Korea's Third National Communication under the United Nations Framework Convention on Climate Change

Low Carbon, Green Growth

The Republic of Korea

"Today, on the occasion of the 60th anniversary of the founding of the Republic of Korea, I want to put forward 'Low Carbon, Green Growth' as the core of the Republic's new vision. Green growth refers to sustainable growth which helps reduce greenhouse gas emission and environmental pollution.

It is also a new national development paradigm that creates new growth engines and jobs with green technology and clean energy. Green growth is a future strategy that will enable a Miracle on the Korean Peninsula to succeed the Miracle on the Han River."

President Lee Myung-bak
August 15, 2008
Address on the national liberation day of the Republic of Korea

Foreword

By the Minister of Environment

I am pleased to present the Republic of Korea's Third National Communication under the United Nations Framework Convention on Climate Change (UNFCCC).

Our planet has been suffering from climate change impacts such as drought, flood, ecosystem disruption, etc. We are now at a point where climate disasters will threaten the survival of mankind if we fail to take adequate action.

In response, the international community has been making efforts to protect the environment by minimizing the impacts of climate change. The 17th session of the Conference of the Parties (COP 17) to the UNFCCC, recently held in Durban, South Africa, resulted in a decision to come to an agreement that will take effect in 2020. This new deal is to require both developed and developing countries to reduce greenhouse gas (GHG) emissions.

As a part of this international effort, Korea is making the effort to shift to a new paradigm that can reduce GHG emissions and foster economic growth simultaneously. One major example is *Low Carbon, Green Growth*.

During the 60th anniversary of founding of the Republic of Korea on August 15th, 2008, President Lee Myung-bak announced the *Low Carbon, Green Growth* paradigm as a new vision for the nation's next 60 years ahead. To promote this vision, the Presidential Committee on Green Growth was established, and the *Framework Act on Low Carbon, Green Growth* was enacted. This paradigm will make it possible to create a virtuous cycle of synergy between the environment and the economy while reducing GHG emissions.

During the COP 15 held in Copenhagen in 2009, Korea announced its national GHG reduction goal of 30 percent below the business as usual (BAU) projection by 2020. This goal is in line with the substantial deviation from the baseline of Non-Annex I countries indicated in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Since Korea is a Non-Annex I country under the Kyoto Protocol, this is such a challenging goal that set a great example.

In order to accomplish this goal, the Greenhouse Gas Inventory & Research Center of Korea (GIR) was founded in June 2010 to systematically manage the national GHG inventory and scientifically

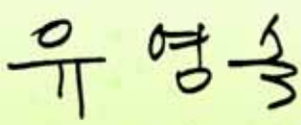
analyze the GHG reduction potentials. Subsequently, Korea has set the *GHG reduction goals by sector, by industry, and per annum*. These goals have been set for 25 different sub-sectors, including industries, building and transport, in the implementation plan for the reduction goal as of July 2011.

Also, the *GHG and Energy Target Management Scheme* was implemented in 2011 to assign a GHG emission cap to the GHG emitters that exceed legally-determined thresholds. This scheme is expected to cover about 90 percent of the industrial GHG emissions, and 70 percent of the total national GHG emissions.

Korea's commitment to green growth and climate change action has been recognized globally, as demonstrated by the OECD adoption of the green growth declaration, and the UN publication of the special report on the green growth of Korea. In addition, the government of Korea established the Global Green Growth Institute (GGGI) in August 2010 as an international asset to globally promote and disseminate the green growth paradigm.

This report, the Republic of Korea's Third National Communication, will be submitted to the UNFCCC as a sequel to our second report in 2003. As Korea is one of the few Non-Annex I countries to be submitting the report for the third time, we believe this demonstrates our strong, voluntary commitment to actively respond to climate change. The report summarizes the nation's accomplishments in efforts to reduce GHG emissions, including key strategies and measures, the GHG inventory compilation up to 2009, national climate change adaptation measures established in 2010, green technology investments for green growth, etc.

It is our strong conviction that taking action against climate change is not an option; rather, we believe it is a responsibility which every country should take. Utilizing our national achievements in green growth, we will continue to actively participate in the global efforts tackling climate change. We are already bridging developed and developing countries in response to climate change and promoting the *Low Carbon, Green Growth* paradigm with a focus on developing countries. Korea will stay committed to making voluntary efforts and continue to broaden the reach of cooperative activities globally for a better future.



Yoo Young Sook
Minister of Environment
December 2011

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Acronyms and Abbreviations

1PL	First-party logistics provider
2PL	Second-party logistics provider?
3PL	Third-party logistics providers
4PL	Fourth-party logistics provider
ADB	Asian Development Bank
AEO	Annual Energy Outlook
AFACI	Asian Food and Agricultural Initiative
ALU	agriculture and land use
APP	Asia-Pacific Partnership on Clean Development and Climate
ARM	Atmospheric Radiation Measurement
BAU	Business As Usual
BFI	Biofuels Initiative
BIS	Bus Information System
C&D	commercialization and deployment
C_2F_6	hexafluoroethane
C_4F_{10}	perfluorobutane
C_6F_{14}	perfluorohexane
CAFE	Corporate Average Fuel Economy
CARDI	Cambodian Agricultural Research Development Institute
CCD	Climate Change Division
CERT	Committee on Energy Research and Technology
CFC	chlorofluorocarbon
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2 Eq.	carbon dioxide equivalents
COP	Conference of the Parties
CRF	Common Reporting Format
CSLF	Carbon Sequestration Leadership Forum
DAR	Myanmar Department of Agricultural Research
EACP	East Asia Climate Partnership
EGCFE	Experts Group on Clean Fossil Energy
EGEEC	Expert Group on Energy Efficiency & Conservation
EGNRET	Expert Group on New and Renewable Energy Technologies
EHRD	National Institute of Environmental Human Resources Development
EMBARC	Embrapa Brazilian Agricultural Research Corporation
EPA	U.S. Environmental Protection Agency
Eq.	equivalents
ESCO	Energy Service Company
ETITF	Energy Trade and Investment Task Force
EWG	Energy Working Group
Ex-Im	Export-Import Bank
FY	fiscal year
G8	Group of Eight
G20	Group of Twenty
GAW	Global Atmosphere Watch
GCCE	Global Climate Change Education
GCM	Global Climate Model
GDA	Global Development Alliance
GDP	gross domestic product
GEF	Global Environment Facility
Gg	gigagram
GGGI	Global Green Growth Institute
GHG	greenhouse gas
GIR	Greenhouse Gas Inventory & Research Center of Korea
GPS	global positioning system
GWP	global warming potential
ha	hectare
HCFC	hydrochlorofluorocarbon
HD	high definition
HFC	hydrofluorocarbon
HFC-23	fluoroform
HFEs	hydrofluorinated ethers
HRFCO	Han River Flood Control Office
HVAC	heating, ventilation, and air conditioning
IAC	Industrial Assessment Center
IEA	International Energy Agency
INRAA	National Institute of Agricultural Research of Algeria
IOOS	Integrated Ocean Observing System
IPCC	Intergovernmental Panel on Climate Change
iPET	Institute of Planning and Evaluation for Technology of Food, Agriculture, Forestry and Fisheries
IPTA	Paraguay Institute of Agricultural Technology
IPY	International Polar Year
IRENA	International Renewable Energy Agency
IRENA	International Renewable Energy Agency
IRG	International Resources Group
ITS	Intelligent Transportation System
ITTO	International Tropical Timber Organization
KAFACI	Korea-Africa Food & Agriculture Cooperation Initiative
KARI	Kenya Agricultural Research Institute
KECO	Korea Environment Corporation
KEEI	Korea Energy Economics Institute
KEI	Korea Environment Institute
KEITI	Korea Environment Industry & Technology Institute
KEMCO	Korea Energy Management Corporation
KEPRI	Korea Electric Power Research
KETEP	Korea Institute of Energy Technology Evaluation and Planning
KFRI	Korea Forest Research Institute
kg	kilogram
KICSD	Korea Institute Center for Sustainable Development
KICT	Korea Institute of Constuction Technology
KICTEP	Korea Institute Construction & Transportation Technology Evaluation and Planning
KIEP	Korea Institute for Economic Policy
KIPF	Korea Institute of Public Finance

KISTEP	Korea Institute of S&T Evaluation and Planning
km	kilometer
km^2	square kilometers
KMA	Korea Meteorological Administration
KOICA	Korea International Cooperation Agency
KOPIA	Korea Project on International Agriculture
KREI	Korea Rural Economic Institute
KTI	Korea Transport Institute
kWh	kilowatt-hour
LULUCF	Land Use, Land-Use Change and Forestry
MCST	Ministry of Culture, Sports and Tourism
ME	Ministry of Environment
MEST	Ministry of Education, Science and Technology
MIFAFF	Ministry of Food, Agriculture, Forestry and Fisheries
MKE	Ministry of Knowledge & Economy
MLTM	Ministry of Land, Transport and Maritime Affairs
mm	millimeter
MMT	million metric tons
$MMTCO_2$	million metric tons of carbon dioxide
MOU	Memorandum of Understanding
MPAS	Ministry of Public Administration & Security
MPG	miles per gallon
MPO	metropolitan planning organization
MRV	Measurement, Reporting, and Verification
MSF	Ministry of Strategy and Finance
MSM	Multi-Scale Modeling
MSW	municipal solid waste
Mt	million tonnes (= 1 Tg)
MW	Ministry of Health & Welfare
MW	megawatt
MWe	megawatts electric
MWh	megawatt-hour
MY	model year
N_2O	nitrous oxide
NAAS	National Academy of Agricultural Science
NASA	National Aeronautics and Space Administration
NF_3	nitrogen trifluoride
NFRDI	National Fisheries Research & Development Institute
NGMS	National Greenhouse Gas Management System
NGO	nongovernmental organization
NIAS	National Institute of Animal Science
NIER	National Institute of Environmental Research
NIMR	National Institute of Meteorological Research
NIR	National Inventory Report
NO_x	oxides of nitrogen
NP	nuclear power
NSTC	National Science & Technology Commission
NTI	National Transit Institute
O_3	ozone
℃	degree Celsius ([℉] - 32) × 5/9
ODS	ozone-depleting substance
OECD	Organisation for Economic Co-operation and Development
℉	degree Fahrenheit [℃] × 9/5 + 32
OPEC	Organization of the Petroleum Exporting Countries
PCGG	Presidential Committee on Green Growth
PFC	perfluorocarbon
PHEV	plug-in hybrid electric vehicle
PhiliRice	Philippine Rice Research Institute
PIH	plug-in hybrid
PM	particulate matter
POES	Polar Operational Environmental Satellites
PTC	production tax credit
PV	Photovoltaic
PVC	Polyvinyl Chloride
R&D	research and development
RD&D	research, development, and demonstration
RDA	Rural Development Administration
REC	renewable energy credit
REDD	reducing emissions from deforestation and degradation
REDI	Renewables and Efficiency Deployment Initiative
REEEP	Renewable Energy and Energy Efficiency Partnership
REPI	Renewable Energy Production Incentive
RES	renewable energy standard
RFS	renewable fuels standard
RGGI	Regional Greenhouse Gas Initiative
RISA	Regional Integrated Science and Assessments Program
ROK	Republic of Korea
RPS	renewable portfolio standard
S&A	synthesis and assessment
SCAN	Soil Climate Analysis Network
SEN	Save Energy Now
SERI	Samsung Economic Research Institute
SERVIR	Regional Visualization and Monitoring
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SUV	sport utility vehicle
SWAT	Soil and Water Assessment Tool
T&D	transmission and distribution
TAO	Tropical Atmosphere Ocean
Tg	teragram
Tg CO_2 eq.	teragrams of carbon dioxide equivalents
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UzSPCA	Uzbek Scientific-Production Center of Agriculture
VAAS	Vietnam Academy of Agricultural Science
VHTR	Very-High-Temperature Reactor
WAP	Weatherization Assistance Program
WMO	World Meteorological Organization
WRP	Wetland Reserve Program

Executive Summary

Chapter 1 National Circumstances

As of 2010, the Republic of Korea (hereafter Korea) became the 26th most populous country in the world with a population above 48 million, accounting for about 0.7 percent of the world's population.

64.5 percent of Korea's total land area is forests and woodlands, and 19.7 percent is agricultural land. The annual mean temperature range is 12.7℃ (54.9℉) as the country is located in the middle latitudes.

[Figure 1] Geographic location

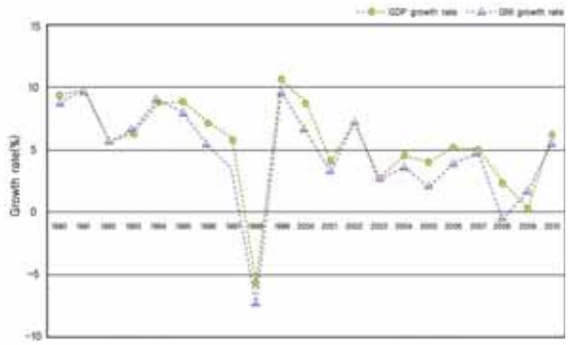
Korea is a presidential republic with three branches of government: executive, legislative, and judicial. The executive branch is made up of the President's Office, the Prime Minister's Office, several independent agencies, 15 cabinet-level ministries, plus the Ministry of Special Affairs. Two independent agencies (the Board of Audit & Inspection and National Intelligence Service), two commissions, and three councils report directly to the President. Two independent ministries and three commissions directly report to the Prime Minister. The executive branch also includes 18 affiliated agencies under their relevant ministries, headed by a vice-minister level commissioner (Figure 1).

The government of Korea operated the *Special Committee on Climate Change*, an inter-ministerial community to advise, develop, and implement climate change policies, from 1998 through 2007.

In 2008, *Low Carbon, Green Growth* was established as a national vision and the Presidential Committee on Green Growth (PCGG) was instituted to actively promote relevant policies and measures in addressing climate change.

From 1990 until 2010, Korea’s economy grew at an annual average rate of five percent. The nominal gross domestic product (GDP) increased from USD 270.3 billion to 1,014 billion. In that same time frame, the per capita GDP in Korea increased from USD 6,305 to 20,735.

Even though the global economy has recently been in decline (as evidenced by the European and US financial crises) and despite sharply rising oil prices, the economy of Korea continues to show 4 percent annual growth. With the new paradigm for economic growth,



Source : The Bank of Korea

[Figure 2] GDP and GNI growth rate

about two percent of the national GDP will be in green growth investments to simultaneously promote environmental protection and economic growth.

Primary energy consumption increased by 5.2 percent annually from 1990 until 2009, recording roughly 243.3 million tonnes of oil equivalent (TOE) as of 2009. Sources report, oil accounted for about 42.1 percent of the energy consumption in the same year, followed by coal (28.2%), LNG (13.9%), nuclear energy (13.1%), and hydro-power (0.5%).

Also, as energy security has become more eminently important, the government of Korea is making efforts to be able to supply more stable, cost-effective, and sustainable energy.

As of 2009, public roads accounted for 74.8 percent of modal share, followed by subway (17.0%), rail (8.0%), aviation (0.1%), and marine transport (0.1%). During a 20-year period, 1990 to 2009, the share of public roads had decreased due to factors such as the urban rail network expansion, as well as due to factors such as the shortened work week, etc. In contrast the shares of rail and subway still increased in the same time frame.

Population growth and increasing per capita income led to higher levels of car ownership. The number of registered vehicles in the country increased from 3.4 million in 1990 to 17.9 million in 2010, which is more than a five-fold rate of increase. In the same period, the number of passenger cars experienced a six-fold increase, from 2.1 million to 13.6 million.

Waste generation has become a social and environmental issue in the country due to rapid economic development. In response, the government of Korea is transforming its social structure to promote the virtuous circle of recycling. As of 2009, the amount of waste generation in the country was 357,861 tons per day. The total amount of waste generation has been gradually increasing since 1990. The rate of landfill waste has continued to decrease while the recycling rate has significantly increased. In the same period, the rate of incineration has slowly increased.

Economic development plans since 1960 have led to increased urban concentration as the planned development heavily focused on investing in only specific regions due to limited domestic resources and capital. In 2010, urban residents made up approximately 82 percent of the national population.

Over the past 10 years, agricultural land has decreased by 22 thousand hectares (ha) per year. The number of acres of land used for non-agricultural purposes, such as construction of new buildings and public facilities, has increased, while unused agricultural land has also increased.

The net loss of forest area has been 5,000 ha annually in the past decade. While the unused area has increased by 2,000 ha per year

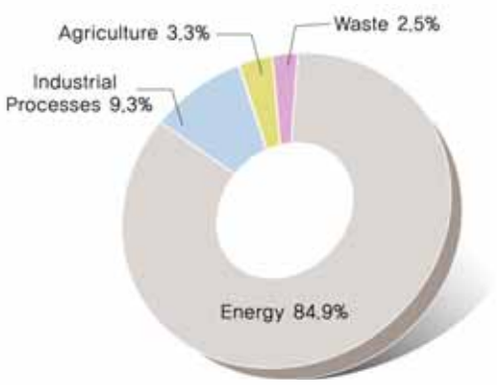
due to deforestation; available agricultural land has also decreased by 7,000 ha annually, as the area has been converted into building sites, road, industrial facilities, etc.

Chapter 2 Greenhouse Gas Inventory

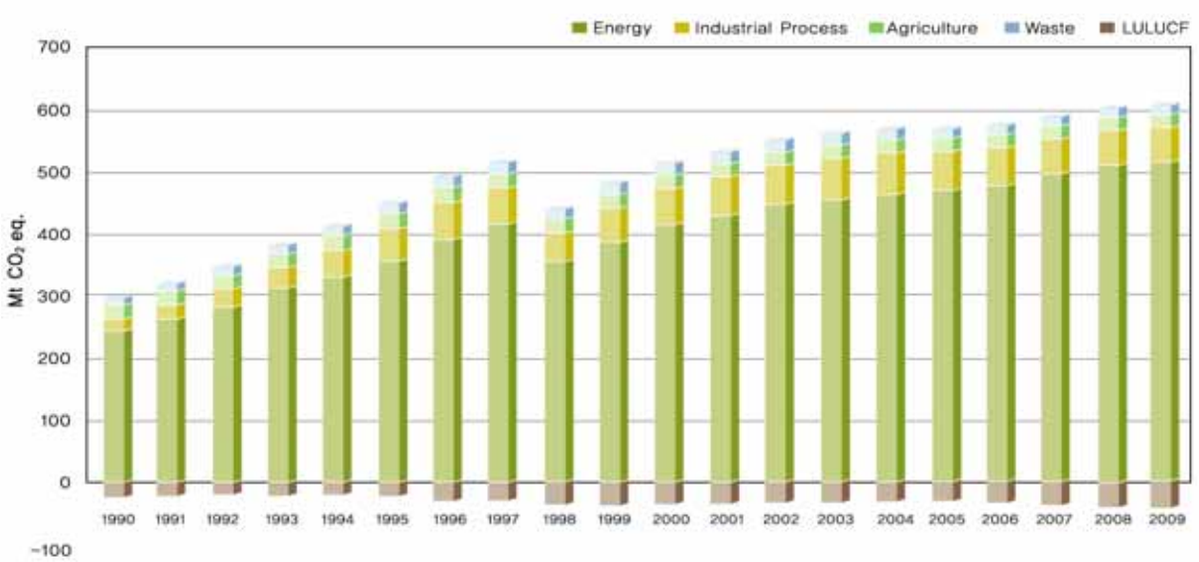
Korea's total greenhouse gas (GHG) emissions (excluding LULUCF) were 607.6 Mt CO_2 eq. in 2009, representing a 105.0 percent increase compared to 1990 and a 0.9 percent increase compared to the previous year. The total net GHG emissions (including LULUCF) were 564.7 Mt CO_2 eq., representing a 106.6 percent increase compared to 1990 and a 0.6 percent increase compared to the previous year. The energy sector accounted for 84.9 percent of the total emissions, followed by industrial processes (9.3%), agriculture (3.3%), and the waste sector (2.5%).

In 2009, GHG emissions per capita were 12.5 t CO_2 eq., an increase of 80.3 percent compared to 1990 levels. Total GHG emissions and GHG emissions per capita continued to increase; however, the rate of increase had been slowing down.

