different social target groups.

With the financial support from GEF, the Center for Hydrology, Meteorology and Environment Science and Technology organized 18 training courses in three provinces, Lao Cai in the North, Ninh Thuan in the Central region and Ben Tre in the South. These training courses introduced the basic concept of climate change, climate change manifestation in Viet Nam and its regions, and adaptation and mitigation measures. They also provided guidance on the content and method for public communication, and the development of climate change action plan framework and adaptation project at the local level.

In 2010, the United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Viet Nam carried out capacity-building and awareness-raising activities in some provinces. Study tours on reducing emissions from deforestation and degradation for policy makers, administrators and experts were conducted in Kien Giang province.

Thirteen workshops on climate change, REDD and UN-REDD have been held in two districts and ten villages in Lam Dong province, attended by hundreds of district and village cadres. Over 5,400 people from 20 villages in Lam Ha and Di Linh districts participated in 78 consultancy meetings. Climate change information was presented in a simple, easy-to-understand, and suitable manner to locals and local administrators, with the use of numerous posters and leaflets. In addition to these activities, information was also broadcast on radio and television. A group of seven communicators were sent out to villages to inform locals about climate change issues.

The Viet Nam NGO Climate Change Working Group was established in February 2008 as a forum to foster discussions and information sharing in order to facilitate inter-agency coordination between NGOs actively seeking solutions to the challenges posed by climate change in different sectors and fields.

In September 2008, the Viet Nam Network of Non-governmental Organizations and Climate Change was established with the following mandate:

- Coordinating climate change response activities between Viet Nam-based NGOs.

- Promoting the best practices of solving climate change-related issues through community-based approaches. Coordinating and supplementing governmental actions.

- Shareing information on climate change projects, programs and solutions in Viet Nam.

So far, six NGOs have joined the network, yielding from rural sustainable development, marine species conservation, natural resources management, public health and environmental education.

Since 2009, a project on "Climate change capacity-building for civil society organizations" has been implemented with funding from Finland. The project consists of three components: (i) Communication and coordination; (ii) Training for climate change adaptation and mitigation; (iii) Experience sharing and expertise exchange, through climate change awareness-raising informational material, workshops, seminars and workshops.

In order to support the Global Campaign for Climate Action and linking Viet Nam's activities with the global climate change response, the Ministry of Education and Training, in collaboration with Oxfam and Save the Children, launched the "Climate is Changing, So is Our Life" competition for students to raise awareness on climate change and the 15th Conference of Parties in Copenhagen in 2009.

CHAPTER 8
LIMITATIONS, CONSTRAINTS AND CAPACITY BUILDING NEEDS

8.1. Limitations and constraints

The following limitations and constraints in various major activities are highlighted as follows:

8.1.1. National GHG inventory

- Related information and activities data for GHG inventory are inadequate, with built-in uncertainties and data management lacks coherence.

- The data collection process is slow. Data verification and validation are not undertaken on a continuous basis.

- The data collection system for greenhouse gas inventory is incomplete. A focal agency responsible for the national inventory's data collection, analysis, verification and update has not been established or designated.

- Research, assessment and verification for certain country-specific emission factors remains incomplete.

- A database supporting the inventory is not yet available.

- There is an inadequate pool of greenhouse gas inventory technical experts in the ministries and agencies. Inter-agency coordination remains to be desired.

8.1.2. Climate change impact and response measures

- The application of the MAGICC/SCENGEN 5.3 model in the development of climate change scenarios, which produces low-resolution grid maps (300 by 300 km), makes it difficult to accurately reflect the local specificities of climate change in Viet Nam.

- The database for impact assessments and adaptation measures development, particularly data used in adaptation measure cost-benefit analyses, is incomplete.

- There is currently a lack of in-depth analysis to distinguish and assess impacts induced by climate change from other natural phenomena.

- Adaptation impact assessment and response measure development models and tools are insufficient, in particular for cross-sector or inter-regional assessments.

- The assessment of technological needs for adaptation lacks capacity, methodology and database.

- There is a shortage of technical experts capable of running impact assessment and adaptation measure development models.

8.1.3. GHG mitigation options

- Insufficient long-term planning information and data, and the over-reliance on projections for 2025 impose additional approximations for a number of longer term projections and computations.

- Some IPCC emission factor defaults for energy technologies may not be suitable when applied to Viet Nam's current circumstances.

- Data on investment costs, fuel prices and other costs were assembled from a variety technical reports and sources leading to increased uncertainty levels in GHG mitigation option assessments.

- Master plans for various GHG mitigation-related sectors have not been developed or are incomplete.

- The technical capacity to apply models such as MARKAL, LEAP, EFOM-ENV, STAIR,

DSSAT, and COMAP in the development and assessment of mitigation options and mitigation projects remains limited.

8.1.4. Adoption of environmentally sound technologies

- Outdated technologies continue to be in widespread use, causing the level of environmental pollution, including the emission of greenhouse gases, to rise.

- The combination of insufficient investment and a lack of technical experts make it difficult for the comprehensive transfer and application of modern environmentally sound technologies.

- High capital costs hinder the development and application of renewable energies.

- Any expansions in scale and scope of applications for environmentally sound technologies are limited by insufficient capacity and resources.

8.1.5. Systematic observation and climate change research

- Existing hydro-meteorological observational infrastructure and telecommunication systems are insufficient and lack uniformity.

- The current observation network is insufficient and inadequately distributed across climate zones and therefore unable to meet the demands for climate monitoring, early disaster warning and control.

- Professionals have limited technical capacity.

- Broad national studies have not been conducted with regard to the application of comprehensive multi-sectoral approaches to assess climate change impacts and develop adaptation measures for the most vulnerable sectors and ecosystems.

8.1.6. Education, training and public awareness

- Climate change education, training and awareness-raising plans and programs are unavailable at the national level.

- Higher-education curricula and content remain in pilot stage. There is no course material available at the primary and secondary education levels.

- The dissemination of basic information on climate change relies on efforts by specialised bodies, NGOs and international collaborative projects. Public awareness-raising has been therefore limited, reaching only select agencies and provinces. Furthermore, awareness-raising activities remain campaign-like rather continuous projects and are yet to be permanent fixtures in mainstream media programs.