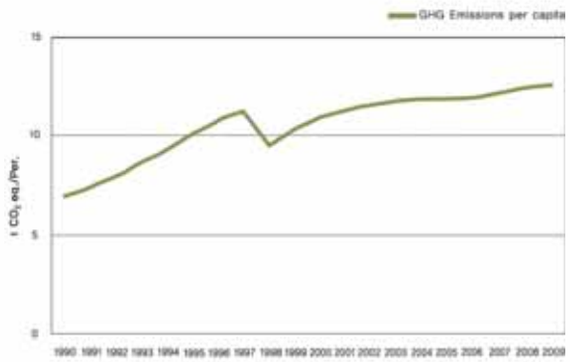
GHG emissions per real GDP in 2009 were 619.0 t CO_2 eq. per KRW billion, showing a 22.9 percent decrease from 1990. Emissions per GDP reflected a decreasing trend until 2009 when emissions per GDP indicated a slight increase. The increase could be attributed to increased demand for electricity due to extraordinary weather patterns and events.



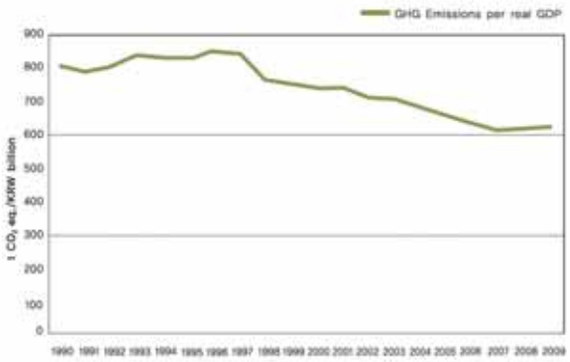
[Figure 3] Sectoral GHG emissions



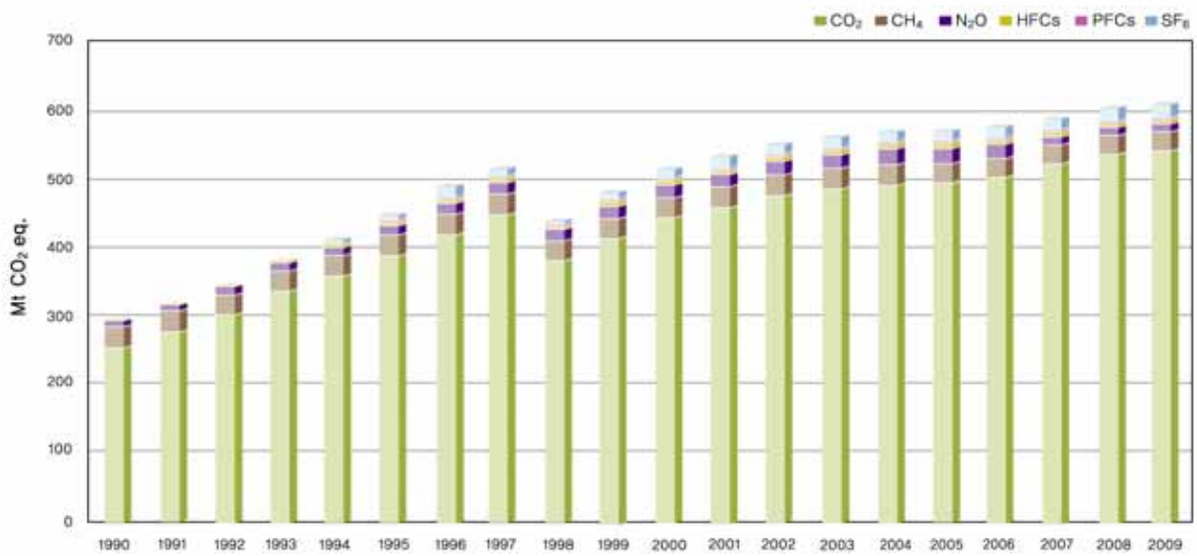
[Figure 4] Trends in GHG emissions and removals by sector



[Figure 5] GHG emissions per capita



[Figure 6] GHG emissions by real GDP



[Figure 7] GHG emissions by sources

In 2009, GHG emissions by gas were as follows: CO_2 was responsible for the highest proportion of total emissions (89.0%), followed by CH_4 (4.6%), SF_6 (3.1%), N_2O (2.1%), HFCs (1.0%), and PFCs (0.4%).

CO_2 and N_2O increased by 112.5 percent and 18.8 percent, respectively, compared to 1990 levels while CH_4 decreased by 9.1 percent. HFCs and SF_6 increased by 5.2 percent and 160.3 percent, respectively, but PFCs decreased by 4.2 percent compared to 1995 levels.

Chapter 3 Policies and Measures

As a member of the UNFCCC, Korea is actively moving forward with voluntary, multilateral policies and measures in several sectors, in order to find a solution to the global issue of climate change. Since 1998, Korea has organized and operated the *Special Committee on Climate Change*, which has led to the formation and promotion of *Comprehensive Action Plans for UNFCCC*.

Recently, Korea changed its policy direction to be more aggressive in its stance against climate change and proposed the *Comprehensive*

<Table 1> Summary of the policies & measures for GHG reduction by sector

Sector		Strategy	Policies and measures
All sectors		Reduction of GHG emissions caused by fossil fuels	GHG and Energy Target Management Scheme
Energy and industrial sector	Demand	Enhanced energy demand management in the industrial sector	Voluntary agreement
			Energy audit system
			Consultation on energy use plan
			Investment support for energy efficiency facilities
			Energy Service Company (ESCO) business expansion
			Cap on energy consumption for government and public sectors
	Supply	Expansion of new & renewable and clean energy supply	Program for new & renewable energy promotion
			Expansion of integrated energy supply system
			Stable supply of natural gas
			Maintenance of appropriate level of nuclear power generation
			Expansion of biodiesel supply
	Efficiency	Expansion of high-efficiency equipment supply	Energy efficiency standard & labeling program
			Enforcement of e-standby program
			High-efficiency equipment certification
	Reduction	Promoting early action on GHG reduction	Korea voluntary emission reduction registration program
			Industrial ad-hoc working groups for addressing climate change
Buildings		Intensification of building design standards	Building code for envelope insulation & energy-efficient design
			Energy efficiency labeling program for buildings
			Green building certification program
			Green building activation plan
Transport		Enhanced management of transport demands and efficient traffic system	Low carbon smart transit system
			Green public transport
		Revitalization of low emission vehicles	Foundation for distribution of electric vehicles
		GHG & energy policy for vehicles	Implementation of production and distribution of high-efficiency vehicles
		Establishment of low carbon distribution system	Low cost, high efficiency green distribution system
Agricultural & livestock		Improvement of agro-dairy farming methods	Reduction of CH_4 emissions from paddy fields
			Reduction in N_2O emissions in paddy field and upland
			Improvement of ruminant enteric fermentation
			Utilization of livestock manure as resources
Forestry		Protection and expansion of forest carbon sinks	Maintenance and enhancement of carbon sequestration potential
			Prevention of deforestation
			Afforestation/reforestation
		Implementation of forest carbon offset projects	Introduction of forest carbon offset program
		Promotion of use of wood bio-energy	Promotion of use of wood bio-energy
Waste		Minimization of waste occurrences and resource recovery	Reduction of waste
			Expanding reuse and recycling of waste
			Utilization of waste resources as energy

Action Plan for Climate Change (2008~2012), which includes environmental and industrial strategies, along with a framework for international cooperation. Additionally, the government of Korea has announced the recently decided national mid-term GHG reduction goal of 30 percent below BAU by 2020. Relevant policies and measures for each sector are being implemented systematically.

The power and industrial sectors are promoting efforts for GHG reduction policies centered on energy demand, supply, and efficiency improvement. A variety of policies are in place to manage energy demands for the industrial sector, including expanding the supply of new & renewable and clean energy sources, and improving energy efficiency by increasing the supply of high efficiency equipment.

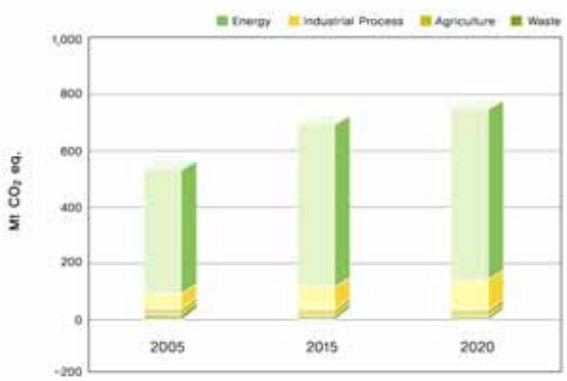
In the building sector, efforts to reduce GHG emissions are made through the reinforcement of building design standards for energy, the expansion of the efficiency level certification system, and the enhancement of green building certification programs.

In the transport sector, policies are being enforced in relation to the strengthening of transport demand management, improvement of the public transit system, increasing the number of low-emission vehicles, establishing a low-carbon distribution system, etc.

In addition, a variety of policies are being promoted for the improvement of agricultural & livestock farming methods. In the forestry sector, policies are being implemented for the protection and expansion of forest carbon sinks, and forest carbon offset projects. Lastly, in the waste sector, policies are in place for the minimization of waste generation, and the expansion of recycling and resource recovery programs.

Chapter 4 Projected Greenhouse Gas Emissions and Reductions by Sector

The overall national GHG emissions are projected to increase by 36.1 percent by 2020, compared to 2005 levels, as the sustainable growth rate will be maintained. The projected emissions for 2005 to 2020 by sector are estimated as follows: the energy sector will increase by 33.5 percent and industrial processes will increase by 81.8 percent. On the other hand, the agriculture sector is expected to decrease by 7.5 percent and the waste sector is expected to decrease by 14.9 percent. Sinks in LULUCF are estimated decrease by 26.0 percent.



[Figure 8] Projected GHG emissions

Examining GHG emissions in specific sub-sectors of energy; the emissions share of the energy industry will increase from 37.8 to 38.8 percent between 2005 and 2020, due to continuously increasing power consumption; and

the emissions of manufacturing and construction industries will increase from 28.7 to 33.1 percent during the same period. However, due to improved fuel efficiency and decline in annual new car registrations, the emission share of the transport sector is expected to decrease from 17.4 to 15.7 percent. Emissions in other sectors are also likely to decrease from 14.8 to 11.1 percent due to a decline in population growth and improvements in energy efficiency.

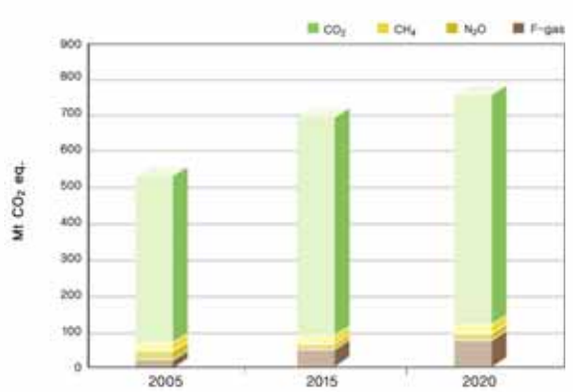
Regarding industrial processes, due to the growth of related industries such as display and semiconductors, fluoride gas (hereafter F-gas) emissions are expected to increase rapidly.

In the agriculture sector, emissions from livestock and agronomy will decrease by 2.1 and 10.1 percent respectively, in 2020 compared to 2005, and emissions from the waste sector are also expected to decrease due to the increase of waste product recycling. Net sinks from the LULUCF sector will decrease by 26.0 percent in 2020 compared to 2005 levels.

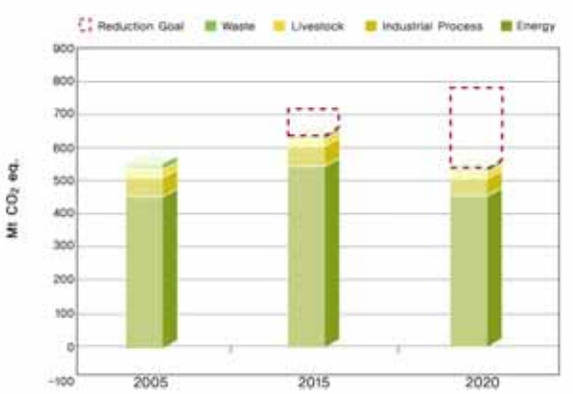
By GHG type, CO_2 emissions, which are primarily caused by fuel combustion, for 2020 are projected to increase by 32.0 percent compared to 2005 levels, and the emissions share will slightly decrease, from 86.7 to 84.1 percent. Additionally, F-gas emissions, primarily from industrial processes, will show a high increase rate of 235 percent for 2020 compared to 2005 levels. During the same period, the emission share will more than double in size, increasing from 4.3 to 10.7 percent.

CH_4 emissions are estimated to increase by 0.4 percent in 2020 compared to 2005 levels, and the emission share is projected to decrease from 5.0 to 3.7 percent during the same period. N_2O emissions are expected to decrease by 48.1 percent during the same period, resulting in an emissions share will decrease from 3.9 to 1.5 percent.

When looking at GHG emission projections upon pursuing the reduction goals, the total GHG emission of Korea in 2020 is expected to be decreased by 30 percent compared to BAU projection. The reduction rates below BAU in 2020 by sector are estimated as follows: 27 percent decrease in energy sector, 51 percent decrease in industrial processes sector, 7 percent decrease in agriculture sector, and 12 percent decrease in waste sector.



[Figure 9] Projected GHG emissions by type



[Figure 10] Projected GHG emissions by sources regarding reduction goals

Chapter 5 Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures

Over the last century (1912~2010), the temperature in Korea increased by 1.8℃ due to the impact of global warming including that of urbanization. Annual precipitation also increased by 17 percent. Compared to the 1912~1921 period, winter days shortened by 17 days while summer days lengthened by 19 days between 2001 and 2010. Regarding GHG atmospheric concentration levels, the annual increase of CO_2 concentration levels over the past 12 years

<Table 2> Climate change effect, vulnerability, and adaptation action plan

Impacts & vulnerabilities	Adaptation measures
Health ▪ Increased death and disease from heat waves ▪ Increased death from meteorological disasters ▪ Spreading of disease from insects and rodents ▪ Increased patients (e.g. asthma, allergy)	**Health** ▪ Investigation of damages from heat waves ▪ Measures to prevent harm to those vulnerable to heat waves ▪ Monitoring & management of infectious disease ▪ Monitoring & management of infectious disease from insects and rodents ▪ Expand allergy monitoring and response facilities
Natural disasters ▪ Increase in meteorological disasters ▪ Increase in the scale of disaster damage ▪ Increased frequency of extreme weather	**Natural disasters** ▪ Analysis of vulnerable areas and higher disaster prevention standards ▪ Maintain disaster risk facility, build disaster information system ▪ Climate-friendly land use management system
Agriculture ▪ Crop cultivation area moving northward ▪ Change of crop cultivation seasons ▪ Obstacles to productivity & stability of agricultural ecosystem	**Agriculture** ▪ Development and dissemination of crop cultivation technologies and new crops ▪ Stable water supply for agricultural use ▪ Prevent storm and flood damage ▪ Forecast and develop system to prevent spread of disease & insect pests and livestock disease
Forest ▪ Movement of forest vegetation area ▪ Changes in forest ecosystem structure ▪ Increased forest disasters ▪ Change in number of insect pests and disease occurrences	**Forest** ▪ Biodiversity conservation in situ and ex situ ▪ Maintenance and increase of forestry productivity ▪ Prevention policy of forest fire, landslides, and disease & insect pests
Ocean & fisheries ▪ Coastal erosion and flooding due to sea level rise ▪ Damage to marine ecosystem and changes in fishery resources due to increasing water temperature	**Ocean & fisheries** ▪ Management and adaptive response to sea level rise ▪ Monitoring & forecasting changes in fisheries, ensure future fishery resources ▪ Measures to reduce infectious diseases on fisheries and damage from acidification
Water management ▪ Increased damage from floods, droughts, and typhoons ▪ Increased damage due to deterioration of quality and quantity of water resources	**Water management** ▪ Create infrastructure with reduced vulnerability and improve facilities ▪ The 4 Major Rivers Restoration Project ▪ Improved water quality and preservation of river ecosystem
Ecosystem ▪ Sudden changes in ecosystems due to climate change ▪ Acceleration in domestic inflow of exotic species due to climate change	**Ecosystem** ▪ Monitor ecosystem and evaluate vulnerabilities ▪ Conservation of species and genetic resources and restoration of ecological connection ▪ Prevention and management of damage from foreign species and unexpected outbreaks

(1999~2010) was 2.12 ppm per year, higher than the annual global increase of 1.90 ppm per year. The concentration levels of CH_4 and N_2O, also continued to increase slowly but steadily. However, the concentration level of three types of CFC (CFC-11, CFC-12, and CFC-113) have decreased.

According to the IPCC SRES A1B scenario, the changes in temperatures and precipitation are projected to continue throughout the 21st century. By the end of the 21st century, the temperature will increase by 4℃ and precipitation will increase by 17 percent compared to the past 30 year average (1971~2000). Extreme hot weather and heavy rains are also forecasted to become more frequent. If climate change continues its current trend, various areas including public health, agriculture, forestry, maritime resources, water management, and ecosystems will suffer significant damage.

In accordance with the 2010 *Framework Act on Low Carbon, Green Growth*, the government of Korea has established the *National Climate Change Adaptation Master Plan* to minimize damages resulting from climate change. This measure was jointly established by 13 ministries and 70 climate experts. The vision of this measure is to build a society that is resilient to climate change and to support green growth. The *National Climate Change Adaptation Master Plan* is divided into three major adaptation foundation plans, which include 1) climate change prediction, 2) adaptation industries, and 3) training, promotion, and international cooperation. Additionally, adaptation measures are described in seven different sectors: public health, disasters, agriculture, forestry, ocean and fisheries, water management, and ecosystem. Taking into account the level of uncertainty regarding climate change, the *National Climate Change Adaptation Master Plan* has developed as a continuing 5-year plan. Each year, it is revised and updated based on the results of climate change monitoring and evaluation. Also, in order to ensure the effective implementation of the adaptation measures, the central and municipal governments established specific plans for the implementation. Implementation plans are assessed annually, and performance assessments are submitted as a comprehensive assessment report every 3 years and 5 years.

Chapter 6 Financial Assistance & Technology Transfer

In 2008, Korea proposed the *East Asia Climate Partnership (EACP)* in order to strengthen cooperation with member countries. Through this partnership, a total of USD 200 million will be provided to fund support projects, training, and forums between 2008 and 2012. Under the supervision of the Korea International Cooperation Agency (KOICA) which is a nonprofit agency responsible for managing grants. The EACP is primarily focused on five different sectors (i.e. water, low-carbon city, low-carbon energy, forest, and waste) looking to the needs of developing Asian countries. Moreover, the Global Green Growth Institute (GGGI) was established in June 2010 as an independent non-profit organization to offer solutions to developing countries related to

green growth, as well as making efforts to promote and encourage global cooperative development.

KOICA supports various types of assistance including feasibility studies, collaborative projects, special in-country invitations for intensive training courses, dispatching experts, and assistance to non-governmental organizations. Recently, the focus of KOICA has been promoting environmental awareness and sustainable development in developing countries. Furthermore, the amount of financial support for these types of projects has been increasing every year. KOICA also supports environmental and climate change projects through the Economic Development Cooperation Fund (EDCF), which was founded in 1987 to promote economic development by assisting industrial development and financial stabilization for developing countries, and to further Korea's economic exchange with its partner countries. Major developments include the stand-alone photovoltaic power plant construction project in Mozambique and the Mekong River dike construction and park project developments in Laos. EDCF has participated in the Asian Development Bank's *Future Carbon Fund Project* to support energy efficiency and renewable energy projects for GHG reduction in developing countries.

Korea is also providing funds, technology, and human resources to international environmental organizations such as the *Global Environment Facility* (GEF), the *United Nations Environment Programme* (UNEP), the *United Nations Framework Convention on Climate Change* (UNFCCC), the *United Nations Convention to Combat Desertification* (UNCCD), the *International Tropical Timber Organization* (ITTO), and others. Since joining the GEF in May 1994, the government has donated about USD 5.5 million per annum. The 1st period was from July 1994 to June 1997, the 2nd period was from July 1998 to June 2002, the 3rd period was from July 2002 to June 2006, and the 4th period was from July 2006 to June 2010. Since 2011, Korea has been participating in the transitional committee for the design of the *Green Climate Fund* under the UNFCCC plan. Korea is also promoting various energy technology cooperation projects with countries in East Asia and the Association of Southeast Asian Nations (ASEAN) with a focus on, but not limited to, renewable energy, energy efficiency enhancement, and cleaner fossil fuel technologies.

Furthermore, for the development and distribution of environment friendly and sustainable agricultural technology, the Korean government is cooperating with countries in Asia, Africa, and Latin America to operate pilot projects. Along with partnerships with various international agencies such as the International Energy Agency (IEA), the Asia-Pacific Economic Cooperation (APEC), the Asia-Pacific Partnership on Climate Change, the CCS Leaders Forum, the ASEAN+3 (ASEAN Plus Korea, China, and Japan), the International Renewable Energy Agency (IRENA), and others, Korea is participating in technology cooperation with both developed and developing countries. In particular, Korea is pro-actively providing technical assistance through joint research projects, workshops, seminars, and

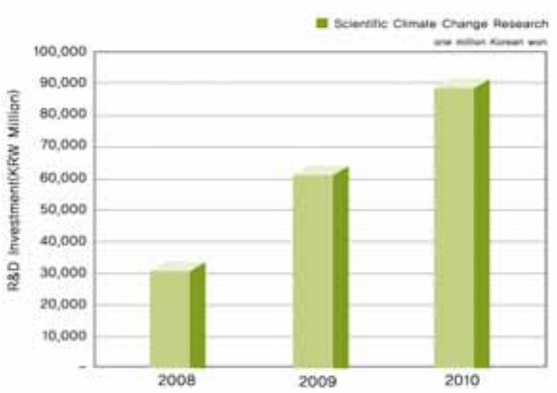
dispatching experts for multilateral cooperation based on initial information sharing. Through regional agriculture cooperation agencies, various projects have been promoted for achieving climate change adaptation, increasing crop productivity, and food security for developing countries in Asia and Africa.

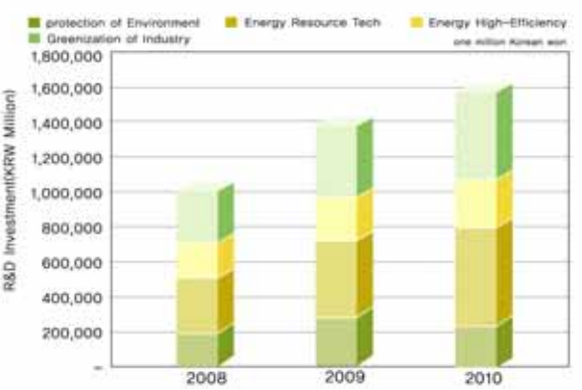
Chapter 7 Research and Systematic Observation

The government of Korea has developed a mid- and long-term technology road map in the fields of energy, transport, agriculture, maritime, ecology, etc., in order to strengthen the capacity to address climate change through research and technological development. The nation is expanding investments in national R&D programs and also pressing for balanced investment between scientific climate change research (for prediction and adaptation), and green technology development for GHG reduction.

The scientific climate change research is divided into climate change prediction and modeling technology and adaptation technology, such as climate change impact assessment and adaptive technology. Climate change prediction and modeling can be broken down into climate change monitoring, climate change causality analysis, climate change forecasting, climate change science information utilization, and other services. Beginning in 2010, the government of Korea is pursuing a specialized, deployment road map extending to 2030, that is divided into three time periods. Climate Change Impact Assessment and Adaptive Technology is divided into seven areas: health, food security, water management, marine, natural disaster, forestry, and generic technology. For areas such as water management, marine and disaster technology which require timely market entrance, speedy demonstration and distribution, short-term yet concentrated investment is encouraged. On the other hand, for health, food security, forestry, and generic technology which require long-term nurturing, long-term continuous investments are being made to assure international competitiveness.

Green technology development for GHG reduction is divided into the following





Source: PCGG, Green Technology Development research and analysis data (2011)

[Figure 11] Investment on scientific climate change research in recent 3 years

[Figure 12] Investment on green technology development in recent 3 years

categories: technology for the protection of the environment and reuse of resources, high-efficiency energy technology, energy resource technology and green technology for industrial and space assets. The goal of technology for the protection of the environment and positive reuse of resources is to encourage industrial participation in government-supported demonstration and dissemination plans, in which the government of Korea would be responsible for research and development of public technologies, while universities and institutes would be responsible for fostering climate expertise. For high-efficiency energy, the spotlight is on the development and distribution of the following: Integrated Gasification Combined Cycle (IGCC) technology, LED illumination/green IT technology, power IT & electrical equipment efficiency technology, and secondary rechargeable high efficiency battery technology, etc. Regarding energy source technologies, the focus has been on using alternative energy sources such as natural renewable energy or non-carbon energy sources, instead of fossil fuels that cause GHG emissions. Some examples of these energy source technologies include, but are not limited to, silicon solar cells, non-silicon solar cells, bioenergy, advanced light-water reactors, fast reactors, nuclear fusion, hydrogen energy, fuel cells, wind power, and so forth. The government of Korea also has been expanding investments in ongoing green technology research development, high-efficiency & low-emission vehicle technology, intelligent transport and logistics technology, ecological space and urban regeneration technology, co-friendly low-energy building technology and green process technology in accordance with environmental loading and energy consumption projections.

Systematic observations regarding climate change are focused on the atmosphere, ocean, agriculture and forestry. To monitor the long-term changes in atmospheric substances that cause climate change (GHG, reactive gases, aerosols, atmospheric radiation, etc.), the government of Korea has been operating the Korea Global Atmosphere Watch Center (GAW) in Anmyeondo. As a member state of the WMO, the nation is also operating 11 GSNs and 5 GUANs (GCOS Upper Air Networks) for temperature, atmospheric pressure, and precipitation measurement. There are 34 centers in the South Coast that observe changes in surface water temperature and 48 centers that observe changes in sea levels. In order to continuously observe the fluctuating levels of water, CO_2, and energy, the government of Korea has constructed three material flux system towers in major agricultural regions. These towers not only observe changes in vegetation, but also periodically observe the health of soil, biodiversity, and forest ecosystems. On June 27, 2010, the government of Korea successfully launched its first geostationary satellite (*Cheonlian Satellite*), a Communication, Ocean, and Meteorological Satellite (COMS). Since April 1, 2011, regular meteorological observations have been performed with the satellite.

Chapter 8 Education, Training and Public Awareness

Korea is committed to strengthening cooperative efforts between public and private sectors, encouraging community activities, as well as promoting education and training on climate change and global warming in order to build public consensus and a foundation from which to respond to climate change.

Education and training are offered not only for elementary schools, middle schools, high schools, and colleges, but also for the general public and experts. As information on climate change is actively disseminated through central and local governments, cooperation between public and private organizations, as well as community activities are growing - both quantitatively and qualitatively.

Korea is also making efforts to systematize climate change & energy education into the official curriculum for elementary schools, middle schools, and high schools. In 2010, the *Korea Society of Energy and Climate Change Education* (KSECE) was established to set the direction of mid- and long-term climate change education and the related academic contents through conferences and journal publications. Also, a guidance plan has been developed to ensure the effectiveness of the educational material and after-school programs have been designed and demonstrated to be able to approach climate change in friendlier and easier ways.

Since 2010, in addition to the curriculum, the *Save Energy, Save Earth (SESE) NARA* program has been implemented to establish reasonable energy-saving habits for children and young people. Additionally, through systematic climate change training and practice, energy-saving policy research schools have been designated to raise awareness and encourage green lifestyles in students.

In addition, there are specialized graduate schools for climate change to train professionals and to build foundations for research related to climate change actions. Professional training is offered for public officials and experts in the field of climate change, and the general public can also receive related training.

As climate change has become a focal talking point globally, government agencies and related industries have begun making efforts to improve public awareness about voluntary GHG reduction through special programs, campaign advertising, events, and other promotional activities.

The Green Energy EXPO, Energy-saving Travelling Exhibitions, and Green Growth EXPO are currently in operation and various promotional materials will be produced and distributed for the general public to better understand climate change issues and practice green lifestyles. For the internet generation, electronic environmental education will be emphasized on government websites, as well as separate websites dedicated to educating youth on environmental issues.

The government of Korea will seek measures for the relevant industries regarding climate change and host weekly climate change events to spread the issues to the general public. By expanding various private-public cooperation projects and hosting public events such as *Earth*

Day, *Environment Day*, *Energy Day*, etc., the government of Korea is promoting a public campaign on climate change.

In addition, the government of Korea is making ongoing efforts to raise public awareness by hosting various exhibitions and competitions to encourage the public to adopt habits to combat climate change.

The civil society in Korea has recognized climate change and energy issues as a major challenge for the nation's sustainable development and green growth, and has expanded various activities to tackle climate change, including policy proposals to the government and voluntary civil action.

Also, as a cooperation model for civic and public organizations, *Local Agenda 21* for the sustainable development of local regions shares climate change and sustainable growth issues with diverse members of the community, contributing to green citizen actions and the improvement of policy components of local governments, and promoting commitment to a green lifestyle through the Green Start Network.

Chapter 1

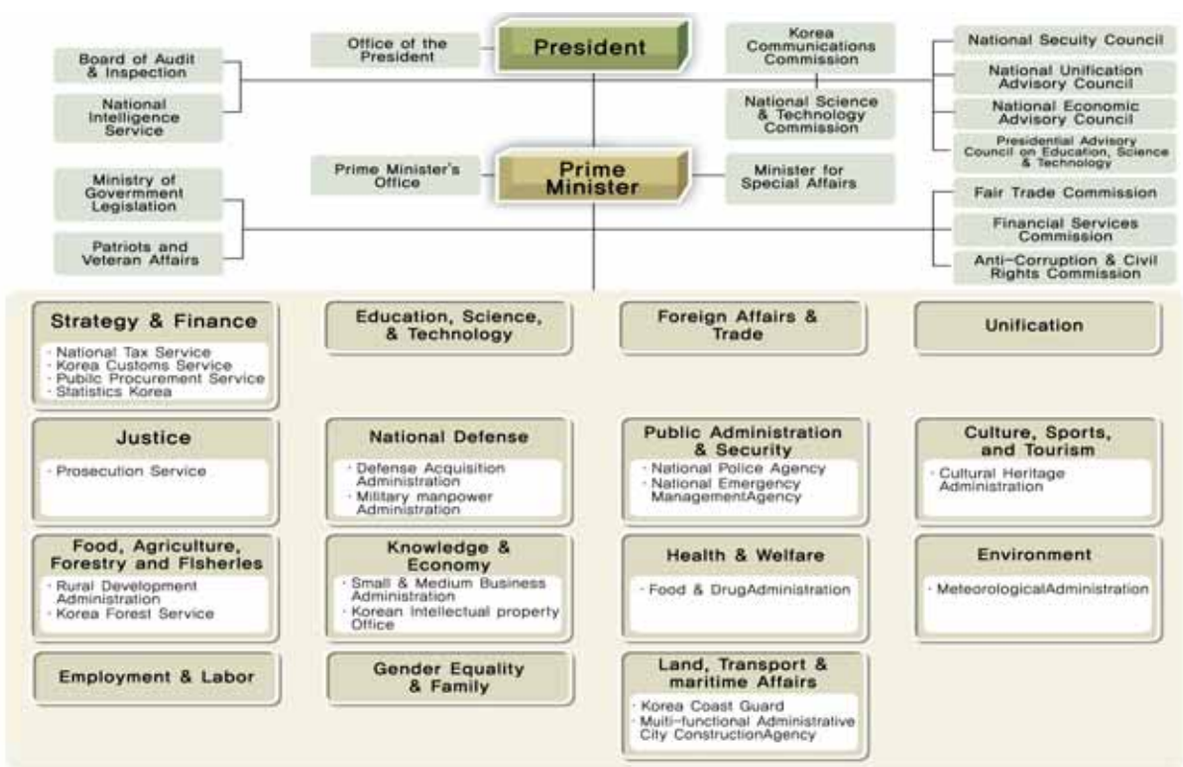
National Circumstances

Chapter 1 National Circumstances

1. Government structure

The Republic of Korea is a presidential republic with three branches of government: executive, legislative, and judicial. The executive branch is composed of the President's Office, the Prime Minister's Office, several independent agencies, and 15 cabinet-level ministries plus the Ministry of Special Affairs. Two independent agencies (the Board of Audit & Inspection and National Intelligence Service), two commissions, and three councils report directly to the President. Two independent ministries and three commissions directly report to the Prime Minister. The executive branch also includes 18 affiliated agencies under their relevant ministries, headed by a vice-minister level commissioner. The executive branch is headed by the President, held in check by the Legislative Branch, consisting of the National Assembly members who are directly elected by the people (Figure 1-1). As with most stable three-branch systems, the government of Korea has a careful system of checks and balances in place. For example, the separation of the executive branch and legislative branch prevent the concentration of power and guarantee the freedom and rights of the citizens.

The government of Korea had operated a *Special Committee on Climate Change*, an inter-ministerial community to advise, develop, and implement climate change policies from



Source: www.president.go.kr

[Figure 1-1] Government of Korea (executive branch)

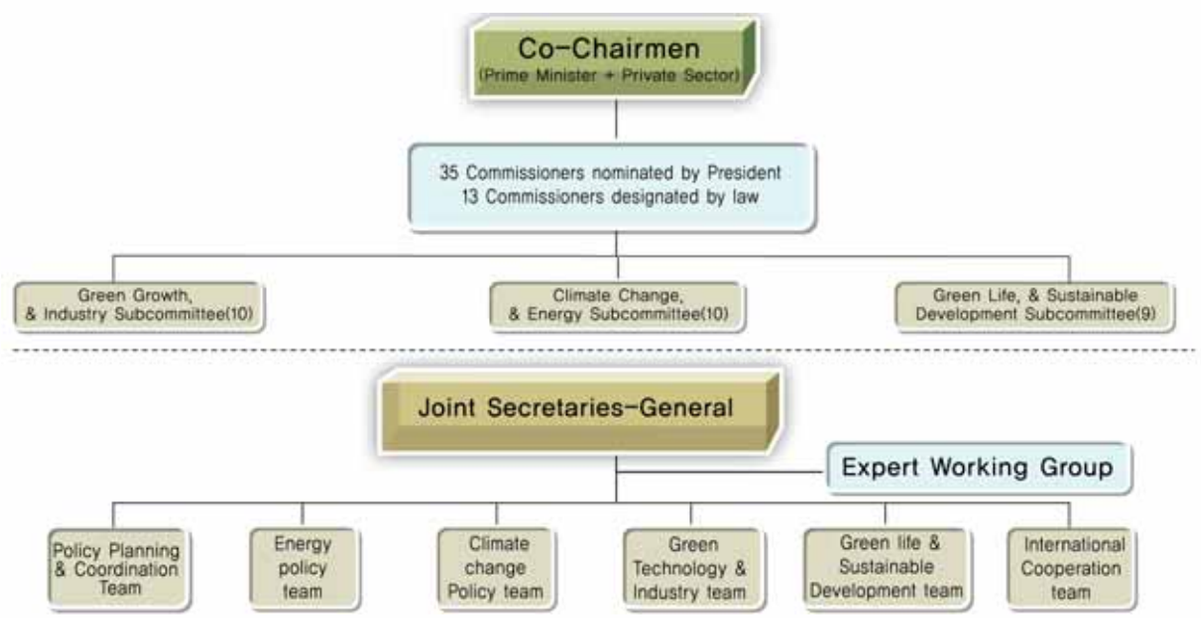
1998 through 2007. This committee had established and implemented *3-Year Comprehensive Action Plans for the UNFCCC*.

On August 15th 2008, President Lee Myung-bak declared *Low Carbon, Green Growth* as a national vision in his address regarding the 60th anniversary of the founding of the Republic of Korea. Subsequently, the *Presidential Committee on Green Growth* (PCGG) was established in February 2009, under the direct supervision of the president, for the overall management and direction of green growth. The PCGG has made efforts to reduce GHG emissions not only to make *green* a new growth engine, but also to break from excessive dependence on fossil fuels. In this way, the PCGG is taking the initiative in addressing climate change. While the Prime Minister and a civilian chairperson jointly serve as co-chairs of the PCGG, its foundation was based upon the Presidential Directives in the *Regulations on Composition and Operation of Presidential Committee on Green Growth*, as issued on January 5th, 2009. Also, as a working-level task force, the Secretariat was organized to support the operation of the PCGG and to establish strategies for green growth (Figure 1-2).

Addressing climate change is a matter of national security. This would require efforts from every aspect of society, especially when dealing with GHG reductions. Many agencies of the central government are directly or indirectly linked to climate change policies. According to the *Comprehensive Action Plan for Climate Change* established in 2008, at least 15 out of the 45 central government agencies have been implementing relevant tasks regarding climate change.

2. Population profile

As of 2010, the total population of Korea was estimated to be 48.8 million, with approximately 24.5 million males and 24.3



Source: www.greengrowth.go.kr

[Figure 1-2] Presidential committee on green growth

million females. In terms of sex ratio, there are 100.8 males per 100 females. The national population accounts for about 0.7 percent of the world's total population (6.89 billion), ranked as the world's 26th most populous country. Korea is also the world's 3rd most densely populated country after Bangladesh and Taiwan with a population density of 486 persons per square kilometer (excluding city-states, self-governing dependent territories, and unrecognized independent countries).

The annual average growth rate of the population was at 3 percent in the 1960s, but it continued to decrease due to the improved social status of women and higher per capita income. While the campaign to control the growing population has been in place, the population growth rate decreased below 2 percent in the 1970s. After 1995, the growth rate decreased below 1 percent until 2005, when it rapidly dropped below 0.5 percent, where it has remained since. If this trend continues, the national population is projected to hit the 49.3 million mark by 2020, and fall to 48.6 million by 2030 (Table 1-1).

In terms of age groups, the average age of the total population increased from 31.8 in 2000 to 38.0 in 2010, and average life expectancy also increased from 75.6 years (71.7 for men, 79.2 for women) in 1999 to 80.6 years (77.0 for men, 83.8 for women) in 2009. The population aged over 65 also increased from 7.2 percent in 2000 to 11.0 percent in 2010.

In the same time frame, the economically active population (aged between 15 and 64) decreased from 72.5 to 71.7 percent. As the population aged below 14 decreased to 16.2 percent in 2010 from 21.0 percent in 2000, the burden of elderly dependency increased.

<Table 1-1> Population size and density

Year	Total population (Million)	Annual growth Rate (%)	Population density (person per km^2)
1990	42,869	0.99	438
1995	45,093	1.02	449
2000	47,008	0.84	464
2005	48,138	0.48	474
2010	48,875	0.30	486
2020	49,326	0.09	490
2030	48,635	-0.02	484

Source: Statistics Korea

3. Geographic profile

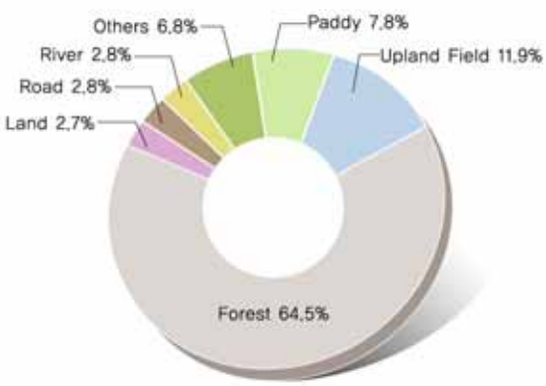
Korea is located horizontally between 125°04' and 131°52' east longitude and vertically between 36°06' and 38°27' north latitude. The country shares the Yellow Sea with People's Republic of China to the west, and the East Sea and Korean Straits with Japan to the east and the south, respectively. In the north of the country, the Democratic People's Republic of Korea (i.e. North Korea) shares the border along the Military Demarcation Line (MDL).

The total land area covers 99,392 square

[Figure 1-3] Geographic location of Korean peninsula

kilometers (km^2) as of 2010. The approximate north-south length of the land is 550 kilometers (km) long and the approximate eat-west width is 300 km, with over 3,200 islands scattered off the mainland.