8.2. Capacity-building needs

- One of the NTP's objectives is the review of the existing legislation related to climate change, supplementation and completion of the legal framework, with policies and mechanism in order to support climate change response activities in Viet Nam. The NTP also establishes a Climate Change Science and Technology Program.

- Climate change and sea-level rise scenarios were developed in 2009.

- Governmental bodies and provincial governments are developing their action plans to respond to climate change.

- Viet Nam has carried out a number of climate change-related projects (Annex 1)

In order better fulfill its duties and commitments as a Party to the UNFCCC and the KP, Viet Nam has identified its capacity-building needs for the following areas:

8.2.1. Institutional and administrative

- Legislations to guide and support the implementation of the UNFCCC and climate change response programs in Viet Nam must continue to be concretized to ensure the broadest possible participation nationally, under an integrated climate change response program.

- Coordination between ministries, agencies and provinces needs to increased and strengthened.

- Ministerial, agency and provincial climate change response action plans need to be promptly developed and mainstreamed into social and economic development programs.

- Capacity-building for administrators and specialists in climate change and GHG inventory-related ministries, agencies and provinces must continue to be strengthened.

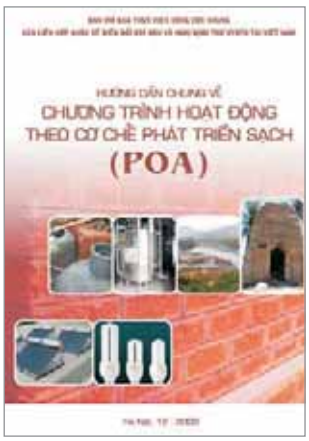
8.2.2. Technology development and transfer

- It is necessary to assess the level of technological needs, including endogenous demand, in mitigation and adaptation at the ministerial, agency and provincial levels.

- Technical experts and professionals need to be trained in order to facilitate the prompt and successful adoption of new technologies.

- It is important to seize opportunities to steer development towards a low-carbon economy through the implementation of climate change, particularly CDM projects.

- Technology transfers originating from abroad and destined for priority areas are required to be climate-friendly and compatible with Viet Nam's sustainable development.



8.2.3. Financial capacity

- Develop long-term and medium-term financial plans in climate change action plans to ensure the implementation of climate change response activities.

- Maximize international financial support (bilateral and multilateral) through the implementation of climate change projects and programs in Viet Nam.

- Mobilize domestic funds from all economic sectors to effectively implement the UNFCCC.

8.2.4. Education, training and public awareness

- Develop climate change education and training programs in school curricula.

- Develop specialized information programs (on newspapers, journals, television, websites, etc.) to raise public awareness on climate change.

- Promote climate change-related gender issues.

- Organize climate change awareness-raising activities via information dissemination campaigns, educational games and competitions.

8.3. International support for the development of the Second National Communication and beyond

As a developing country, Viet Nam has received financial assistance from the GEF through the UNEP for the preparation of national communications under the UNFCCC. The development of the Second National Communication also received technical support from the UNESCAP.

From 1999 to 2002, Viet Nam developed the Initial National Communication to the UNFCCC, funded by the GEF and co-funded by the Government of Viet Nam at US$212,500 and US$50,000, respectively.

Between 2004 and 2005, Viet Nam implemented the second phase of the Expedited Financing for Interim Measures for Capacity Building in Priority Areas project - a follow-up to the Initial National Communication. Funded to the amount of US$ 100,000, the project sought to build capacity and maintain interim activities pertaining to the collection and dissemination of information related to climate change response between the Initial and Second National Communication.

From 2006 to 2010, Viet Nam implemented project "*Viet Nam: Preparation for Second National Communication under the United Nations Framework Convention on Climate Change.*" Of a total project expenditure of US$485,000, US$405,000 was provided by GEF trust funds, US$60,000 by reciprocal funds from the Government of Viet Nam, and US$20,000 in-kind by UNESCAP through the provision of technical experts on-site.

Viet Nam highly appreciates and values the assistance provided by the GEF and the UNEP and technical support from UNESCAP and related international organizations. The preparation of this Second National Communication also shed light on the current challenges and shortcomings faced by climate change-related activities in Viet Nam. These were summarized in Section 8.1.

The approval and implementation of the NTP reflect Viet Nam's proactive stance in climate change response, as it looks forward to increased technical and financial support from developed countries and international organizations.

Areas where continued capacity building would directly benefit the preparation and quality of future communications to the UNFCCC are:

- Scenario development using new and highly reliable models and tools for the entire territory and for each specific economic region.

- Determination of Viet Nam-specific emission factor values, through survey and analysis, in order to reduce uncertainties of national GHG inventories.

- Assessment of vulnerability for ecosystems, economic and social impacts from climate change and development of appropriate adaptation measure that include policy measures.

- Application of cost-benefit analysis to evaluate climate change response measures and solutions.

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ANNEX 1

Major Climate Change Projects in Viet Nam since 2000

No.	Theme/Project name	Donor	Implementing agency	Objective	Duration
1.	**Impact Assessment and Adaptation Measures**				
1.1	Vulnerability Assessment for Viet Nam Coastal Zones	The Netherlands	MONRE	Assess Viet Nam coastal zones' vulnerability to rising sea level (phase 2)	2000 - 2004
1.2	Impacts of Climate Change on Water Resources and Adaptation measures	Denmark	MONRE	- Build capacity to respond to climate change impacts on water resources	2008 - 2009
1.3	Ho Chi Minh City Adaptation to Climate Change: A Summary Report	Asian Developmen Bank	Ho Chi Minh City	- Enhance the city capacity to respond to climate change	2008 - 2009
1.4	Asian Cities Climate Change Resilience Network	Rockefeller Foundation	Can Tho, Binh Dinh, Da Nang	- Develop mitigation and adaptation capacity in a number of cities	2009 - 2010
1.5	Climate Change Impacts in Huong River Basin and Adaptation in its Coastal District Phu Vang (Thua Thien Hue)	The Netherlands	MONRE	- Build capacity to respond to climate change for sectors, economic areas and communities - Help implement the National Strategy on Poverty and Hunger Alleviation and Sustainable Development	2006 - 2008
1.6	Developing & implementing CC adaptation measures to increase resilience of national development	UNDP	MONRE	- Protect the environment and natural resources; - Develop institutional capacity and human resources, encourage technology transfer, and promote research and development	2008 - 2012