The configuration of the land surface is higher in the east than in the west. Mountainous regions rising 1,000 m above sea level are clustered towards the north and east forming a ridge along the terrain, which declines steeply towards the East Sea and descends slowly westward towards the Yellow Sea. About 64.5 percent of the land area is forested, and about 19.7 percent is agricultural land (Figure 1-4).



[Figure 1-4] Land use status (%), 2009

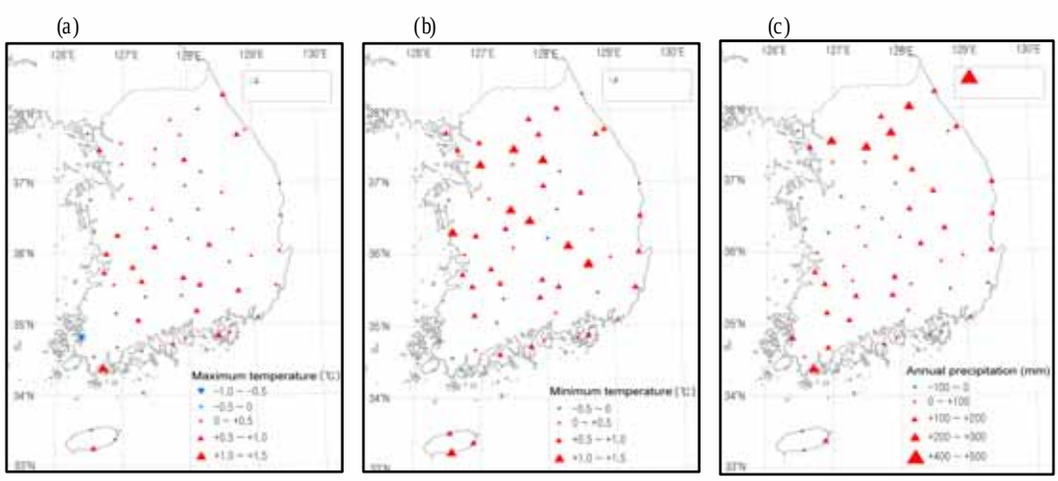
4. Climate profile

Located in the temperate mid-latitude zone, Korea has four distinct seasons. The annual average temperature range is 12.7℃ (54.9℉)

Winters are cold and dry due to the continental high atmospheric pressure, and summers are generally hot and humid because of the North Pacific anticyclone. During spring and autumn, the migratory anticyclones often provide relatively clear skies and dry climates.

During the last 10 years (2001~2010), according to observations made from 61 observational points, the annual average temperature had risen by 0.5℃ compared to a previous 30-year period (1971~2000). All seasons, except summer, showed 0.6℃ increase.

During the aforementioned 10-year period, the annual mean maximum temperature increased by 0.5℃, and it increased by 0.6℃ during spring and winter. The annual mean minimum temperature increased by 0.6℃, and it increased by 0.8 and 0.7℃ in fall and winter, respectively. The average annual precipitation in



[Figure 1-5] Past 10 years (2001~2010) compared to the annual average (a) Maximum temperature (b) Minimum temperature (c) Annual precipitation

the past 10 years has increased by 97.4mm (7.4%) compared to the prior 30-year period (1971 to 2000). Summer precipitation, which accounts for 55.3 percent of annual rainfall, increased by 86.7mm compared to the national average[1]. This accounts for 89 percent of the overall increase.

As shown, in the last 10-year period, most regions indicated an increasing trend regarding the annual mean maximum and minimum temperatures (Figure 1-5). The temperature ranges vary depending on the regions: the highest temperature was between -0.6 and 1.1℃, and the lowest temperature was between -0.5 and 1.5℃. The annual precipitation increased in most regions, especially in the northern part of Gyeonggi Province.

5. Economic profile

From 1990 until 2010, Korea's economy grew at an annual average rate of five percent. The nominal gross domestic product (GDP) increased from USD 270.3 billion to 1,014 billion. In the same time frame, the per capita GDP in Korea increased from USD 6,305 to 20,735 (Table 1-2, Figure 1-6).

<Table 1-2> National GDP (nominal) and GDP per capita

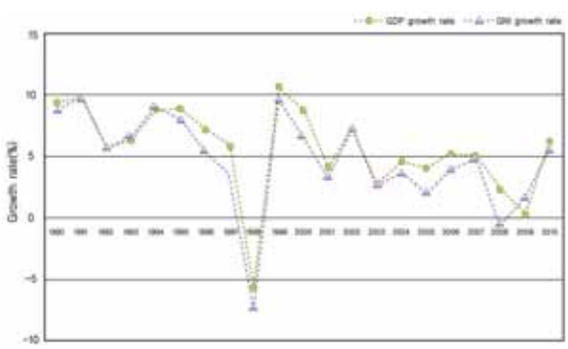
Category	Nominal GDP (USD billion)	Per capita GDP (USD per person)
1990	270.3	6,305
1995	531.3	11,782
2000	533.5	11,349
2005	844.7	17,547
2010	1014.3	20,753

Source: The Bank of Korea

The nation had a high economic growth rate in the 1970s. Yet, the nation recorded a deficit for most of the 1990s. In the 1990s, the trade balance had deteriorated as the number of exports decreased due to high wages and rising commodity prices. Also, the deficit continued as the invisible trade balance worsened due to increasing tourism outside the country.

However, the current account started to show a turnaround after 2000, recording over USD 10 billion surplus in the account per annum until 2007. This was possible because the social system began to operate more efficiently, and numerous corporations had restructured themselves.

Even though the global economy has recently been in decline (as evidenced by the European and US financial crises), and despite sharply rising oil prices, the economy of Korea continues to show 4 percent annual growth. With the new paradigm for economic growth, about 2 percent of the national GDP will be invested in green growth to simultaneously promote environmental protection and economic expansion.



Source : The Bank of Korea

[Figure 1-6] GDP and GNI growth rate

1) The average of precipitation observed for the period between 1971 and 2000

The government of Korea began to promote policies that foster heavy and chemical industries in 1980. As a result, this industry became a major part of the national economy. The service industry accounted for more than half of the GDP due to the rapid development of information technology, and weakened trade regulations on services in the 1990s.

The service industry in Korea accounted for 58.2 percent of the production structure, followed by mining and manufacturing (30.8%), and agriculture, forestry and fishing industry (2.6%) (Table 1-3).

<Table 1-3> Structure of production by industry

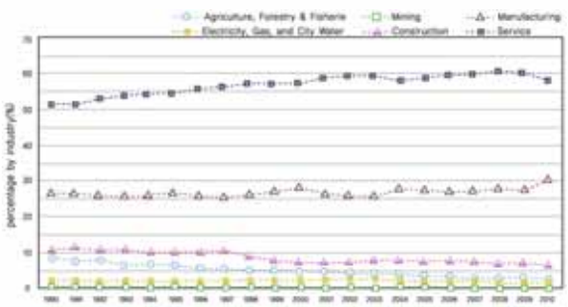
(Unit %)

Year	Agriculture, forestry & fisheries	Mining & manufacturing		Electricity, gas, and city water	Construction	Service
		Mining	Manufacturing			
1990	8.7	0.8	26.6	2.1	10.4	51.5
1995	6.2	0.5	26.7	2.0	10.1	54.6
2000	4.6	0.3	28.3	2.5	6.9	57.3
2005	3.3	0.3	27.5	2.3	7.6	59.0
2010	2.6	0.2	30.6	2.0	6.5	58.2

Source: The Bank of Korea
Note: Domestic value-added and factor income (nominal, annual) based on the total production by economic activities

As for the manufacturing industry, the share of textiles, food/beverages, lumber, primary metal, and furniture have continuously been on the decline. However, the share of technology-intensive industries such as metal, electricity, electronics, and mechanics are on the increase. In terms of specific sectors, shipbuilding, electronics, automobile, and semiconductor production have become more important due to the improvement of the technology and increasing demands for these sectors abroad.

In the service industry, wholesale and retail, food and lodging, transport and warehousing, and financial services all play relatively more crucial roles than other service sectors (Figure 1-7, Table 1-4).



Source: The Bank of Korea

[Figure 1-7] Changes in industrial structure

<Table 1-4> Service industry details

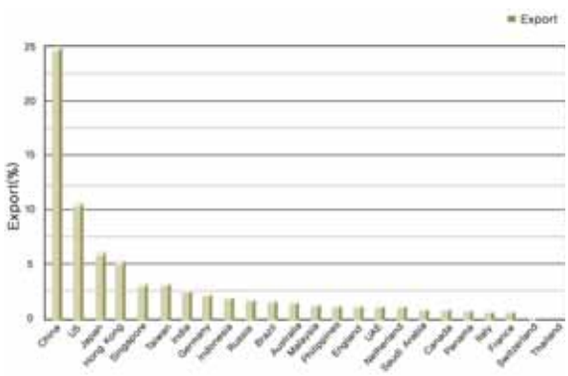
(Unit: %)

	1990	1995	2000	2005	2009
Hospitality, retail, and food	30.6	26.4	23.1	20.4	20.3
Transport and warehousing	10.3	9.9	10.0	10.3	10.1
Finance & insurance	9.7	11.1	11.0	11.1	11.8
Real estate & leasing	10.7	12.8	12.7	11.1	9.7
Information and technology	5.7	6.8	10.1	10.2	9.3
Business services	6.1	6.9	6.8	7.6	7.8
Public administration, defense, Social security	10.4	9.0	8.4	8.9	9.2
Educational services	6.4	6.6	6.5	7.4	7.9
Health & social services	3.9	3.9	5.2	6.5	7.5
Culture & entertainment	1.8	2.1	1.9	2.2	2.3
Other service businesses	4.4	4.5	4.2	4.1	4.1

Source: The Bank of Korea
Note: Domestic value-added and factor income (nominal, annual) based on the total production by economic activities

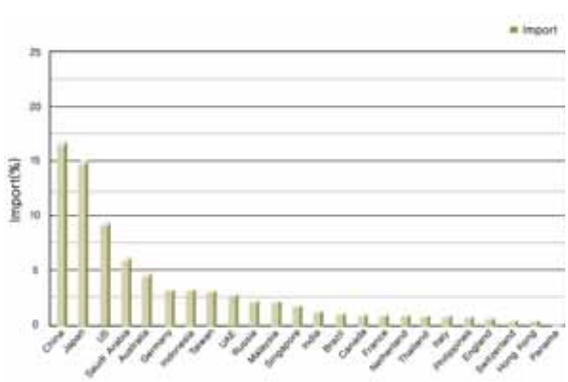
The foundation of Korea's industry is in the export-driven economic policies focusing on processing trade, primarily due to scarcity of natural resources. For this reason, Korea's economy heavily relies on import and exports. China is the largest export partner, accounting for about 25.1 percent of Korea's total exports (USD 466 billion), followed by the US (10.7%),

Japan (6.0%), and Hong Kong (5.4%). China also is the biggest importer, amounting to 16.8 percent of Korea's total imports (USD 425 billion), followed by Japan (15.1%), the US (9.5%), and Saudi Arabia (6.3%) (Figure 1-8, 1-9).



Source: The Bank of Korea

[Figure 1-8] Export by country (2010)



Source: The Bank of Korea

[Figure 1-9] Import by country (2010)

6. Energy

Primary energy consumption increased at the average annual rate of 5.2 percent from 1990 to 2009, recording about 243.3 million tonnes of oil equivalent (TOE) in 2009.

The east asian financial crisis in 1998 caused an 8.1 percent reduction in energy consumption, but the rate of increase was recorded to be 9.3 percent in the following year. In 2000 and 2005, the rate was 6.4 and 3.8 percent, respectively. After 2006, the rate was below 2.0 percent. The rate went below 1.1 percent in 2009 compared to its previous year.

Energy intensity (TOE/USD thousand) in the early 1990s increased due to the expansion of facilities and increased utilization of energy-intensive industries such as petrochemical, steel industries, etc. However, changes in industrial structures and improved energy efficiency, after the 1998 financial crisis, led to a 0.25 percent reduction in energy intensity by 2009.

Korea imported 87.9 percent of the total energy consumption abroad in 1990, increasing to 96.4 percent in 2009. A total of USD 91.2 billion was spent on energy imports (Table 1-5).

As shown in consumption patterns by energy sources, petroleum accounted for 42.1 percent of the consumption, followed by coal (28.2%), LNG (13.9%), nuclear energy (13.1%), and hydraulic power (0.5%) (Table 1-6).

LNG consumption substantially increased, from 3.2 percent in 1990 to 13.9 percent in 2009, and petroleum consumption fell from 53.8 percent to 42.1 percent, in the same time frame. This indicates that oil dependence decreased due to rising oil prices and environmental regulation, as well as expansion of clean energy policies.

Looking at the final energy consumption by sector, the industrial sector accounted for about 58.3 percent of the overall consumption, followed by transport (19.7%), residential and commercial sectors (19.6%), and public and other sectors (2.4%) (Table 1-7).

<Table 1-5> Changes in energy data

Consumption	1990	1995	2000	2005	2009	Annual average increase (1990~2009, %)
Primary energy (million TOE)	93.2	150.4	192.9	228.6	243.3	5.18
Total energy (million TOE)	75.1	122.0	149.9	170.9	182.1	4.77
Energy per capita (TOE)	2.17	3.34	4.10	4.75	4.99	4.48
Energy / GDP (TOE/thousand USD)	0.26	0.29	0.28	0.27	0.25	-0.21
Import dependence (%)	87.9	96.8	97.2	96.6	96.4	0.49

Source: Ministry of Knowledge & Economy, Korea Energy Economics Institute

<Table 1-6> Primary energy consumption by source

(Unit: thousand TOE, %)

Year	Coal	Petroleum	LNG	Hydraulic Power	Nuclear Power	Others *	Total
1990	24,385 (26.2)	50,175 (53.8)	3,023 (3.2)	1,590 (1.7)	13,222 (14.2)	797 (0.9)	93,192 (100)
1995	28,091 (18.7)	93,955 (62.5)	9,213 (6.1)	1,369 (0.9)	16,757 (11.1)	1,051 (0.7)	150,437 (100)
2000	42,911 (22.2)	100,279 (52)	18,924 (9.8)	1,402 (0.7)	27,241 (14.1)	2,130 (1.1)	192,887 (100)
2005	54,788 (24)	101,526 (44.4)	30,355 (13.3)	1,297 (0.6)	36,695 (16.1)	3,961 (1.7)	228,622 (100)
2009	68,603 (28.2)	102,336 (42.1)	33,908 (13.9)	1,213 (0.5)	31,771 (13.1)	5,480 (2.3)	243,310 (100)

Source: Ministry of Knowledge & Economy, Korea Energy Economics Institute
Note: Data after 1997 are based on the new classification system of oil including naphtha
* Including the new & renewable energy after 1992

<Table 1-7> Final energy consumption by sector

(Unit: Thousand TOE, %)

Year	Industrial	Transport	Residential, commercial	Public and others	Total
1990	36,150 (48.1)	14,173 (18.9)	21,971 (29.3)	2,812 (3.7)	75,107 (100)
1995	62,946 (51.6)	27,148 (22.3)	29,451 (24.1)	2,416 (2.0)	121,962 (100)
2000	83,912 (56.0)	30,945 (20.7)	32,370 (21.6)	2,625 (1.8)	149,852 (100)
2005	94,366 (55.2)	35,559 (20.8)	36,861 (21.6)	4,068 (2.4)	170,854 (100)
2009	106,118 (58.3)	35,930 (19.7)	35,722 (19.6)	4,295 (2.4)	182,065 (100)

Source: Ministry of Knowledge & Economy, Korea Energy Economics Institute

The final energy consumption in the industrial sector increased from 48.1 percent, in 1990, to 58.3 percent in 2009. This can be explained by the growth in petrochemical and

steel industries, the continuous increase in non-metallic minerals, as well as increasing power consumption in metal fabrication plants.

The share of energy consumption in the residential and commercial sector continued to decrease, 29.3 percent in 1990 to 19.6 percent in 2009. Energy consumption by fuel type has been rapidly transforming from oil to network energy such as power, city gas, etc.

Energy consumption in the transport sector in the early 2000s was a major determinant of the increase in the final energy consumption. However, as consumption began to slowdown due to increasing oil prices since 2002, the final energy consumption was down to 19.7 percent as of 2009.

As the energy security has become more eminently important, the government of Korea has made efforts to be able to supply more stable, cost-effective, and sustainable energy. For these reasons, the government is promoting building more infrastructures for natural gas supply, investment in district heating and power generation equipment, and expanding new & renewable energy sources.

7. Transport

As of 2009, the public road accounted for 74.8 percent of modal share, followed by subway (17.0%), rail (8.0%), aviation (0.1%), and marine transport (0.1%). Although the share of public road transport was at 87.8 percent as of the 1990s, the share of public roads had decreased due to factors such as the urban rail network expansion, the shortened work week, etc.

The share of rail and subway increased from 1990 to 2009 due to increasing oil prices, expansion of the subway system, and the launch of high speed rail, Korea Train Express (KTX). Passenger service by aviation was continually on the rise after 1990, but it began to decrease after introduction of high speed rail in 2004. There were no significant changes in the marine transport, showing the lowest share in the transportation industry.

Public road accounted for 79.2 percent of

<Table 1-8> Share of transport by type

Unit: Passenger (thousand persons), Freight (thousand tons), Share (%)

	Passenger					Freight				
	1990	1995	2000	2005	2009	1990	1995	2000	2005	2009
Rail	644,814 (4.5)	790,381 (5.7)	837,267 (6.2)	950,995 (8.1)	1,020,319 (8.0)	57,922 (17.2)	57,469 (9.7)	45,240 (6.7)	41,669 (6.1)	38,898 (5.1)
Subway	1,101,677 (7.6)	1,693,003 (12.2)	2,235,221 (16.5)	2,020,360 (17.1)	2,182,346 (17.0)	-	-	-	-	-
Public road	12,721,887 (87.8)	11,289,507 (81.8)	10,410,577 (77.0)	8,801,839 (74.6)	9,588,133 (74.8)	215,125 (63.8)	408,368 (68.6)	496,174 (73.4)	526,000 (76.5)	607,480 (79.2)
Marine transport	8,260 (0.1)	8,702 (0.1)	9,702 (0.1)	11,099 (0.1)	14,868 (0.1)	63,915 (19.0)	129,112 (21.7)	134,467 (19.9)	119,410 (17.4)	120,031 (15.7)
Aviation	11,064 (0.1)	21,009 (0.2)	22,514 (0.2)	17,156 (0.1)	18,061 (0.1)	183 (0.1)	323 (0.1)	434 (0.1)	372 (0.1)	268 (0.1)

Source: Ministry of Land, Transport and Maritime Affair 「Statistical Year book of MLTM」

the domestic freight transport as of 2009. This is due to advances in the road network and courier industry, which also affected modal shifts in marine transport (15.7%), rail (5.1%), and aviation (0.1%).

Population growth and economic development led to increases in car ownership and usage. The number of registered vehicles in the country increased from 3.4 million in 1990 to 17.9 million in 2010, which is more than a five-fold rate of increase (Table 1-9). In the same period, the number of passenger cars grew six-fold, from 2.1 million to 13.6 million.

The number of registered personal vehicles increased from 3.04 million in 1990 to 16.9 million in 2010. The number of persons per vehicle (private only) was 14.1 in 1990, 4.1 in 2000, and 2.9 in 2010.

<Table 1-9> Trends in number of vehicles by type

(Unit: 10,000 cars)

Category	1990	1995	2000	2005	2010
Registered vehicles	339	847	1,206	1,540	1,794
Passenger car	207	601	808	1,112	1,363
Vans	38	61	143	112	105
Trucks	92	182	251	310	320
Special vehicles	1.2	3.3	3.7	4.8	5.6

Source: Ministry of Land, Transport and Maritime Affairs

<Table 1-10> Number of registered cars by purpose

(Unit: 10,000 cars)

Category	1990	1995	2000	2005	2010
Registered cars	339	847	1,206	1,540	1,794
Official use	3.4	4.6	5.0	5.8	6.6
Personal	304 (14.1)	797 (5.7)	1,139 (4.1)	1,456 (3.3)	1,690 (2.9)
Commercial	32	45	62	78	97

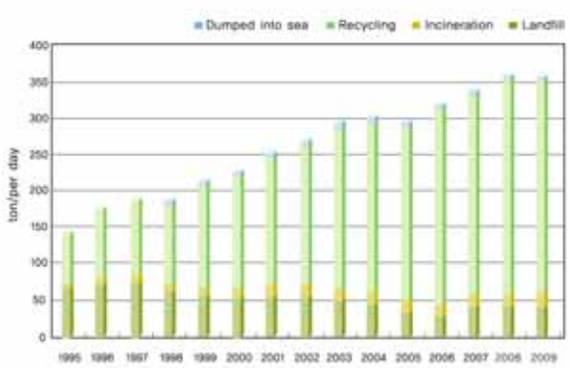
Source: Ministry of Land, Transport and Maritime Affairs
Note: The number in parentheses denotes the number of people per car

8. Waste

Waste generation has become a social and environmental issue in the country due to rapid economic development. In response, the government of Korea is altering its social structure to accomodate a beneficial system of recycling.

Since 1990, the total amount of waste has been gradually increasing. As of 2009, the amount of waste in the country was 357,861 tons per day. Industrial waste was 95,823 tons per day in 1995, and it continually increased to 123,604 tons per day in 2009 (Table 1-11). Despite the fact that construction waste decreased in 1998 and 2004, due to housing recessions and fewer new orders in construction, it continued to increase alongside industrial waste.

In 1995, the amount of Municipal Solid Waste (MSW) was 47,774 ton per day, but it decreased to 44,583 per day in 1998 as the International Monetary Fund (IMF) crisis took place. Total MSW has increased since then, reaching 50,906 tons per day in 2009. Even though income and consumption levels have rapidly increased, MSW has increased only



[Figure 1-10] Waste treatment

<Table 1-11> Trends of waste generation

(Unit: ton per day)

Type	1990	1995	2000	2005	2009
Total	83,962	143,597	226,668	295,723	357,861
Municipal waste	-	47,774	46,438	48,398	50,906
Industrial waste	-	95,823	101,453	112,419	123,604
Construction waste	-	-	78,777	134,900	183,351

Source: Ministry of Environment

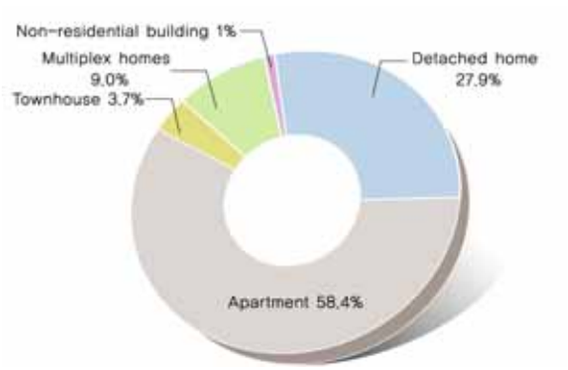
gradually since the *Volume Based Waste Fee System* has been implemented.

In terms of waste treatment, the rate of landfill waste has continued to decrease while the recycling rate has significantly increased. In the same period, the rate of incineration has slowly increased. In 1995, 45.8 percent of the total waste was dumped in landfills, and the remaining 48.9 percent was recycled. However, in 2009, the rate of waste in landfills has decreased to 11.1 percent while the recycling rate increased to 81.8 percent.

9. Building stock and urban structures

Economic development plans since 1960 heavily focused on investing in only specific regions due to limited domestic resources and capitals. This trend has led to urban concentrations in big cities such as Seoul, Busan, Daegu, Gwangju, Daejeon, etc. As of 2010, the urban population accounted for about 82 percent of the total national population.

In terms of housing, multi-dwelling units such as apartments, townhouses, multiplex homes, etc. accounted for 71 percent of all housing. About 58.4 percent of the multi-dwelling units were high-density apartments with at least five floors, followed by



[Figure 1-11] Housing type (2010)

detached homes (27.9%), multiplex homes (9.0%), and townhouses (3.7%) (Fig 1-11).

10. Agriculture

Over the past 10 years, total agricultural land has decreased by 22 thousand hectares (ha) per year. Land used for non-agricultural purposes, such as construction of new buildings and installation of public facilities, has increased and the amount of unused agricultural land has risen.

The area of the agricultural land in Korea was about 1.7 million ha in 2010. Paddy fields accounted for 57.4 percent of the land (984 thousand ha), and the remaining 42.6 percent was farmland (731 thousand ha) (Table 1-12). The rate of agricultural land use has remained at 110 percent without any significant changes for the last five years.

<Table 1-12> Current status of agricultural land use

(Unit: thousand ha, %)

Year	Total	Paddy	Upland field
1990	2,109 (100)	1,345 (63.8)	764 (36.2)
1995	1,985 (100)	1,206 (60.7)	779 (39.3)
2000	1,889 (100)	1,149 (60.8)	740 (39.2)
2005	1,824 (100)	1,105 (60.6)	719 (39.4)
2010	1,715 (100)	984 (57.4)	731 (42.6)

Source: Korea Statistics

Korea has been improving living environments in the rural areas, as well as agriculture-related systems since the 1980s. The government of Korea is focusing efforts on making the agricultural distribution system more efficient. As part of the rural environment improvement, education and welfare facilities will be enhanced, and also, farm village maintenance & residence modernization will be carried out.

Fertilizer usage gradually decreased due to the enactment of eco-friendly agricultural legislation, execution of various policies, and the reduction of overall agricultural area. The government has been implementing a 5-year plans for eco-friendly agricultural development since 2001 (Table 1-13).

The number of livestock in the country increased from 81,117 heads of cattle in 1990 to 162,433 heads in 2010 (Table 1-14). Increased mean domestic consumption is the primary cause of this decade-long trend.

<Table 1-13> Fertilizer consumption

(Unit: thousand tons, %)

Year	Total	Nitrogenous	Phosphorous	Potassic
1990	1,104 (100)	562 (50.9)	256 (23.2)	286 (25.9)
1995	954 (100)	472 (49.5)	223 (23.4)	259 (27.1)
2000	801 (100)	423 (52.8)	171 (21.3)	207 (25.8)
2005	722 (100)	354 (49.0)	162 (22.4)	206 (28.5)
2009	499 (100)	262 (52.5)	102 (20.4)	135 (27.1)

Source: Ministry of Agriculture, Forestry and Fisheries

<Table 1-14> Number of livestock

(Unit: thousand heads)

Category		1990	1995	2000	2005	2010
Ruminant	Korean Cattle	1,622	2,594	1,590	1,819	2,922
	Milk Cow	504	553	544	479	430
Others	Chicken	74,463	85,800	102,547	109,628	149,200
	Pig	4,528	6,461	8,214	8,962	9,881
Total		81,117	95,408	112,895	120,888	162,433

Source: Ministry of Agriculture, Forestry and Fisheries

11. Forests

The forests in Korea belong to a sub-tropical and warm temperate zone. The annual average temperature in the warm-temperate zone which covers most of Korea forest land is between 6 and 14℃, located at 35 to 45° north latitude.

Deciduous broad-leaved trees in the warm-temperate zone of Korea mainly include oak and ash trees. Evergreen needle-leaf trees typically include pine trees, nut pine, and Japanese black pines.

The sub-tropical forest zone is south of 35° north latitude where the annual mean temperatures are over 14℃. This zone includes part of the coastal region in the south, islands off the coast, and Jeju Island where many evergreen broad-leaved trees grow. Major examples of evergreen broad-leaved trees include thorn bushes, *Castanopsis*, *Vaccinium bracteatum*, *Cinnamomum camphora*, *Camellia*, etc.

The forest area in Korea is about 6.4 million ha as of 2010, accounting for 64.5

<Table 1-15> Forest area and growing stock

Year	Forest area (thousand ha) *	Growing stock (thousand m^3)	Growing stock per ha (m^3)
1970	6,611	66,750	10.07
1980	6,568	145,694	22.18
1990	6,476	248,426	38.36
2000	6,422	407,575	63.47
2005	6,394	506,377	79.20
2010	6,369	800,025	125.60

Source: Korea Forest Service
Note: unstocked forests included

percent of the total land area. Of this, privately-owned forest area is about 4.3 million ha, accounting for 68.1 percent of the total forest area (Table 1-15).

The forest areas consist of needle-leaf trees (42.0%), broad-leaved trees (27.9%), and mixed forests (30%) as of 2010. The areas for needle-leaf tree forests are on a declining trend while broad-leaved trees are spreading.

The forest areas, by tree species, consist of pine trees (1,468 thousand ha), big cone pines (461 thousand ha), larches (406 thousand ha), pinus rigida (229 thousand ha), chestnut trees (77 thousand ha), and artificial forests with broadleaved trees (36 thousand ha).

The net loss of forest area in Korea has been 5,000 ha annually in the last decade. The area has increased by 2,000 ha per year due to reforestation. Yet, it has also decreased by 7,000 ha annually as the area has been converted into building sites, road, industrial facilities, etc. Growing stock in the forest was about 800 million m^3 and average growing stock per ha was 125.6 m^3, which is increasing by 3 to 4 percent annually as forest trees younger than 30 years account for more than 59 percent of the forests in Korea, and are at the peak of growth.

<Table 1-16> Forest area by type

(Unit: thousand ha, %)

Year	Total	Conferous forest	Broadleaved forest	Mixed forest	Bamboo
1970	5,700 (100)	3,268 (57.3)	1,207 (21.2)	1,219 (21.4)	6 (0.1)
1980	6,301 (100)	3,249 (51.6)	1,148 (18.2)	1,899 (30.1)	5 (0.1)
1990	6,286 (100)	3,079 (49.0)	1,389 (22.1)	1,810 (28.8)	8 (0.1)
2000	6,268 (100)	2,711 (43.2)	1,666 (26.6)	1,885 (30.1)	6 (0.1)
2005	6,240 (100)	2,699 (43.3)	1,659 (26.6)	1,875 (30.0)	7 (0.1)
2010	6,172 (100)	2,581 (42.0)	1,719 (27.9)	1,865 (30.0)	7 (0.1)

Source: Korea Forest Service

Chapter 2

Greenhouse Gas Inventory

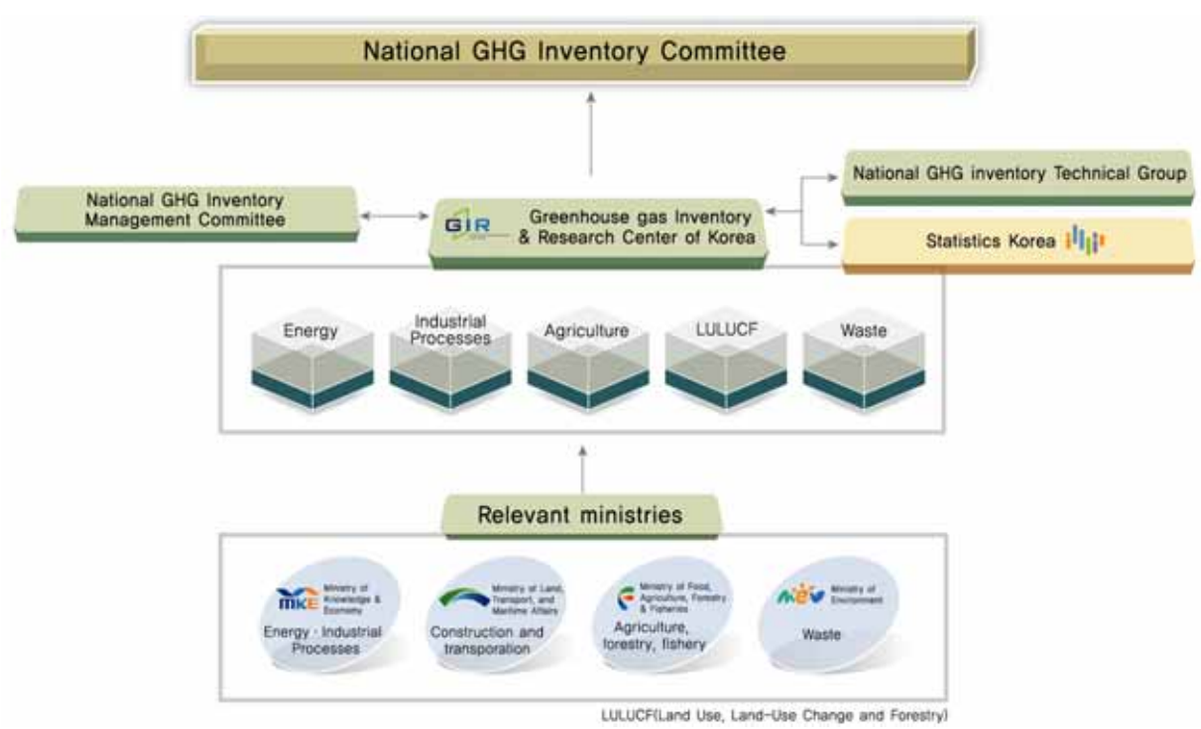
Chapter 2 Greenhouse Gas Inventory

1. Background information

The national greenhouse gas (GHG) inventory was published by the Ministry of Knowledge and Economy (MKE) in accordance with Article 19 of the *Energy Act* before 2010. The *Framework Act on Low Carbon, Green Growth* enacted in 2010, designated the Ministry of Environment as the representative body in charge of the national GHG inventory. As the Act states the principles, roles and system of GHG inventory management and the establishment of the Greenhouse Gas Inventory and Research Center of Korea (GIR), it fortifies the foundation for a transparent and efficient national GHG inventory system. The national GHG inventory preparation procedures are described as follows.

First, GIR provides the guidelines for Measurement, Reporting, and Verification(MRV) for the National GHG Inventory, which have been approved by the National GHG Inventory Committee by the end of February to relevant ministries to prepare the national GHG inventory. GIR revises the previous year's MRV guidelines reflecting verification results derived during the preparation of National Inventory Report(NIR) and Common Reporting Format(CRF) every year. Agencies in each sector designated by the relevant ministries must prepare their part of the GHG inventory following the approved guidelines. The relevant ministries gather and submit them to the GIR by June 30th.

The NIR and CRF submitted by relevant ministries are verified by GIR which is



[Figure 2-1] National GHG inventory management system

Key Organizations

National GHG inventory committee

- Adjustment, review, and approval of the national GHG inventory
- Adjustment, review, and approval of country-specific GHG emission factors and removal factors
- Adjustment, review, and approval of NIR and CRF
- Adjustment, review, and approval of international report regarding the national GHG inventory and related information
- Adjustment, review, and approval of general information on the national GHG inventory

※ The Vice Minister of Environment shall be the commissioner, and the committee will be consisted of 15 members including appointees from outside as well as the commissioner.
Ex officio members will be chief officers from Presidential Committee on Green Growth, Ministry of Knowledge & Economy, Ministry of Land, Transport & Maritime Affairs, Ministry for Food, Culture, Forestry & Fisheries, Ministry of Environment, Statistics Korea, and appointed members will be high-quality experts with relevant knowledge and experience, recommended by ex officio members to the commissioner.

Greenhouse Gas Inventory & Research Center of Korea(GIR)

- Establishment and publication of *National GHG Inventory Management Plan* (Oct 2012)
- Planning and implementation for the overall management of the national GHG inventory
- Management of QA/QC for the national GHG inventory
- Preparation of the *Guidelines for Measurement, Reporting, and Verification (MRV) for the National GHG Inventory*
- Domestic verification for the national GHG inventory
- Preparation for National Inventory Report (NIR) and Common Report Format (CRF)
- Verification and decision on country-specific emission factors and removal factors
- Management and operation of *National GHG Management System* (NGMS)
- Organization and Management of *National GHG Inventory Committee*, National GHG Management Inventory Committee National GHG Technical Group

National GHG inventory management committee

- Coordination of MRV for the national GHG inventory
- Coordination of development and verification of the national GHG country-specific emission factors and removal factors
- Coordination of establishment and revision of the *Guidelines for MRV for the National GHG Inventory* and the *Guidelines for National GHG Country-Specific Emission Factors and Removal Factors*

※ The head of the committee is GIR and members are public officers (above director level) from the Presidential Committee on Green Growth, Ministry of Knowledge & Economy, Ministry of Land, Transport & Maritime Affairs, Ministry for Food, Culture, Forestry & Fisheries, Ministry of Environment, Statistics Korea, etc.

National GHG technical group

- Technical review of NIR and verification report
- Technical review of country-specific GHG emission factors and removal factors

- Technical review of the *Guidelines for MRV for the National GHG Inventory* and the *Guidelines for National GHG Country-Specific Emission Factors and Removal Factors*

  ※ Technical Group will be consisted of experts from the GIR, Statistics Korea, and recommended by he relevant ministries(MKE, ME, MIFAFF, MLTM) and by the President of the GIR

Relevant Ministries

- In accordance with Article 36, Paragraph 4 of the *Framework Act on Low Carbon, Green Growth*, relevant ministries required to submit GHG inventories are the Ministry of Food, Agriculture, Forestry & Fisheries (agriculture, forestry, fishery); Ministry of Knowledge & Economy (energy, industrial processes); Ministry of Environment (waste); and Ministry of Land, Transport, and Maritime Affairs (construction and transport).

Agencies

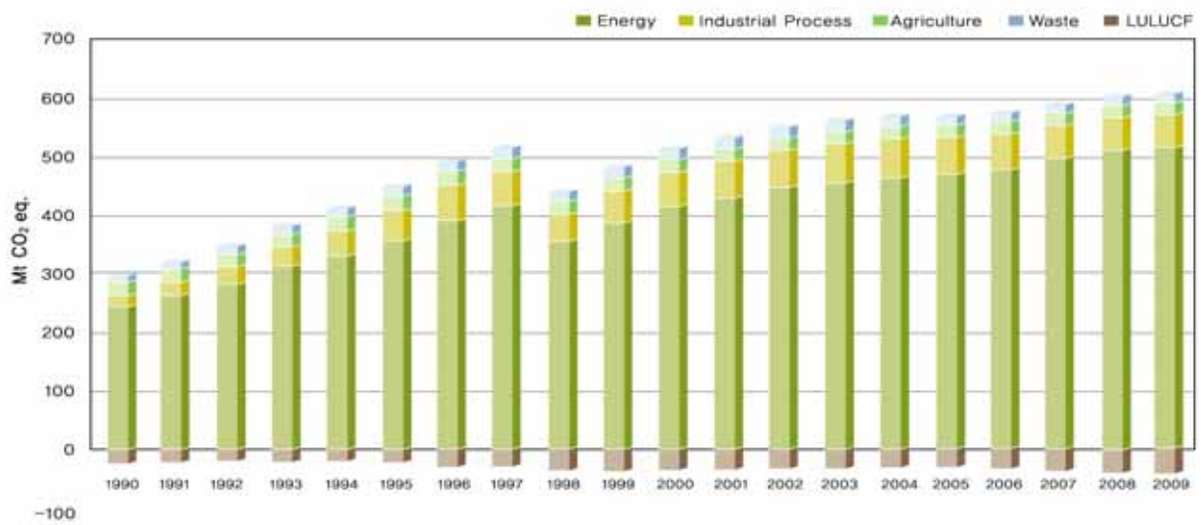
- Agencies, which are designated by the relevant ministries, conduct the task of preparing GHG inventory for each sector, respectively.

  ※ Agencies include Korea Energy Economics institute, Korea Institute of Construction Technology, Korea Transportation Safety Authority, Korea Energy Management Corporation, National Agricultural Research Institute, National Institute of Animal Science, Korea Forest Research Institute, and Korea Environment Corporation.

responsible for preparing the verification report based on the verification results. GIR's experts review the NIR and CRF for each sector; and if necessary, they may be reviewed by outside experts who did not participate in the initial preparation of the GHG inventory by the relevant ministries. Each Ministry must submit the NIR and CRF, revised by themselves reflecting verification result, to GIR by the end of October. After the National GHG Inventory Committee completes the final review of the NIR and CRF, with the technical review of the National GHG Inventory Technical Group and consultation of the National GHG Inventory Management Committee, the results are published in December.