1.7	Reforestation for Adaptation to Climate Change (in Quang Binh province)	Federal Republic of Germany	Viet Nam Red Cross	- Raise awareness and the role of the society in responding to climate change	2006 - 2007
1.8	Benefits on Climate Change adaptation from Small and medium scale hydropower plants: Synergies and trade offs with rural development	Denmark	MONRE	- Study how small- and medium-scale hydropower plants benefit climate change adaptation	2006 - 2009
1.9	Viet Nam - Netherlands Integrated Coastal Zone Management	The Netherlands	MONRE	- Enhance technical and management capacity of Vietnamese partners, through climate change-related issues, to meet requirements for coastal management	2000 - 2003
1.10	Climate Change Adaptation and Mitigation Program - Viet Nam	Denmark	MONRE, Ministry of Industry and Trade, Quang Nam and Ben Tre People's Committees	- Build Viet Nam's capacity in responding to climate change to ensure the sustainable development and protect people from adverse impacts of climate change - Support the National Target Program on Energy Efficiency and Conservation	2009 - 2013
1.11	Supporting Program to Respond to Climate change	Japan, France	MONRE	- Support climate change-related actions and policies in accordance with the National Target Program to Respond to Climate change	2009 - 2012
2.	**Greenhouse gas mitigation**				
2.1	Viet Nam National Strategy Study on Clean Development Mechanism	Australia	MONRE	- Analyze CDM potential in Viet Nam - Develop a strategy to expand CDM market in Viet Nam	2001 - 2005

2.2	Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (PREGA)	Asian Development Bank	Ministry of Industry and Trade (MIT)	- Promote investment in REGA technologies to achieve the goal of greenhouse gas mitigation - Generate a pipeline of investment projects for financing through commercial, multilateral and bilateral sources such as CDM and GEF. - Identify policy and institutional barriers when disseminating REGA technology - Study and develop financial models for REGA projects	2002 - 2004
2.3	Biogas Program for the Animal Husbandry Sector in Viet Nam (piloting in three provinces of Bac Ninh, Hai Duong and Nghe An)	The Netherlands	MARD	- Reduce greenhouse gas emissions	2002 - 2005
2.4	Livestock Waste Management in East Asia	Global Environment Facilities, the World Bank	MONRE	- Reduce greenhouse gas emissions by CH4 sinks	2006 - 2010
2.5	National Action Framework for Reduction of Emission from Deforestation and Degradation (REDD)	UNDP	MARD	- Implement the REDD program under United Nations	2008 - 2010
2.6	Viet Nam Energy Efficiency Public Lighting	Global Environment Facilities	Viet Nam Academy of Science and Technology	- Reduce electricity consumption in public lighting in several cities, contributing to greenhouse gas emission reduction	2005 - 2009
2.7	Energy Conservation and Efficiency in Small and Medium Scale Enterprises	Global Environment Facilities	Ministry of Science and Technology	- Increase energy efficiency of small- and medium-scale businesses	2005 - 2009

2.8	Sustainable Land and Forest Management	UNDP	MARD	- Propose policy instruments to support forest degradation reduction. Improve the management policies of forest degradation and enhance carbon sinks and greenhouse gas reduction	2009 - 2012
3.	**Capacity building**				
3.1	Capacity Building for Clean Development Mechanism (CD4CDM) in Viet Nam	The Netherlands	MONRE	- Develop human resources and form a framework that will facilitate CDM projects in the country - Produce a pipeline of Viet Nam potential CDM projects, and adopt a straightforward and transparent procedure to validate and approve CDM projects in Viet Nam - Share experience in CDM implementation with other countries globally and in the region	2003 - 2006
3.2	Community-based Adaptation to Climate Change	Canada	Thu Thien Hue	Build capacity of formulating response strategy to climate change (at national and local levels)	2002 - 2005
3.3	Vietnam: Expedited financing for measures for capacity building in priority areas	UNEP	MONRE	- Improve performances related to climate change - Build capacity of preparing climate change programs, encourage technology transfers - Review news on technology transfer and public opinions on climate change	2004 - 2006
3.4	Capacity Development for National Climate Change Focal Point	Denmark	MONRE	- Develop capacity of providing information of NCCFP to policy makers in relevant ministries and sectors	2006 - 2009

				- Reconfirm the role of NCCFP in international cooperation	
3.5	Mainstreaming CC into socio-economic development planning	UNDP	Ministry of Planning and Investment (MPI)	Assist MPI in the integration of climate change into the social and economic development plan (nationally and locally)	2008
3.6	Preparedness for Disasters Related to Climate Change	The Netherlands	Viet Nam Red Cross	- Build mitigation capacity of Viet Nam to reduce negative impacts for people in areas that are susceptible to natural disasters and climate change	2003 - 2006
3.7	Community-based Natural Disaster Risk Management	The Netherlands	Viet Nam Red Cross	- Reduce climate change-induced disaster impacts via building capacity for the Red Cross and community	2007 - 2010
3.8	Strengthening national capacities to respond to climate change in Vietnam, reducing vulnerability and controlling GHG emissions	UNDP	MONRE	- Develop capacity for partners of National Target Programs in policy-making and planning, information and research	2009 - 2012
3.9	Capacity Building Project on Climate Change for Civil Society Organizations	Finland	Civil Society Organizations (CSO)	- Raise awareness of CSOs about mitigation and adaptation to climate change - Build capacity to integrate mitigation and adaptation measures into relevant programs	2009 - 2012
4.	**Education and Training**				
4.1	MediaNet Program	The UK	Viet Nam News Agency	Train journalists of environmental issues, including climate change	2008 - 2011
4.2	Capacity Building Project on Climate Change for Civil Society Organizations	Finland	CSO	- Raise awareness of CSOs about mitigation and adaptation to climate change - Build capacity to integrate mitigation	2009 - 2012