GIR references the Revised 1996 IPCC Guidelines, GPG 2000, and GPG-LULUCF developed by IPCC as the estimation methodologies of the national GHG inventory.[2] The sectors in the GHG inventory preparation include energy, industrial processes, agriculture, LULUCF (land-use, land-use change, and forestry), and waste[3]. As designated by the Kyoto Protocol[4], the six direct GHGs such as CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 are included in estimating the National GHG Inventory. Estimation units, using Global Warming Potentials (GWP)[5] for the conversion, is Million tonne CO_2 equivalent (Mt CO_2 eq.).

2) Good Practice Guidance for Land Use, Land-Use Change and Forestry (2003)
3) Solvent and Other Product Use sector is not included since the emission levels from this source is negligible.
4) Adopted on Dec 1997 in Japan, the Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC), aimed at fighting global warming. Korea joined as of Nov 2002.
5) Global-warming potential is a relative measure of how much heat a GHG traps in the atmosphere, used in AR2



[Figure 2-2] Trends in GHG emissions and removals

<Table 2-1> GHG emissions and removals by sector

(Unit : Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Energy	243.1	357.7	414.4	469.6	476.6	495.8	509.6	516.0	112.3%
Industrial Processes	20.2	51.3	58.4	64.1	62.8	58.6	58.3	56.7	180.6%
Agriculture	22.7	23.5	22.4	20.3	19.7	19.3	19.4	19.8	-12.6%
LULUCF	-23.1	-22.4	-36.5	-32.4	-33.5	-37.5	-41.0	-42.9	85.6%
Waste	10.4	15.5	18.5	16.3	16.6	15.2	15.1	15.1	44.8%
Total Emissions[6]	296.4	448.1	513.7	570.3	575.7	588.8	602.3	607.6	105.0%
Total Net Emissions[7]	273.3	425.6	477.2	537.9	542.2	551.3	561.4	564.7	106.6%

Indirect GHGs[8] are also calculated, and reported Nitrogen Oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compound (NMVOC), and sulfur dioxide (SO_2).

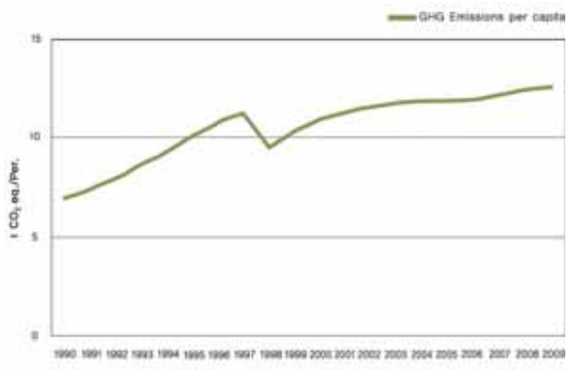
2. National GHG emissions

Total GHG emissions were 607.6 Mt CO_2 eq. in 2009, representing a 105.0 percent increase since 1990 and a 0.9 percent increase from 2008. Total GHG net emissions were 564.7 Mt CO_2 eq., in 2009, representing a 106.6 percent increase since 1990, and a 0.6 percent increase since 2008 (Figure 2-2, Table 2-1).

A. Total GHG emissions per capita

GHG emissions per capita were 12.5 t CO_2 eq. in 2009, representing an 80.3 percent increase since 1990 and a 0.6 percent increase since 2008. While total GHG emissions and GHG emissions per capita continued to increase,

6) Total Emissions: excluding LULUCF
7) Total Net Emissions: total GHG emissions by sources minus removals by sinks
8) Indirect GHGs combine with other substances, which results in the creation of GHGs



[Figure 2-3] GHG emissions per capita

<Table 2-2> GHG emissions per capita

(Unit: Mt CO_2 eq., Million, t CO_2 eq. per person)

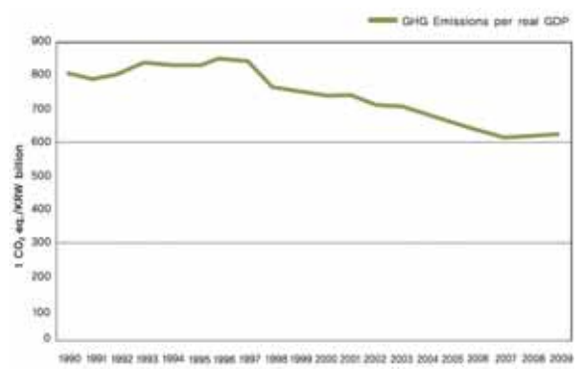
	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Total emissions	296.4	448.1	513.7	570.3	575.7	588.8	602.3	607.6	105.0%
Estimated population	42,869	45,093	47,008	48,138	48,297	48,456	48,607	48,747	13.7%
Total emissions per capita	6.9	9.9	10.9	11.8	11.9	12.2	12.4	12.5	80.3%

source: Statistics Korea

the rate of increase had been slowing down (Figure 2.3, Table 2-2).

B. GHG total emissions by real GDP

GHG emissions per real GDP in 2009 were 619.0 t CO_2 eq. per KRW billion, showing a 22.9 percent decrease since 1990 (Figure 2-4,



[Figure 2-4] GHG emissions by real GDP

<Table 2-3> GHG emissions by GDP

(Unit : Mt CO_2 eq., KRW billion, t CO_2 eq./KRW billion)

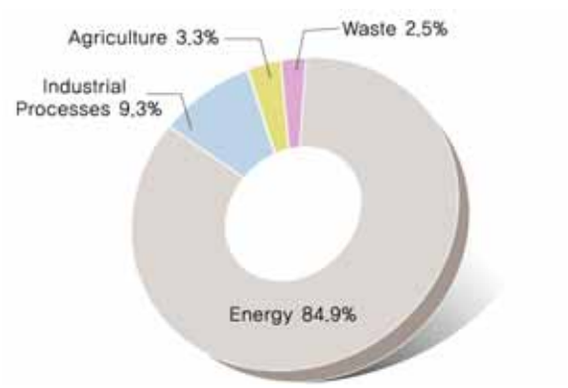
	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Total emissions	296.4	448.1	513.7	570.3	575.7	588.8	602.3	607.6	105.0%
Real GDP	368,986	539,424	694,628	865,241	910,049	956,515	978,499	981,625	166.0%
Total emissions per real GDP	803.2	830.6	739.6	659.1	632.6	615.6	615.6	619.0	-22.9%

Source: Bank of Korea

Table 2-3). Emissions per GDP reflected a decreasing trend until 2009 when emissions per GDP indicated a slight increase. The increase could be attributed to increase demand for electricity due to extraordinary weather patterns and events.

3. GHG emissions by sector

Total GHG emissions consisted of the following sectors: 84.9 percent from the energy sector, 9.3 percent from industrial processes, 3.3 percent from agriculture, and 2.5 percent from the waste sector (Figure 2-5).



[Figure 2-5] GHG emissions by sector

A. Energy

Emissions from the energy sector in 2009 were 516.0 Mt CO_2 eq., accounting for 84.9 percent of the national total. These result showed a 112.3 percent increase since 1990, and a 1.3 percent increase since 2008. The majority of emissions in the energy sector came from fossil fuel combustion, which comprised 98.8 percent of the total emissions. 44.9 percent of GHG emissions by fossil fuel combustion came from the energy industry, 27.6 percent from manufacturing and construction, 16.2 percent from transport, and 11.3 percent from other sectors (Table 2-5).

GHG emissions consisted of the following energy sources: 50.4 percent from coal, 35.4 percent from oil, 14.2 percent from gaseous fuel, and 0.1 percent from biomass. GHG emissions from coal increased by 170.1 percent, oil by 33.1 percent, gaseous fuel by 926.8 percent, biomass by 129.8 percent since 1990. The increased use of coal and gaseous fuel in the energy industry raised the GHG emission levels.

Even though the use of clean and new & renewable energy sources had been growing, emissions from the energy industry were still increasing because of the increased power consumption caused by the growth of energy-intensive industries and the service industries. In particular, emissions from commercial facilities, mechanical equipment, housing, oil (chemicals), and primary metal occupied a large proportion of GHG emissions. Meanwhile, emissions from other sectors showed a reduction trend - this was caused by decreased consumption of hard coal in households that had experienced raised income levels.

<Table 2-4> GHG emissions in energy sector

(Unit: Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Fuel combustion	237.7	354.5	410.0	463.7	470.4	489.1	502.8	509.6	114.4%
Fugitive emissions from fuel	5.4	3.2	4.4	5.9	6.2	6.7	6.8	6.4	18.0%
Total emission	243.1	357.7	414.4	469.6	476.6	495.8	509.6	516.0	112.3%

<Table 2-5> GHG emissions in fuel combustion

(Unit: Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Energy industry	48.8	95.8	137.0	177.5	187.2	198.2	211.1	228.7	368.7%
Manufacturing industry & construction	77.0	115.2	129.6	134.6	136.0	144.6	150.0	140.8	82.9%
Transport	35.4	64.9	70.1	81.9	82.7	84.0	81.8	82.6	133.4%
Other	76.5	78.6	73.4	69.6	64.4	62.3	59.9	57.6	-24.7%
Total	237.7	354.5	410.0	463.7	470.4	489.1	502.8	509.6	114.4%

<Table 2-6> GHG emissions in industrial processes sector

(Unit: Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Mineral production	18.1	31.5	28.4	27.6	27.5	29.8	29.8	28.8	59.0%
Chemical industry	1.0	4.6	7.9	11.4	9.8	0.9	0.8	0.8	-25.2%
Metal production	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	77.3%
Halocarbon and SF_6 production	1.0	2.6	3.2	0.0001	0.0002	0.0002	0.0002	0.0002	-100.0%
Halocarbon and SF_6 consumption	0.0	12.5	18.8	24.9	25.3	27.6	27.4	27.0	115.8%*
Total emission	20.2	51.3	58.4	64.1	62.8	58.6	58.3	56.7	180.6%

* emission change rate from 1995 to the latest reported year

B. Industrial processes

Emissions from the industrial processes sector in 2009 were 56.7 Mt CO_2 eq., accounting for 9.3 percent of the national total. This reflected a 180.6 percent increase from 1990, and a 2.7 percent decrease from 2008. Mineral production constituted 50.8 percent of total GHG emissions, chemical industry constituted 1.4 percent, metal production constituted 0.3 percent, halocarbon and SF_6 production constituted 0.0003 percent, and halocarbon and SF_6 consumption constituted 47.6 percent (Table 2-6).

Cement production accounted for 80.5 percent of mineral production and for 40.9 percent of industrial processes emissions. Cement production was a major source of emissions.

Total emissions from industrial processes sector had declined since 2005. The reason was that GHG emissions decreased due to the installation of technology to decompose HFCs and N_2O (emitted from nitric acid production processes).

As the industries for heavy electric equipment, semiconductors, and displays developed, emissions from halocarbon and SF_6 consumption had increased since 1990. However, these emissions decreased, more recently, as the use of NF_3 increased.

C. Agriculture

Emissions from the agriculture sector in 2009 amounted to 19.8 Mt CO_2 eq., accounting for 3.3 percent of the national total. This indicated a 12.6 percent decrease since 1990, and a 2.3 percent increase since 2008.

Rice cultivation accounted for 31.1 percent of the emissions, followed by cropland (30.0%), enteric fermentation (19.4%), and manure management (19.1%) (Table 2-7).

Emissions had been decreasing in the agronomy[9] sub-sector due to the reduction in paddy fields and the use of fertilizer. Emissions in the livestock sub-sector were also in a decreasing pattern in early 2000. Since then, the increase of meat consumption had led to an increasing trend in livestock emissions.

9) Agronomy is the science and technology of producing and using plants for food, fuel, feed, fiber, and reclamation

D. Waste

Emissions from the waste sector in 2009 amounted to 15.1 Mt CO_2 eq., accounting for 2.5 percent of the national totals. This represented a 44.8 percent increase compared to 1990, and a 0.1 percent decrease compared to 2008.

Solid waste disposal accounted for 50.0 percent of the total emissions, followed by incineration (38.2%), wastewater handling (8.2%), and other sectors (3.7%) (Table 2-8). The total emissions from the waste sector were mainly affected by landfill and incineration. From 1990 to 2000, the total emissions from the waste sector had increased because the waste management policies changed to promote more incineration rather than landfill use. As energy recovery from the incinerating facilities has been increasing since 2000, the emissions from the waste sector has also decreased.

<Table 2-7> GHG emissions in agriculture sector

(Unit: Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Enteric fermentation	3.0	4.0	3.6	3.2	3.4	3.5	3.7	3.8	27.3%
Manure management	2.5	3.5	3.4	3.3	3.4	3.5	3.7	3.8	52.4%
Rice cultivation	10.2	9.0	8.7	7.6	6.9	6.3	6.2	6.2	-39.6%
Agricultural soils	6.9	6.9	6.7	6.1	5.9	5.8	5.8	5.9	-13.6%
Field burning of agricultural residues	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	4.8%
Total emission	22.7	23.5	22.4	20.3	19.7	19.3	19.4	19.8	-12.6%

<Table 2-8> GHG emissions in waste sector

(Unit: Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
Solid waste disposal	7.4	9.7	9.3	8.5	8.3	7.6	7.4	7.5	1.5%
Waste-water handling	1.5	1.5	1.3	1.3	1.2	1.2	1.2	1.2	-19.9%
Waste incineration	1.4	4.2	7.7	6.0	6.7	5.9	5.9	5.7	297.7%
Other	0.0	0.0	0.2	0.4	0.5	0.5	0.5	0.6	219.4%*
Total emission	10.4	15.5	18.5	16.3	16.6	15.2	15.1	15.1	44.8%

* emission change rate from 2000 to the latest reported year

<Table 2-9> Removals in LULUCF sector

(Unit : Mt CO_2 eq.)

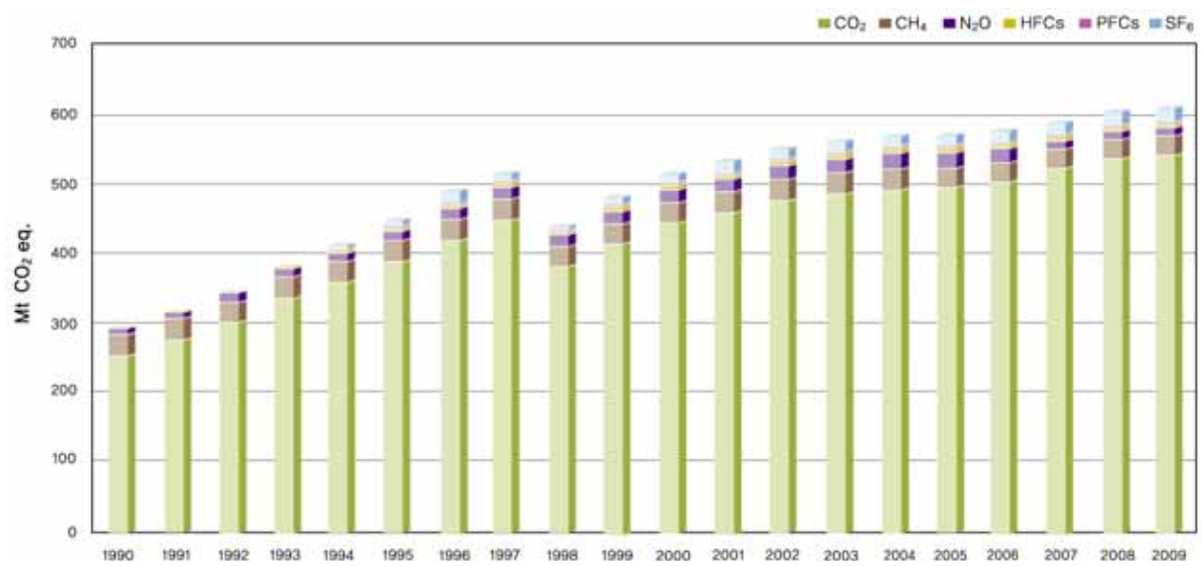
	1990	1995	2000	2005	2006	2007	2008	2009	Change from the latest reported year
Forest land	-23.1	-22.4	-36.5	-32.4	-33.5	-37.5	-41.0	-42.9	85.6%
Net emission (sink)	-23.1	-22.4	-36.5	-32.4	-33.5	-37.5	-41.0	-42.9	85.6%

E. LULUCF

Removals of GHGs in LULUCF were 42.9 Mt CO_2 eq. in 2009, 85.6 percent increase from 1990 levels, and a 4.7 percent increase from 2008 levels. Since Korea does not fertilize nitrogen in forested land and has a low proportion of organic soil, there were no non-CO_2 emissions in LULUCF.

4. Greenhouse Gas emissions by gases

The share of CO_2 in the total GHG emissions in 2009 was 89.0 percent, followed by 4.6 percent of CH_4, 3.1 percent of SF_6, 2.1 percent of N_2O, 1.0 percent of HFCs, and 0.4 percent of PFCs. Compared to the levels in 1990, CO_2 and N_2O emissions increased by



[Figure 2-6] GHG emissions trends

<Table 2-10> Greenhouse gas emission by sources

(Unit : Mt CO_2 eq.)

	1990	1995	2000	2005	2006	2007	2008	2009	Change from base to latest reported year
CO_2	254.4	389.0	444.3	494.6	501.9	521.8	535.0	540.6	112.5%
CH_4	30.5	29.1	29.1	28.8	28.4	27.8	27.9	27.7	-9.1%
N_2O	10.5	14.9	18.3	22.2	20.3	11.9	12.3	12.5	18.8%
HFCs	1.0	5.6	8.4	6.7	6.1	7.4	6.9	5.9	5.2%*
PFCs		2.4	2.2	2.8	2.9	3.1	2.9	2.3	-4.2%*
SF_6		7.1	11.3	15.3	16.0	16.9	17.4	18.6	160.3%*
Total emission	296.4	448.1	513.7	570.3	575.7	588.8	602.3	607.6	105.0%
LULUCF	-23.1	-22.4	-36.5	-32.4	-33.5	-37.5	-41.0	-42.9	85.6%
Net emission (with LULUCF)	273.3	425.6	477.2	537.9	542.2	551.3	561.4	564.7	106.6%

* 2009 increase rate compared to 1995 levels

112.5 percent and 18.8 percent, respectively, and CH_4 emissions decreased by 9.1 percent. Emissions of HFCs and SF_6 increased by 5.2 percent and 160.3 percent, but PFC emissions decreased by 4.2 percent (Figure 2-6, Table 2-10).

A. Carbon dioxide (CO_2)

CO_2 emissions (without LULUCF) amounted to 540.6 Mt CO_2 eq. in 2009, accounting for 89.0 percent of the total GHG emissions. This represents a 112.5 percent increase compared to 1990 and a 1.1 percent increase compared to 2008. Compared to 1990, CO_2 emissions in 2009 increased by 116.2 percent in energy sector, by 53.6 percent in industrial processes sector, and 297.1 percent in waste sector. The removals from LULUCF increased by 85.6 percent (Figure 2-7).

The major source of CO_2 emissions is the combustion of fossil fuel. In 2009, it comprised 93.6% of the total CO_2 emissions. With the exception of the Asian financial crisis in 1998, the emissions from energy industries kept increasing because of an increase of the fuel consumption in energy industries.

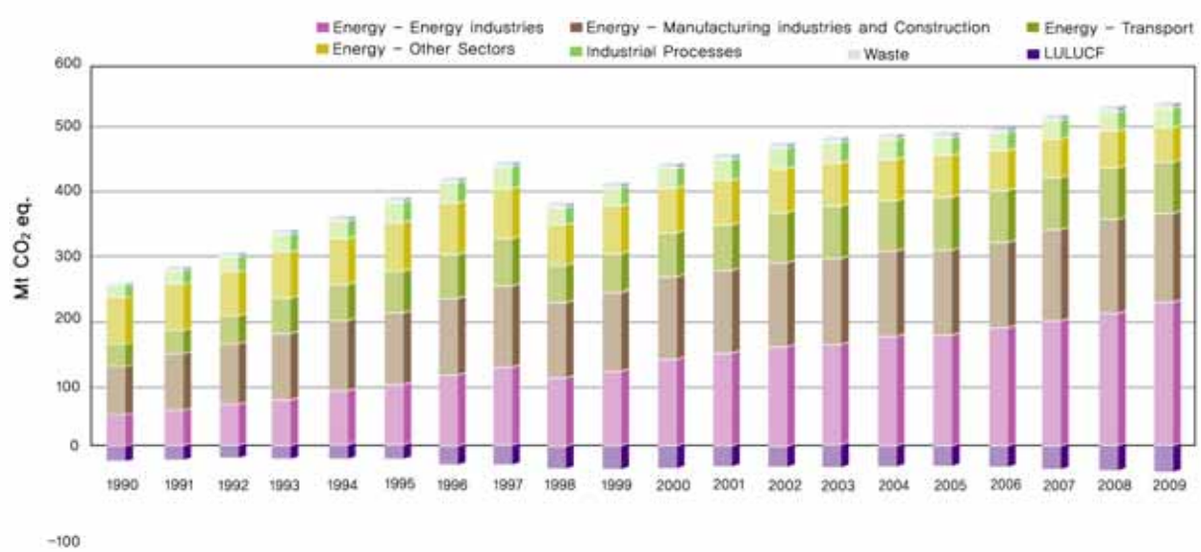
B. Methane (CH_4)

CH_4 emissions in 2009 were 27.7 Mt CO_2 eq., accounting for 4.6 percent of the total GHG emissions. These emissions represented a 9.1 percent decrease compared to 1990, and a 0.6 percent decrease compared to the previous year.

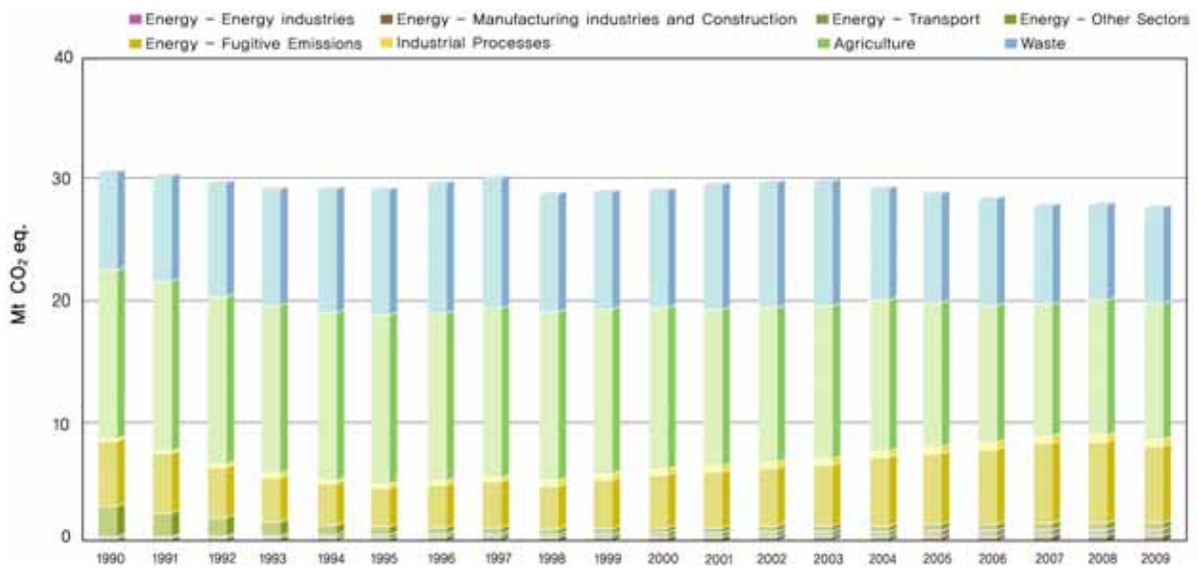
The major sources of CH_4 emissions are rice cultivation and the fugitive emissions from natural-gas processing.

In 2009, CH_4 emissions from fuel combustion in the energy sector decreased by 48.1 percent. CH_4 emissions from the industrial processes sector increased by 350.7 percent compared to 1990, because of the increase of production of ethylene and styrene in chemistry industries.

In the agricultural sector, emissions from enteric fermentation, manure management, and field burning of agricultural residues increased by 27.3, 46.7, and 7.2 percent respectively, but



[Figure 2-7] CO_2 emission by sources and sinks



[Figure 2-8] CH_4 emission by sources

emissions from rice cultivation decreased by 39.6 percent. In the waste sector, solid waste disposal decreased by 1.5 percent and waste-water handling decreased by 55.5 percent (Figure 2-8).

C. Nitrous oxide (N_2O)

N_2O emissions amounted to 12.5 Mt CO_2 eq., 18.8 percent increase compared to 1990 and a 2.0 percent increase compared to 2008 (Figure 2-9).

The major source of N_2O emissions is the agricultural sector, accounting for 68.4 percent of the overall national emissions and 47.6 percent of N_2O emissions from agricultural soils.

As decomposition of N_2O (emitted from nitric acid production process) took place since 2007, the emissions from the industrial processes sector significantly decreased.

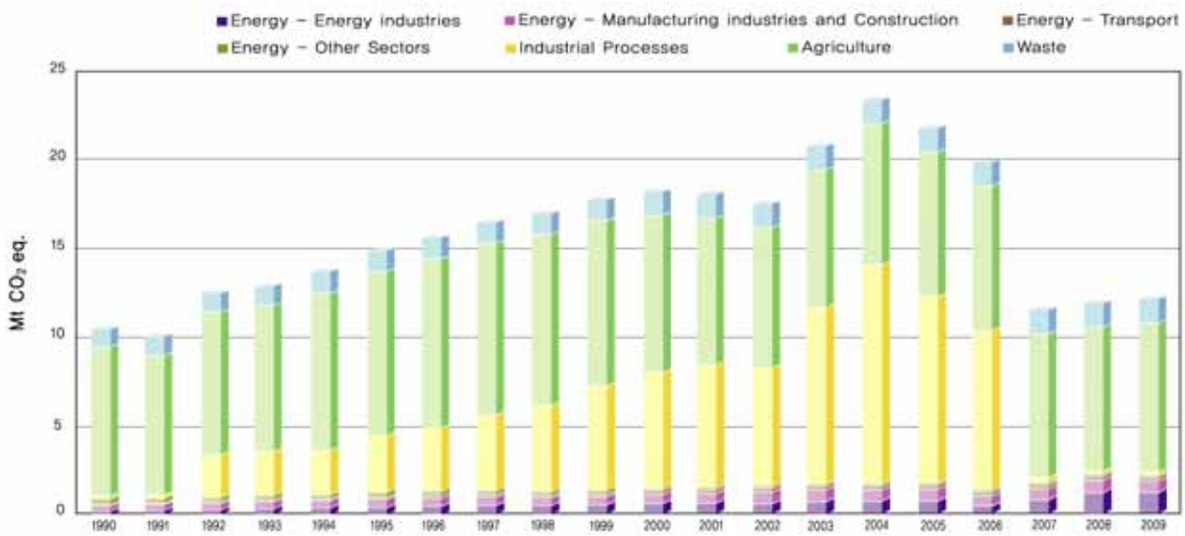
Changes in N_2O emissions in 2009 compared to 1990 were as follow: 175.2 percent increase in the fuel combustion from energy industries, 55.2 percent increase in livestock manure management, and 314.0 percent increase in waste incineration. However, emissions decreased in agricultural land and industrial processes, by 13.6 and 104.2 percent, respectively.

D. Hydrofluorocarbons (HFCs)

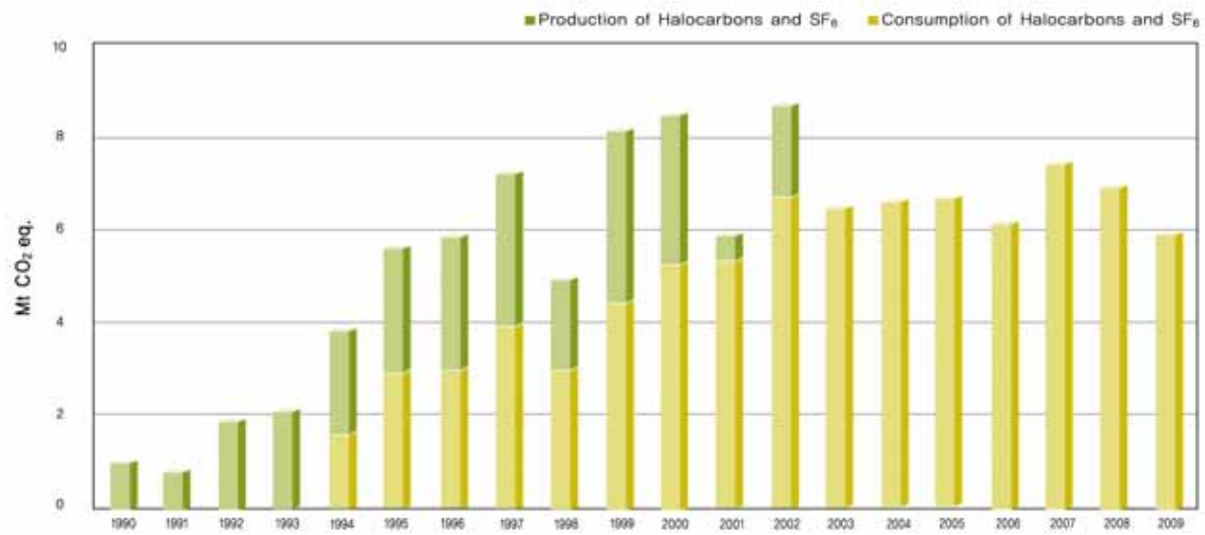
HFCs emissions in 2009 were 5.9 Mt CO_2, accounting for 1.0 percent of total GHG emissions. These represented a 5.2 percent increase compared to 1995 and 14.7 percent decrease compared to the previous year (Figure 2-10).

HFCs emissions, which are released from HCFC-22 production, decreased because of the application of HFC-23 decomposition technology by thermal oxidation since 2003.

Major sources of HFCs emissions are mostly refrigeration and air conditioning equipments and semiconductor manufacturing.



[Figure 2-9] N_2O emission by sources



[Figure 2-10] HFCs emission by sources

E. Perfluorocarbon (PFCs)

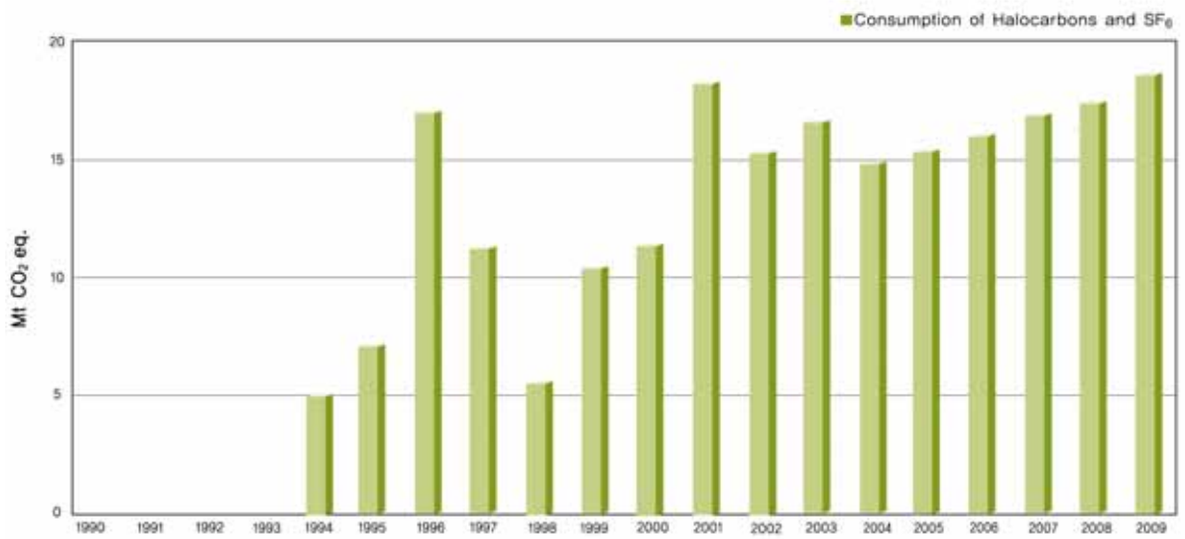
PFC emissions in 2009 were 2.3 Mt CO_2 eq., which accounted for 0.4 percent of the total GHG emissions. This represents a 4.2 percent decrease compared to 1995 and a 22.1 percent decrease compared to the previous year (Figure 2-11).

The major sources of PFCs are the semiconductor industries and the display industries.

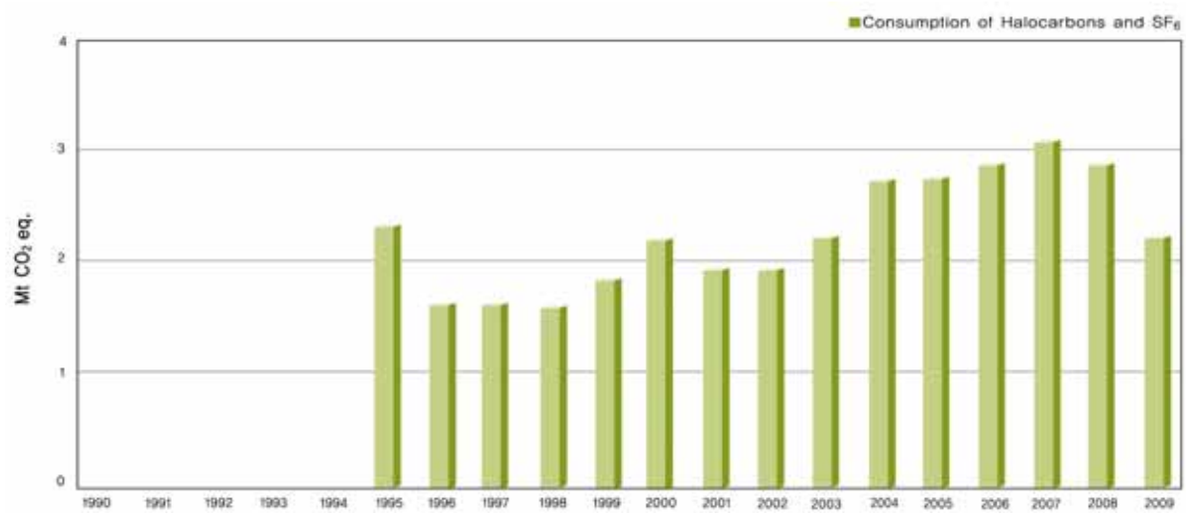
F. Sulfur hexafluoride (SF_6)

SF_6 has emissions accounted for 3.1 percent of the total emissions in 2009.

SF_6 emissions were 18.6 Mt CO_2 eq. in 2009, representing about a 160.3 percent increase compared to 1995 and a 7.0 percent increase compared to the previous year (Figure 2-12). The major source of SF_6 are the heavy electric equipments industries and the display industries.



[Figure 2-11] PFCs emission by sources



[Figure 2-12] SF_6 Emission by Sources

Chapter 3

Policies and Measures

Chapter 3 Policies and Measures

As a member of the UNFCCC, Korea is actively pursuing voluntary, multilateral policies and measures in several sectors, in order to contribute to the international joint effort to find a solution to the global issue of climate change. Since 1998, with the Prime Minister as the head, Korea has organized and operated the *Special Committee on Climate Change*, which consists of the heads of major government offices and administrations, to cope with the climate change issue. This committee has led to the formation of the *Comprehensive Action Plans for UNFCCC*, which was then promoted after in-depth consideration and discussion.

Recently, Korea enhanced its climate change policies to pursue more active, combative measures. As a result, the government proposed the *Comprehensive Action Plan for Climate Change*(2008~2012), which includes contents related to environment, industry and a framework for international cooperation, etc. This plan was launched to counter global climate change and to begin working towards the initiation of a low carbon society through green growth.

The power and industrial sectors are promoting efforts for GHG reduction policies centered on energy demand, supply, and efficiency improvement. Regarding energy demand, strict demand management policies for the industrial sector are being pursued. For energy supply, a variety of policies are in place to expand the supply of new & renewable and clean energy sources. By increasing the supply of high efficiency equipment, efforts for improvement in energy efficiency are also being promoted.

In the building sector, efforts to reduce GHG emissions are being made through the reinforcement of design standards for energy-saving buildings. For this purpose, the energy efficiency level certification system is being expanded, and the green building certification program is being improved.

In the transport sector, policies are being enforced for the improvement of the public transport system, the increase of low-pollution vehicles, the establishment of a low-carbon distribution system, and so forth. In addition, a variety of policies are being promoted to improve the management methods for the agriculture sector. In the forestry sector, policies are being implemented for the protection and expansion of forest carbon sinks, and forest carbon offset projects. Lastly, in the waste sector, policies are in place for the minimization of waste generation and for the expansion of recycling programs and resource recovery.

The aforementioned promotional strategies and their individual measures are arranged as shown in Table 3-1. The major contents of specific policies and measures in each promotion strategy, such as GHG targets, trends and current status, are summarized in Table 3-2.

<Table 3-1> Summary of the policies & measures for GHG reduction by sector

Sector		Strategy	Policies and measures
All sectors		Reduction of GHG emissions caused by fossil fuels	GHG and Energy Target Management Scheme
Energy and industrial sector	Demand	Enhanced energy demand management in the industrial sector	Voluntary agreement
			Energy audit system
			Consultation on energy use plan
			Investment support for energy efficiency facilities
			Energy Service Company (ESCO) business expansion
			Cap on energy consumption for government and public sectors
	Supply	Expansion of new & renewable and clean energy supply	Program for new & renewable energy promotion
			Expansion of integrated energy supply system
			Stable supply of natural gas
			Maintenance of appropriate level of nuclear power generation
			Expansion of biodiesel supply
	Efficiency	Expansion of high-efficiency equipment supply	Energy efficiency standard & labeling program
			Enforcement of e-standby program
			High-efficiency equipment certification
	Reduction	Promoting early action on GHG reduction	Korea voluntary emission reduction registration program
			Industrial ad-hoc working groups for addressing climate change
Buildings		Intensification of building design standards	Building code for envelope insulation & energy-efficient design
			Energy efficiency labeling program for buildings
			Green building certification program
			Green building activation plan
Transport		Enhanced management of transport demands and efficient traffic system	Low carbon smart transit system
			Green public transport
		Revitalization of low emission vehicles	Foundation for distribution of electric vehicles
		GHG & energy policy for vehicles	Implementation of production and distribution of high-efficiency vehicles
		Establishment of low carbon distribution system	Low cost, high efficiency green distribution system
Agricultural & livestock		Improvement of agro-dairy farming methods	Reduction of CH_4 emissions from paddy fields
			Reduction in N_2O emissions in paddy field and upland
			Improvement of ruminant enteric fermentation
			Utilization of livestock manure as resources
Forestry		Protection and expansion of forest carbon sinks	Maintenance and enhancement of carbon sequestration potential
			Prevention of deforestation
			Afforestation/reforestation
		Implementation of forest carbon offset projects	Introduction of forest carbon offset program
		Promotion of use of wood bio-energy	Promotion of use of wood bio-energy
Waste		Minimization of waste occurrences and resource recovery	Reduction of waste
			Expanding reuse and recycling of waste
			Utilization of waste resources as energy