				and adaptation measures into relevant programs	
4.3	Community-based Adaptation to Climate Change in Quang Tri Province	UNEP	Viet Nam Union of Science and Technology Associations	- Raise awareness and capacity of teachers and students, and vulnerable communities to climate change; - Study options on adaptive livelihoods to climate change	2009 - 2010
5.	**Others**				
5.1	Viet Nam Initial Communication to UNFCCC	UNEP	MONRE	- Build technology and science capacity, gather and update efficient data for climate change and national greenhouse gas inventory to facilitate the national policy making process	1999 - 2002
5.2	Enabling Activities for the Preparation of Initial National Communication Related to the UNFCCC	UNEP	MONRE	- Gather relevant information under the guide of UNFCCC on preparation for National Communications	2005 - 2006
5.3	Viet Nam: Preparation of the Second National Communication to UNFCCC	UNEP	MONRE	- To help Viet Nam fulfil their obligations via preparation for the Second National Communication (SNC) based on guidelines approved in COP 8	2006 - 2009
5.4	Seal-level rise Scenarios and Possible Disaster Risk Reductions in Viet Nam	Denmark	MONRE	- Propose measures to protect humans and infrastructure in coastal zones from sea level rise, - Propose strategies for utilization and conservation of natural resources and environment in coastal zones	2008 - 2009

ANNEX 2

Viet Nam CDM projects registered by EB (as of 10/2010)

N.O	Project name	Duration	Total mitigation potential (tCO_{2e})
1	Rang Dong Oil Field Associated Gas Recovery and Utilization Project (Ba Ria - Vung Tau province)	10 years (2001 - 2011)	6,770,000
2	Song Muc Hydro Power Station Regeneration Project in Viet Nam (Thanh Hoa province)	07 years (2007 - 2013)	29,066
3	Dong Thanh Landfill gas CDM Project in Ho Chi Minh City	07 years (2008 - 2014)	1,033,328
4	Wind power plant No 1 - Binh Thuan 30 MW (Binh Thuan province)	07 years (2009 - 2015)	405,921
5	Cao Phong Reforestation Project (Hoa Binh province)	16 years (2008 - 2023)	42,645
6	Phu Mau Hydropower Project (Lao Cai province)	07 years (2009 - 2015)	95,438
7	Muong Sang Hydropower Project (Son La province)	07 years (2009 - 2015)	35,056
8	Suoi Tan Hydropower Project (Son La province)	07 years (2009 - 2016)	102,487
9	So Lo Hydropower Project (Hoa Binh province)	07 years (2009 - 2015)	114,422
10	Nam Pia Hydropower Project (Son La province)	07 years (2009 - 2016)	348,940
11	Wastewater treatment with Anaerobic Digester at Viet Ma starch processing plant (Tay Ninh province)	10 years (2009 - 2019)	398,140
12	Wastewater treatment with Anaerobic Digester at Truong Thinh starch processing plant (Tay Ninh province)	10 years (2009 - 2019)	423,890
13	Ta Niet Hydropower Project (Son La province)	07 years (2009 - 2016)	71,232
14	Phuoc Hiep I sanitary Landfill gas CDM project, Ho Chi Minh city	07 years (2009 - 2015)	926,454
15	An Diem III Hydropower Project (Lao Cai province)	07 years (2009 - 2016)	276,878
16	AVN08-S-01, Methane Recovery and Biogas Utilization Project, Nghe An province, Viet Nam	07 years (2009 - 2016)	360,222
17	AVN08-S-02, Methane Recovery and Biogas Utilization Project, Nghe An province, Viet Nam	07 years (2009 - 2016)	217,077
18	VN08-WWS-04, Methane Recovery and Biogas Utilization Project, Lao Cai province, Viet Nam	07 years (2009 - 2016)	317,474
19	VN08-WWS-03, Methane Recovery and Biogas Utilization Project, Yen Bai province, Viet Nam	07 years (2009 - 2016)	277,329
20	VN08-WWS-05, Methane Recovery and Biogas Utilization Project, Quang Tri province, Viet Nam	07 years (2009 - 2016)	285,771
21	Nam Gion Hydropower Project (Son La province)	07 years (2011 - 2018)	288,092
22	Nam Khoa 3 Hydropower Project (Lao Cai province)	07 years (2010 - 2016)	324,030
23	Nam Khot Hydropower Project (Son La province)	07 years (2010 - 2017)	195,471
24	Yam Tann Sien Hydropower Project (Lam Dong province)	07 years (2011 - 2018)	278,257
25	Ha Rao Quan Hydropower Project (Quang Tri Province)	07 years (2010 - 2017)	85,596
26	Coc Dam Hydropower Project (Lao Cai province)	07 years (2010 - 2017)	115,304
27	Lap Vo Rice Husk Biomass Power Plant (Dong Thap Province)	07 years (2011 - 2017)	276,545
28	Chieng Cong Hydropower Project (Son La Province)	07 years (2010 - 2017)	162,725
29	Pa Khoang Hydropower Project (Dien Bien Province)	07 years (2010 - 2017)	49,560
30	Dak Ne Hydropower Project (Kon Tum Province)	07 years (2010 - 2017)	144,158
31	Ea Drang 2 Hydropower Project (Dak Lak Province)	07 years (2010 - 2017)	96,383
32	Dak Rung Hydropower Project (Dak Nong Province)	07 years (2010 - 2016)	120,799
33	Suoi Sap 3 Hydro Power Project (Son La Province)	07 years (2010 - 2017)	194,417
34	Landfill gas recovery and utilization in Nam Son, Tay Mo landfills in Hanoi	07 years (2010 - 2017)	2,615,870

ANNEX 3

Potential greenhouse gas mitigation projects

Project 1. Dinh Hai rice husk combustion power co-generation

❖ ***Background:***

- The project's location is in the industrial zone of Tra Noc, Can Tho City. The total installed capacity of the power plant is 7 MW, with an annual gross power generation of 35 million kWh and gross steam generation of about 569 thousand tonnes.

- This project aims to produce and sell steam (for heating) to other manufacturers in the industrial zone and contribute electricity to the national power grid.

❖ ***Objectives:***

- Utilize rice residues for electricity generation to support power needs of other manufacturing facilities in the industrial zones and contribute to the national grid.

- Reduce greenhouse gas emissions.

- Support the local and national social and economic sustainable development.

❖ ***Activities:***

- Provide steam to other manufacturing facilities in the industrial zone.

- Replace the steam that has been produced by diesel-fueled steam generators.

- Generate electricity from rice husks.

❖ ***Expected results:***

- Less dependence on the fossil fuel in electricity production.

- Mitigation potential of 41,118 tonnes of CO_2 a year.

❖ ***Budget:*** US$2.4 million

❖ ***Duration:*** 2010-2016

Project 2. Electricity generation from bagasse at KSC, Viet Nam

❖ ***Background:***

- Purpose of the project will enhance the efficiency of the power plant by upgrading the existing cogeneration system.

- Bagasse from sugar processing will be used as input fuel for steam generators.

❖ ***Objectives:***

- Promote the utilization of the readily available local biomass, reduce heavy reliance on fossil fuels and, as a result, mitigate greenhouse gas emissions.

- Provide cheap electricity, due to reduction in transmission loss, which in turn results in cost reduction and quality improvement.

❖ ***Activities:***

- Install a new biomass residue-fired power plant at the site.

- Increase the electricity generation capacity of the existing cogeneration plant, with the additional electricity produced by adding a new 15 MW turbine to extend the electricity production time in the existing backpressure turbine when operating it at a higher load factor.

- Improve energy efficiency of the existing plant.

❖ ***Expected results:***

- Less dependence on the fossil fuel in electricity production.

- Mitigation potential of 18,141 tCO_2 a year.

❖ ***Budget:*** US$5.1 million

❖ ***Duration:*** 2010-2016

Project 3. NAT&L bagasse-based cogeneration power

❖ ***Background:***

- This project is undertaken by Nghe An Tate & Lyle (NAT&L) Sugarcane Joint Venture Company. It uses bagasse to generate steam and electricity for the company's internal demand and contributes the surplus electricity to the national power grid.

- The project will have an 18 MW generator installed on the premise of NAT&L in Nghe An province.

- Part of the project's steam production is supplied to the sugar producing facilities, while the rest will be used for electricity generation.

❖ ***Objectives:***

- Promote the utilization of the readily available local biomass, reduce heavy reliance on fossil fuels and mitigate greenhouse gas emissions.

- Provide cheap electricity due to transmission loss reduction, leading to cost-cutting and quality improvement.

- Ensure the company's stable production with the additional generated electricity.

❖ ***Activities:***

Generate electricity from the renewable resource and contribute to the national electricity gird, which will help contribute to the power grid development and local socio-economic growth.

❖ ***Expected results:***

- Reduced reliance on the fossil fuel in electricity production.
- Increased utilization of renewable resources
- Mitigation potential of 28,596 tCO_2 a year.

❖ ***Project budget:*** US$11.9 million

❖ ***Duration :*** 2010-2016

Project 4. NhonTrach 1 natural gas based combined cycle power plant

❖ ***Background:***

- The power plant uses natural gas extracted from Nam Con Son basin as fuel.
- Gas supply for the 450 MW plant is about 450 million m^3 a year.
- Generated electricity is to be supplied to the national grid.

❖ ***Objectives:***

- Promote the use of natural gas, which burns more cleanly and produces less greenhouse gas than coal or diesel.
- Improve air quality and reduce concentration of SO_2 and NOX in the atmosphere.
- Promote the use of high-efficiency turbines.

❖ ***Activities:***

- Install and operate a new natural gas-based power plant to connect to the national grid.
- Utilize the available local natural gas.

❖ ***Expected results:***

- Better utilization of renewable natural gas.
- Mitigation potential of 447,955 tCO_2 a year.

❖ ***Project budget:*** US$312.6 million

❖ ***Duration:*** 2010-2019

Project 5. 15 MW Hiep Son coke ovens waste heat power

❖ ***Background***

This project aims at building the Hiep Son 15 MW coke ovens waste heat power plant on the premise of a coking plant in Hiep Son district, Hai Duong province. The project adopts an advanced technology - a clean-type heat-recovery coke oven called QRD_2000 which can produce 350,000 tonnes of coke a year.

- Two 35 tonnes-per-hour waste heat boilers and a 15 MW steam turbine and generator are to be installed in the project.
- Electricity output of the project is expected to be 110,880 MWh.

❖ ***Objectives:***

- Utilize waste heat to produce electricity, save energy and natural resources and improve the environment.
- Reduce the reliance of the energy industry on fossil fuel and subsequently greenhouse gas emissions.
- Install a new coking plant which adopts and extends the modern technology of clean-type heat-recovery coke ovens.
- Replace the conventional coking technology with a more advanced and environmentally sound one.
- Reduce heat pollution by recovering excess heat, and eliminate waste heat temperature by using steam generators with a flue gas desulphurization system, which removes SO_2 from the flue gases, improving the air quality.

- Create job opportunities for local residents and increase their income.

❖ ***Activities:***

Install and operate a waste heat recovery coke oven power plant.

❖ ***Expected results:***

Mitigation potential of 61,798 tCO_2 a year

❖ ***Project budget:*** US$15.5 million

❖ ***Duration:*** 2010-2019

Project 6. Van Don wind power

❖ ***Background:***

- Van Don, an island commune off the coast of Quang Ninh province, is currently using diesel-generated electricity.

- This project will build a 10 MW wind power plant, consisting of 10 turbines located in Quan Lan, Minh Chau, Ngoc Vung, Thang Loi and Ban Sen. Annual gross power production is estimated at 30,000 MWh a year.

❖ ***Objectives:***

- Utilize the island's wind resources to produce and supply electricity to industrial manufacturing facilities, seafood processing factories, tourism services and residential use.

- Reduce greenhouse gas emissions through increased wind power use.

- Contribute to the local sustainable development.

❖ ***Activities:***

- Phase 1: install five turbines with total capacity of 5 MW in Quan Lan, Minh Chau, Ngoc Vung and Thang Loi.

- Phase 2: install five turbines with total capacity of 5 MW in Quan Lan, Minh Chau, Ngoc Vung Ban Sen and Van Canh.

- Set up further 16 km of high-voltage 22/35 kV transmission line, 20 km of low-voltage 0.4 kV transmission line and establish 15 to 30 400 - 500 kVA transformer substations.

❖ ***Desired results:***

- Substitute for part of diesel-based power.

- Increased use of renewable resources in Viet Nam.

- Larger share of industry in the island's GDP.

- Mitigation potential of 22,911 tCO_2 a year

❖ ***Budget:*** US$10.5 million

❖ ***Duration:*** 2011-2018

Project 7. Nhon Chau wind farm

❖ ***Background:***

- Nhon Chau, an island commune (Cu Lao Xanh) of Quy Nhon City under Binh Dinh Province, is currently using electricity produced by a diesel-based system, which includes a 110 kW substation, a 220 kW substation and 30 substations of 1.2 to 30 kW. Electricity price is at about VND2,000/kWh.

- The island has an enormous wind energy potential, with an average wind velocity of 7 to 7.5m/s and therefore enables the installation of many wind turbines to serve the population's needs.

❖ ***Objectives:***

- Utilize wind power potential to ensure a substantial electricity supply to the island.

- Reduce greenhouse gas emissions.

- Lower power price to VND800/kWh.

❖ ***Activities:***

Install two wind turbines with total capacity of 500 kW.

❖ ***Expected results:***

Wind power plant in place of several diesel-fired power generators.

- Higher electricity output to serve the needs of industry, tourism, aquaculture, culture and society.

- Mitigation potential of 1,200 tCO_2 a year.

❖ ***Budget:*** US$0.5 million

❖ ***Duration:*** 2011-2020

Project 8. Anaerobic wastewater treatment and energy recovery project at Xa Bang Rubber Factory, Ba Ria Rubber Company

❖ ***Background:***

- Wastewater from the natural rubber production processes is treated through a combination of open anaerobic digester and an aerobic lagoon.

- Methane which so far has been directly released into the atmosphere will be retrieved and used in electricity generation.

❖ ***Objectives:***

Recover methane for electricity generation, with an estimated capacity of 1,907 MWh/year, to support part of the factory power needs.

- Reduce carbon dioxide emissions from electricity generation.

❖ ***Activities:***

Install a further closed anaerobic lagoon system to recover methane released from the treatment of 300,000 tonnes of wastewater with chemical oxygen demand of 6,640 mg/l produced by manufacturing 15,000 tonnes of natural rubber a year.

❖ ***Expected results:***

- Methane emission reduction by a system of anaerobic lagoons and carbon dioxide mitigation for the energy industry.

- Lower chemical oxygen demand in wastewater.

- Reduced electricity budget.

- Mitigation potential of 9,400 tCO_2/year.

❖ ***Budget:*** US$1.4 million

❖ ***Duration:*** 2011-2020

Project 9. Dong Xanh JSC's wastewater treatment and methane recovery

❖ ***Background:***

- The project will add an anaerobic digester to the wastewater treatment system at the alcohol fuel manufacturing factory of the company in Dai Tan industrial zone, Dai Loc district, Quang Nam province. The recovered biogas will be recycled to produce thermal energy for drying material at the factory.

- The factory produces an average 400,000 liters of alcohol from starch and releases 2,500 m^3 of wastewater a day. Thus an anaerobic digester with biogas extraction capacity will be installed.

❖ ***Objectives:***

- Reduce methane emissions from sewage channels.

- Promote "state-of-the-art" wastewater treatment technologies.

❖ ***Activities:***

Install a wastewater anaerobic digester with methane recovery capacity to produce heat for material drying.

❖ ***Expected results:***

- Reduction in the fossil fuel use of the factory.

- Local air quality Improvement;

- Job opportunities for local people;

- Mitigation potential of 112,125 tCO_2 a year.

❖ ***Budget:*** US$6.8 million

❖ ***Duration:*** 2011-2020

Project 10. Methane recovery for energy production at Khanh Son landfill site

❖ ***Background:***

Khanh Son landfill site is 10 km from Da Nang city's centre and consists of an old controlled dumpsite from 1993 and a recent sanitary landfill site since 2007. The new landfill site receives 600 tonnes of waste a day.

❖ ***Objectives:***

- Utilize methane emitted from waste at the landfill site for electricity generation.

- Reduce greenhouse gas emissions from the landfill site and improve air quality

❖ ***Activities:***

- Design and build a standard landfill site, with the establishment of modern technologies and

procedures and installment of a methane recovery system at the site.

- Install electricity generator driven by methane recovered from the landfill site.

❖ ***Expected results:***

- Reduction in greenhouse gas emissions and improvement in air quality.
- Job opportunities.
- Power supplement for the factory activities.
- Mitigation potential of 40,900 tCO_2 a year.

❖ ***Budget:*** US$3,8 million

❖ ***Duration:*** 2011-2020

Project 11. Song Ong hydropower project

❖ ***Background:***

- The project aims at building a power plant with three generators on Ong River in Quang Son commune, Ninh Son district, Ninh Thuan province.
- Total installed capacity of the plant is 8.1 MW and it can generate a gross electricity output of 40.5 million kWh a year.
- The project will also focus on contributing renewable energy to the national grid.

❖ ***Objectives:***

Produce and supply electricity to the national grid from renewable resources and mitigate greenhouse gas emissions.

❖ ***Activities:***

- Build a water-turbine hydropower plant with high-efficiency generator.
- Encourage the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Less reliance on fossil fuel of power generation.
- Better renewable resources utilization.
- Job opportunities for local people;
- Mitigation potential of 23,540 tCO_2 a year.

❖ ***Budget:*** US$8.2 million

❖ ***Duration:*** 2010-2016

Project 12. Ngoi Phat hydropower project

❖ ***Background:***

- The project plans to build a power plant with three generators on Ngoi Phat River in Bat Xat district of Lao Cai province
- Total installed capacity of the plant is 24 MW and the gross power generation is expected to be 312.7 million kWh.
- The project will make contribution to the national grid by using renewable resources.

❖ ***Objectives:***

Produce and supply power to the national grid from renewable resources and mitigate greenhouse gas emissions

❖ ***Activities:***

- Build a water-turbine hydropower plant with high-efficiency generator.
- Encourage the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Less reliance on fossil fuel of power generation.
- Better renewable resources utilization.
- Job opportunities for local people.
- Mitigation potential of 215,783 tCO_2 a year.

❖ ***Budget:*** US$86,9 million

❖ ***Duration:*** 2010-2020

Project 13. Nam Pong hydropower project

❖ ***Background:***

- The project plans to build a power plant with three generators on Nam Pong River which runs through

Chau Hanh and Chau Phong communes, Quy Chau district of Nghe An province.

- Total installed capacity of the plant is 30 MW and the gross power generation is estimated to be 120 million kWh.
- The project will make contribution to the national grid by using renewable resources.

❖ ***Objectives:***

Produce and supply power to the national grid from renewable resources and mitigate greenhouse gas emissions

❖ ***Activities:***

- Build a water-turbine hydropower plant with high-efficiency generator.
- Encourage the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Less reliance on fossil fuel of power generation.
- Better renewable resources utilization.
- Job opportunities for local people.
- Mitigation potential of 68,265 tCO_2 a year.

❖ ***Budget:*** US$30.9 million

❖ ***Duration:*** 2013-2019

Project 14. Da Den hydropower project

❖ ***Background:***

- The project aims at building a power plant with two generators on Da Den River in Hoa My Tay commune, Tay Hoa district, Phu Yen province.
- Total installed capacity of the plant is 9 MW and the gross power generation will be 32.48 million kWh.
- The plant will contribute renewable energy to the national grid.

❖ ***Objectives:***

Produce and supply power to the national grid from renewable resources and mitigate greenhouse gas emissions

❖ ***Activities:***

- Build a water-turbine hydropower plant with high-efficiency generator.
- Encourage the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Less reliance on fossil fuel of power generation.
- Better renewable resources utilization.
- Job opportunities for local people.
- Mitigation potential of 18,312 tCO_2 a year.

❖ ***Budget:*** US$8.8 million

❖ ***Duration:*** 2011-2017

Project 15. La La hydropower project

❖ ***Background:***

- The project plans to build a power plant with three generators on La La River in Tan Lap commune, Tan Long district of Quang Tri province.
- Total installed capacity of the plant is 3 MW and the gross power generation is expected to be 12.1 million kWh.
- The project will make contribution to the national grid by using renewable resources.

❖ ***Objectives:***

Produce and supply power to the national grid from renewable resources and mitigate greenhouse gas emissions

❖ ***Activities:***

- Building a water-turbine hydropower plant with high-efficiency generator;
- Encouraging the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Less reliance on fossil fuel of power generation.
- Better renewable resources utilization.

- Job opportunities for local people.
- Mitigation potential of 6,822 tCO_2 a year.

❖ ***Budget:*** US$2.8 million

❖ ***Duration:*** 2010-2017

Project 16. Song Giang 2 hydropower project

❖ ***Background:***

- The project plans to build a power plant with three generators on Giang River in Khanh Trung commune, Tan Long district of Quang Tri province.
- Total installed capacity of the plant will be 30 MW and the gross power generation will be 99.5 million kWh.
- The project will make contribution to the national grid by using renewable resources.

❖ ***Objectives:***

Produce and supply power to the national grid from renewable resources and mitigate greenhouse gas emissions

❖ ***Activities:***

- Building a water-turbine hydropower plant with high-efficiency generator;
- Encouraging the employment and development of renewable resource technologies in Viet Nam.

❖ ***Expected results:***

- Lesser reliance on fossil fuel of power generation;;
- Higher renewable resources utilization;
- Job opportunities for local people;
- Mitigation potential of 57,210 tCO_2 a year

❖ ***Budget:*** US$19.8 million

❖ ***Duration:*** 2010-2019

Project 17. Microbial fertilizer production from municipal solid waste in Phuoc Hiep

❖ ***Background:***

- Solid waste is collected and transferred to Phuong Hiep, Cu Chi district of Ho Chi Minh City to be dumped at the sanitary landfill.
- The amount of waste disposed at Phuoc Hiep landfill every day is 3000 tonnes.
- The project aims at establishing a microbial organic fertilizer factory which is capable of producing 1000 tonnes a day, equivalent to 30% of the waste buried at Phuoc Hiep landfill.

❖ ***Objectives:***

- Treat and recycle 365,000 tonnes of garbage a year to produce 85,000 tonnes of microbial fertilizer and 10,000 tonnes of recycled plastic a year.
- Replace chemical fertilizers with microbial fertilizers produced from waste resources to improve the environment and contribute to the agriculture sustainable development.
- Social and economic benefits, such as jobs, income and quality environment, to local people.
- Promote technology of producing microbial fertilizers from waste will be promoted.

❖ ***Activities:***

Establish a microbial fertilizer factory using waste recycling technology.

❖ Expected results:

Mitigation potential of 241,778 tCO_2 a year

❖ ***Budget:*** US$34.2 million

❖ ***Duration:*** 2010-2016

Project 18. Promoting and expanding the use of clean fuel LPG in road traffic

❖ ***Background:***

- As the economy grows, transportation also develops at a rapid rate. Almost all means of road or inland waterway transportation are powered by gas or diesel which is carbon-intensive.
- There have been a few feasibility studies on the use of liquefied petroleum gas (LPG), a clean fuel which is able to replace gas in road traffic, in Viet Nam.

❖ ***Objectives:***

- Shift from diesel motors to LPG-powered vehicles in Hanoi, Ho Chi Minh City and Da Nang.

- Reduction in greenhouse gas emissions.

❖ ***Activities:***

- Strengthen technological capacity to enable a conversion from using gasoline to using LPG for motor vehicles.

- Conduct feasibility studies and compare the greenhouse gas mitigation potentials of petrol and LPG.

- Conducting a pilot project of introducing LPG into highway petrol stations with the aim of setting up separate LPG stations after the project.

❖ ***Expected results:***

Mitigation potential of 20.000 tCO_2 a year

❖ ***Budget:*** US$1 million

❖ ***Duration:*** 2011-2020

Project 19. A Luoi Reforestation

❖ Background:

Bringing back forest to the barren orange agent-contaminated land of A Luoi district, Thua Thien Hue province will provide livelihoods to poor local people, mostly ethnic minorities.

❖ ***Objectives:***

- Enhance carbon sinks.
- Improve living standards for local people.
- Improve soil protection and erosion control.
- Increase fertility and water retention capacity of soil.

❖ ***Activities:***

Cover 4,000 ha of barren land with plants and forest and create an intermediate zone for natural forests.

❖ ***Expected results:***

- 4,000 ha of reforestation on barren land in A Luoi district;
- Reforestation in degraded grassland or desertified land;
- More livelihoods for 1000 households of farmers in the area;
- Mitigation potential of 101,000 tCO_2 a year.

❖ ***Budget:*** US$2.7 million

❖ ***Duration:*** 2011-2040

Project 20. Installing solar water heating systems in the south of Viet Nam

❖ ***Background:***

- Electric water heaters are currently widely used among Vietnamese people, especially in urban areas. Electricity consumed for heating water comprises 15% of household power consumption.

- Hours of sunshine in the south of Viet Nam is high, thus this area has great potential for developing solar energy.

❖ ***Objectives:***

- Encourage energy-saving activities through the replacement of usual electric water heaters by solar-powered ones.

- Reduce greenhouse gas emissions.

❖ ***Activities:***

- Raise public awareness and encourage people to use solar-powered water heating appliances.

- Install 22,000 solar water heaters in household, kindergartens, small hotels and buildings in the south of Viet Nam.

❖ ***Expected results:***

- Reduction in household electricity consumption for water heating in the south of Viet Nam and resulting cuts on greenhouse gas emissions from fossil fuel-based power generation.

- Increased use of renewable resources and promotion of energy conservation.

- Safe and stable energy use and higher life standards for people.

- Mitigation potential of 7,596 tCO_2 a year.

❖ ***Project budget:*** US$11.5 million

❖ ***Duration:*** 2010-2017

ANNEX 4

Summary of National greenhouse gas inventory for the year 2000

Unit: thousand tonnes

Source/sink	Emissions of CO_2	Removals of CO_2	CH_4	N_2O	NO_x	CO	HFCs	SO_2	NMVOC	Total CO_2 equivalent (CO_2+CH_4+N_2O)
Total green house gas emissions emissions/removals	143,514.64	-75,748.73	3,164.12	53.83	312.63	4,344.83	0.28	9.86	364.44	150,899.73
I. Energy	45,900.00		308.56	1.27	222.23	1,609.17			224.40	52,773.46
A. Fuel combustion activities	45,900.00		68.35	1.27	222.23	1,609.17			224.40	47,729.05
1. Energy industries	11,174.15		0.15	0.09	24.92	2.05			0.54	11,205.20
2. Manufacturing industries and construction	15,020.36		1.47	0.20	33.90	42.37			2.81	15,113.23
3. Transportation	11,886.00		1.41	0.10	125.08	472.82			90.11	11,946.61
4. Commercial/Institutional sector	2,957.56		0.22	0.03	2.23	30.51			3.07	2,971.48
5. Residential sector	2,314.27		64.70	0.84	21.95	1,047.43			125.30	3,933.37
6. Agriculture/Forestry/Aquaculture	1,373.03		0.40	0.01	14.15	13.99			2.57	1,384.53
7. Others	1,174.63		0	0	0	0	0	0	0	1,174.63
B. Fugitive Emissions from Fuels	0		240.21	0	0	0	0	0	0	5,044.41
1. Solid fuels	0		89.26	0	0	0	0	0	0	1,874.46
2. Oil and Natural Gas	0		150.95	0	0	0	0	0	0	3,169.95
II. Industrial processes	10,005.72		0	0	0.79	4.40	0.28	9.86	140.04	10,005.72
A. Cement Production	6,629.05							3.99		6,629.05
B. Lime Production	821.99									821.99
C. Road paving with Asphalt									82.46	
D. Glass production									1.59	

E. Chemical Industry	19.00					0.05		0.56	0.03	19.00
F. Iron and Steel Production	2,535.68				0.18	2.06		2.45	0.21	2,535.68
G. Pulp and Paper Production					0.61	2.29		2.86	1.51	
H. Drink production									37.20	
I. Food Production									17.04	
J. HFC consumption										
III. Solvent										
IV. Agriculture			2,383.75	48.49	54.74	1,503.39				65,090.65
A. Enteric fermentation			368.12							7,730.52
B. Manure management			164.16							3,447.36
C. Rice cultivation			1,782.37							37,429.77
D. Agricultural soils				45.87						14,219.70
E. Prescribed burning of Savannas			9.97	1.23	4.46	261.71				590.67
F. Field Burning of Agricultural Residues			59.13	1.39	50.28	1,241.68				1,672.63
V. LULUCF	87,608.92	-75,748.73	140.33	0.96	34.87	1,227.87				15,104.72
A. Changes in forest and other woody biomass stocks	0	-49,830.18								-49,830.18
B. Land conversion	40,665.17		140.33	0.96	34.87	1,227.87				43,909.70
C. Abandonment of Managed Lands	0	-7,330.33								-7,330.33
D. CO_2 emissions and removals from soils	46,943.75	-18,588.22								28,355.53
VI. Waste			331.48	3.11						7,925.18
A. Solid waste			266.52							5,596.92
B. Wastewater			1.35							28.35
C. Industrial wastewater			63.61							1,335.81
D. Human waste				3.11						964.10

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