<Table 3-2> Policies & measures for GHG reduction by sector

Policy & measures	Details	Type	Status
GHG and Energy Target Management Scheme	▪ Setup of maximum allowance for annual GHG emissions for businesses emitting more than 125,000 t CO_2 eq. of GHG or facilities emitting more than 25,000 t CO_2 eq. (2012 as the standard) ▪ Fine will be imposed on businesses when the standard is not met	Regulation Institutionalized	Implemented
Energy and industrial sector			
Energy demand			
Voluntary agreement	▪ Targets will be expanded to include businesses with annual energy-consumption over 5,000 TOE to businesses with over 2,000 TOE ▪ Industries will voluntarily set and actualize their energy-saving and GHG reduction goals	Institutionalized & financial aid	Implemented
Energy audit system	▪ Industries with annual energy consumption over 2,000 TOE will comply with mandatory audit implementation every five-years ▪ Industries with annual energy consumption over 200,000 TOE will be partly audited every three-years	Regulation & financial aid	Implemented
Consultation on energy use plan	▪ Businesses with large scale energy consumption are required to have a discussion on their energy-consumption plan with the government ▪ The targets of consultation include: city development, industrial complex development, port development, etc.	Regulation	Implemented
Investment support for energy-efficiency facilities	▪ Replacing outdated, low-efficiency facilities and increasing the distribution of high efficiency equipments. ▪ Long-term, low interest loans and tax support for investment in energy-efficient facilities	Institutionalized & financial aid	Implemented
Energy Service Company(ESCO) business expansion	▪ From including simple equipments like lightening equipment in the beginning, recently includes more complex equipment such as small scale co-generation facilities and waste heat recovery system.	Institutionalized & financial aid	Implemented
Cap on energy consumption for government and public sectors	▪ Public institutions are to set energy-saving goals by year and make efforts to fulfill them	Regulation	Implemented / Modified
Energy Supply			
Program for new & renewable energy promotion	▪ *1 Million Green Homes* project to replace the current energy supply with new & renewable energy such PV, solar, and geothermal energy by 2020 ▪ Investment support for the development of core technology for new & renewable energy	Institutionalized & financial aid	Implemented
Expansion of integrated energy supply	▪ Introduction of the integrated energy supply system to large residential areas, commercial districts, and industrial complexes ▪ Utilization of heat from waste incineration for district heating	Institutionalized & financial aid	Implemented
Stable supply of natural gas	▪ Diversifying natural gas sources that are concentrated in Middle East and Southeast Asia ▪ Enhancement the stability of mid-and long-term supply through the expansion of storage facilities	Recommended	Implemented
Maintenance of appropriate level of nuclear power generation	▪ Maintaining a certain percentage of nuclear power generation out of the total long-term power supply	Recommended	Implemented
Expansion of biodiesel supply	▪ Develop next-generation biofuels through oil pilot project, marine plants, and biodiesel from animal fats ▪ Tax exemption for biodiesel oil in 2011, adapt Renewable Fuel Standard (RFS) by 2012	Institutionalized (Regulation forthcoming) & financial aid	Implemented

<Table 3-2> Policies & measures for GHG reduction by sector (continued)

Policy & measures	Details	Type	Status
Energy efficiency improvement through high efficiency equipment			
Energy-efficiency Standard & Labeling Program	▪ Efficiency grades [1-5] are labeled on 24 items, such as refrigerators and washing machines. ▪ Prohibits production and sales of items below grade 5	Regulation	Implemented
Enforcement of e-standby program	▪ All electronic products produced after 2010 met the requirement for having standby energy below 1W, ▪ Products failing to meet the requirement will be labelled with the stand-by energy warning label	Regulation	Implemented
High-efficiency equipment certification	▪ A system to enhance market reliability by having the government certify high-efficiency items ▪ Certified products receives <e Mark>, funding, and tax support	Institutionalized	Implemented
Foundations for GHG reduction at the early stage			
Korea voluntary emission reduction registration program	▪ Compensation of actual reduction to encourage emission reduction in advance ▪ Compensation for reduction above 100 t CO_2 eq. such as rationalization of energy use and development of new & renewable energy	Institutionalized & incentives	Implemented
Industrial ad-hoc working groups for addressing climate change	▪ Organize and operate task force for GHG reduction by industries such as electric power, steel, and refined oil ▪ Data collection and analysis of GHG reduction technology, development of guidelines, for GHG inventories, corporate internal emission trading scheme	Institutionalized Recommended	Implemented
Buildings			
Building code for envelope insulation & energy-efficient design	▪ Increased insulation standard for new buildings by 20 percent or more ▪ Enhanced insulation policies and technological standards for low-carbon houses by 2017, and the establishment of Net Zero Carbon House by 2025.	Institutionalized	Implemented
Energy-efficiency labeling program for buildings	▪ Installation of energy-saving facilities and equipment for apartments ▪ Certification for energy efficiency in buildings above certain standards	Institutionalized & financial aid	Implemented
Green building certification program	▪ Inducement of GHG reduction such as energy-saving and removing pollutants during the entire process ▪ Tax relief on building registration for eco-friendly buildings, more flexible building standards such as landscaping, height, and registration tax reliefs to expand the program	Institutionalized & financial aid	Implemented
Green building activation plan	▪ Revise the *Low energy eco-friendly home construction standard and performance* established in 2009 for Joint homes ▪ Provide Green remodeling guidelines by building type and offer the applicable technology development, support and financial aid	Institutionalized	Plan

<Table 3-2> Policies & measures for GHG reduction by sector (continued)

Policy & measures	Details	Type	Status
Transport			
Low carbon smart transit system	▪ Expansion of Intelligent Transportation System (ITS) to 25 percent of paved roads by 2020 ▪ Smart highway R&D by integration of high-road technology, ITS, and next-generation automotive technology	Institutionalized	Implemented
Green public transport	▪ Expand the operation of the Metropolitan Bus (MBUS) in order to reduce capital traffic problems and revitalize public transport ▪ Expand pedestrian-first areas; increase public transport-only zones; and implement public bicycle systems	Institutionalized Incentives	Implemented
Revitalization of low emission vehicles	▪ Build foundation for distribution of electric vehicles by 2011 ▪ Support for the private buyers and expansion of charging infrastructure after 2013	Institutionalized Incentives	Implemented
Establishment of low carbon distribution system	▪ Construction of inland distribution complexes in five major districts ▪ Utilize third-party logistics to reduce cost	Institutionalized Incentives	Implemented
GHG and energy policy for vehicles	▪ Suggests a standard for fuel efficiency for auto manufacturers with annual sales over 1,000 in order to accelerate distribution of high-efficiency vehicles ▪ Small-scale manufacturers and importers will use separate standards	Institutionalized	Implemented
Agriculture & livestock			
Reduction of CH_4 emissions from paddy fields	▪ CH_4 emissions reduction through rice cultivation methods, water management, soil ameliorant, farming management, etc. ▪ Publish and supply *Manual of rice plantation technology for CH_4 reduction* to supply the CH_4 reduction technology to the fields	Institutionalized	Implemented
Reduction in N_2O emissions in paddy field and dry field	▪ Emissions reduction through the measurement of N_2O emissions by developing eco-friendly agricultural five-year plan(in effect since 2001) ▪ Reduction of nitrogen fertilizer through customized fertilizer distribution and eco-friendly agricultural direct-pay policy	Institutionalized	Implemented
Improvement of ruminant enteric fermentation	▪ CH_4 emissions reduction through livestock improvement program, increase in payment for high-quality forage, and addition of rumen fermentation modifier ▪ Perform research to reduce methane emission by conducting research on methane-reduced feed, forage additives, and microorganism control	Institutionalized	Planned
Utilization of livestock manure as resources	▪ Reusing resource of livestock manure through compost, liquefaction, and renewal. ▪ To promote reusing livestock manure as resource, policies for livestock manure management and use were institutionalized in 2007 and livestock manure support program has been promoted in farming and agricultural areas	Institutionalized & Financial aid	Implemented

<Table 3-2> Policies & measures for GHG reduction by sector (continued)

Policy & measures	Details	Type	Status
Forestry			
Maintenance and enhancement of carbon sequestration potential	▪ Implemented forest tending projects by establishing 1st phase of *five-year plan for forest tending*(2004~2008) for stainable forest management and to increase carbon sequestration potential ▪ Implementing forest tending projects by establishing 2nd phase of five-year plan for forest tending (2009~2013) responding to climate change through expansion of carbon sinks and increased values of forest	Institutionalized & financial aid	Implemented
Prevention of deforestation	▪ Introduced system for forest land conversion permits and forest resources replacement charge scheme to prevent excessive forest conversion ▪ Established permit standards for forest conversion and introduced pre-consultation scheme through enactment of Forest Land Management Act	Institutionalized	Implemented
Afforestation/ Reforestation	▪ Established *Five-year unused land afforestation plan* (2007-2011) for the purpose of expanding forest carbon sink ▪ As urban areas expanded after the integration of cities and agricultural areas in 1995, central and local government, and civic organizations have actively been working on urban afforestation projects	Institutionalized	Implemented
Introduction of forest carbon offset program	▪ Introduced forest carbon offset program to establish a basis to participate in GHG and energy target management and emission trading schemes ▪ Enacted *the regulation on pilot projects of forest carbon offset program* to build an operating system for the pilot projects	Institutionalized	Implemented
Promotion of use of wood bio-energy	▪ Implementing policies for expansion of use of wood bio-energy to achieve the supply goal of new & renewable energy ▪ Providing subsidy for installation of wood pellet manufacturing facilities	Institutionalized & financial aid	Implemented
Waste			
Reduction of waste	▪ Enact the "Workplace waste reduction guideline" for producers ▪ Regulations regarding packing space ratio, packing times, methods, etc for distributors ▪ Implementation of standardized bin bags, restriction of disposable items, and pilot project for food waste regulation	Institutionalized	Implemented
Expanding reuse and recycling of waste	▪ Enforcing and implementing laws regarding circulating resources of electronic products and motor vehicles ▪ Funding support for vehicle purchases and public recycling facilities for food waste ▪ Enforce recycling requirement for public sewage treatment facilities with treatment capacity below 5,000 tons per day	Institutionalized	Implemented
Utilization of waste resources as energy	▪ Solid fuel production using combustible waste ▪ Technology development and professional manpower promotion through R&D program to convert waste resources into energy, and to build low carbon green zone	Institutionalized & financial aid	Implemented

1. Institutional foundation

A. Climate change response system

After assessing that inter-ministerial level preparations are required to cope with the climate change issues, the *Special Committee on Climate Change* was created and has been in operation since 1998. This has led to the formation of *Comprehensive Action Plans for UNFCCC*, which was then endorsed after in-depth consideration and discussion.

With the *1st Comprehensive Action Plans for UNFCCC(1999~2001)*, Korea had implemented 17 projects (such as voluntary agreement, alternative energy development and increases in sewage treatment rates) along with 111 detailed implementation plans (such as an ESCO program to provide support for energy service companies and a program to expand carbon sinks). Korea also pushed several policies and measures by establishing the *2nd Comprehensive Action Plans for UNFCCC (2002~2004)*, which included the acceleration of the development of GHG reduction technology and environmentally friendly energy, reinforcement of the action plans for GHG reduction, and encouragement of participation and cooperation by citizens.

Meanwhile, through the *3rd Comprehensive Action Plans for UNFCCC (2005~2007)*, the nation is pushing new ideas for advancement goals: participating in international efforts to cope with the issue of global warming, establishing the foundation for the convergence of the economic structure in order to achieve

<Table 3-3> Framework act on low carbon, green growth

Category	Framework Act (64 Articles)	Enforcement Decree (44 Articles)
Chapter 1 General provisions	Purpose, definitions, basic principles	Purpose, greenhouse gases description
Chapter 2 National Strategy for Low Carbon, Green Growth	National strategy for low carbon discharge and green growth, establishment and implementation of actions plans, etc.	Establishment of 5-year plan, review and evaluation of progress in national strategy and local action plans
Chapter 3 Presidential Committee on Green Growth	Composition and operation of Presidential Committee on Green Growth, etc.	Presidential Committee on Green Growth, subcommittees, task force, local committees, etc.
Chapter 4 Promotion of low carbon discharge and green growth	Green economy, green industry, recycling of resources, green management, green technology, finance, taxation system, etc.	Green industries investment company, standardization of green technology and green industries, institutions pursuing development of clusters and complexes for green technology and green industries, etc.
Chapter 5 Realization of low carbon society	Coping with climate change and management of targets for energy, reporting on GHG emitted and energy consumed, introduction of cap and trade system, etc.	Principles and role of management of targets for greenhouse gases and energy, establishment and management of national integrated information management system for greenhouse gases, etc.
Chapter 6 Realization of green life & sustainable development	Establishment and implementation of basic plans for sustainable development, green homeland, water management, low-carbon traffic systems, green building, etc.	Management of green homeland, targets for greenhouse gas reduction in traffic sector, standards for green buildings, etc.
Chapter 7 Supplementary provisions	Enhancement of international cooperation, reporting to national assembly, preparation of national reports, etc.	Fines for negligence, etc.

Low Carbon, Green Growth 3-year milestones and future direction

After the declaration of *Low Carbon, Green Growth* as the new national vision on August 15, 2008, the government of Korea has been working collaboratively with companies and citizens to advance a comprehensive green growth policy. This policy seeks to develop an effective GHG reduction scheme and foster green industries as a new growth engines for Korean economy. Societal transition is becoming apparent through the implementation of these activities.

「3-year green growth milestones

| Pursuing green growth with all sectors of society | The government of Korea have formed a network consisting of citizens, industry, and local governments to enable the successful joint implementation of green growth. Korea has set out its long-term vision to become the world's 7th green power by 2020 and 3rd by 2050, and formed the *National Strategy for Green Growth and five-year plan* covering a range of environmental, economic, and social policies. Through these rapid development of policies and actions, Korea is becoming better recognized globally as a model for green growth.

| Efficient GHG reduction scheme development | The government of Korea has delineated the national mid-term GHG reduction goal to be 30 percent below BAU projections by 2020 (November 2009) and the GHG reduction goals by sector and industry (July 2011). Accordingly, efforts to meet the reduction goals have been promoted through the enforcement of the *GHG and Energy Target Management Scheme*. This system assigns GHG reduction goals to facilities of which emissions exceed legally-determined thresholds. The Greenhouse Gas Inventory & Research Center of Korea (GIR) was founded for the comprehensive, qualitative improvement of national GHG emissions management, and analytical support for the setting and effective management of national GHG reduction goals.

| Tangible results for green technology and industry | The government of Korea has significantly increased investments in green R&D in order to develop green technologies and foster industrial growth and tries to derive achievement in the field of green technologies and industries through the development of 27 core green technologies.

- Investment for green R&D : KRW 1.5 trillion (2008) to KRW 2.2 trillion (2010), 47% increased
- In 2010 (compared to 2007), the number of suppliers in new & renewable energy increased 2.1-fold; the workforce employed by this sector increased 3.7-fold, sales increased 6.5-fold, and amount of exports increased 7.3-fold,
- Top 2 world ranking in market share for 2nd generation lithium batteries; top 2 world ranking in LED device production; release of Korea's first full speed electric vehicle-Hyundai BlueOn

| Promoting green lifestyles | Traditional transport system focused on road and automobiles has shifted to greener transport system focused on rail, coastal shipping, and mass transit. Reinforcement of the design standards for energy performance in newly constructed buildings and spread of 'green homes' significantly improve energy and fuel efficiency of buildings. In addition, various campaigns to spread the concept of green lifestyles and nationwide practical exercises, such as 'Green Start', 'We Green', are being launched.

| Strengthen climate change disaster response | On a national level, the government of Korea has established climate change adaptation measures in the seven areas of focus (health, extreme weather events, agriculture, forestry, maritime/fisheries, water management, ecosystems). The *4 Major Rivers Restoration Project* had been promoted to secure water supply and prevent flood damage.

| Strengthen Global Leadership for Green Growth | The government of Korea has been playing a lead role in spreading green growth policies globally. The nation also has been taking substantial action in lending technical, financial, and knowledge-based support for green growth to developing countries through projects currently in progress via the Global Green Growth Institute (GGGI), East Asia Climate Partnership (EACP), etc.

- Since 2009, green ODA* grant-aid has been expanded through the EACP
- GGGI was launched in June 2010.

* Green ODA is the concept covering Official Development Assistance(ODA) supporting climate change response and *Low Carbon, Green Growth* of developing countries.

Future Direction of Progress

For the last three years, Korea has succeeded in establishing basic infrastructure for green growth, such as laws, institutions, and long-term plans. Institutional basis to encourage voluntary participation to reduce GHG emissions and save energy, however, need to be improved.
In the future, Korea will accelerate its transition to a green economy that can easily adapt to climate change and energy crisis through continuous promotion of green growth policy. Additionally, plans will be implemented to more closely link *Low Carbon, Green Growth* to citizen lifestyles and industrial sites.

low GHG emissions, and minimizing the negative impacts of climate change on the quality of life. Korea also promoted policies and measures on three projects; the reduction of GHG by sector, creation of an infrastructure to adapt to climate change, and the creation of an infrastructure to implement the UNFCCC.

These action plans achieved the expected goals but the lack of clear quantitative reduction goals for many GHG reduction policies prevented a comprehensive analysis of the actual GHG reduction effect.

Going beyond the responsive measures of the UNFCCC from before, Korea changed its direction to implement more aggressive strategies. As such, the *Climate Change Response Comprehensive Action Plans (2008~2012)* was developed. This plan includes strategies for the environment and industrial sectors, a framework for international cooperation and aims to advocate the development of a low-carbon society through green growth. The PCGG is proactively leading the plan in response to climate change and is advocating the development of a *low-carbon green society*.

PCGG was launched in February 2009 to build a framework for laws and systems for green growth, such as the *five-year plan for National Strategy for Low Carbon, Green Growth (July 2009), mid-term national GHG reduction goal (November 2009), Framework Act on Low Carbon, Green Growth (January 2010)*, and *the Enforcement Decree (April 2010)*. Amongst these, the framework act includes climate change and energy policies, and sustainable development policies. It consists of 64 articles under 7 chapters (Table 3-3). *The five-year plan* is the overall plan, covering GHG reduction, development and distribution of new & renewable energy, adaptation to climate

change, green construction, green cities, green transport, green life, and international cooperation. Based on strategic key success factors, 10 items have been selected for the plan.

Also the committee took aggressive action to establish the mid-term national GHG reduction goal, which was approved at the Cabinet meeting. The Cabinet-approved decision reflects the changes in the paradigm as well as the long-term national interest despite the short-term disadvantages. President Lee assessed that this meeting was a historic moment for the Cabinet as its goals aligned with the paradigm of developed countries. A 30 percent reduction goal, finalized by the government of Korea, is also in line with the substantial deviation from baseline of non-Annex I countries indicated by the Fourth Assessment Report of the IPCC. This reflected the government's willingness to not only promote green growth national policy, but also create a positive atmosphere for the global community to cope with climate change.

B. GHG and Energy Target Management

1) GHG and Energy Target Management Scheme

The government of Korea has enacted *GHG & Energy Target Management Scheme* as a means of mitigating climate change based on a *Command and Control* method in accordance with the *Framework Act*. This scheme was designed to manage and impose specific GHG reductions and energy consumption standards on large businesses with high energy consumption and GHG emissions. Through this scheme, the government has been able to manage more than 90 percent of the industrial GHG emissions and 70 percent of the overall national GHG emissions, and it will stay committed to achieving the national GHG reduction target while creating green growth engines. As the target management has been implemented, Korea built a system allowing *Measurement, Reporting, and Verification* (MRV) for the GHG emissions and energy consumption. The MRV system will be set up as a basic infrastructure for the emissions trading system.

The controlled entities will be designated as selected targets once the emissions or energy consumptions exceed the legally-determined threshold as specified in the *Enforcement Decree of the Framework Act*. Also, if facilities within the non-controlled entities exceed the threshold, these facilities will also be designated as the selected targets. Selection criteria for entities are GHG emissions over 125,000 t CO_2 eq. and energy consumption over 500TJ. For facilities, GHG emissions over 25,000 t CO_2 eq. and energy consumption over 100TJ meet the selection criteria. The total number of selected target entities is 490 as of November 2011 (no. of facilities is 4,231). By sector, agriculture has 28, power and industry has 384, building and transport have 51, and waste sector has 27 controlled entities. By 2014, businesses with GHG emissions over 50,000 t CO_2 eq. per year and energy consumption over 200TJ per year, facilities with GHG emissions over 15,000 t CO_2 eq. per year and energy consumption over 80TJ per year will also be selected as targets for regulation.

The organizations responsible for operating the management scheme are classified as the

general management and relevant ministries. As the general management organization, Ministry of Environment prepares overall guidelines and standards for target management, checks and evaluates relevant ministries, and supervises verifying agencies. Relevant ministries are designated as follows: Ministry of Knowledge & Economy for industry and energy; Ministry of Food, Agriculture, Forest & Fisheries for agriculture and livestock; Ministry of Land, Transport & Maritime affairs for building and transport; and Ministry of Environment for waste sector. These ministries are in charge of management of their own sectors such as designating controlled entities, setting the target, evaluating performance plan and result, etc.

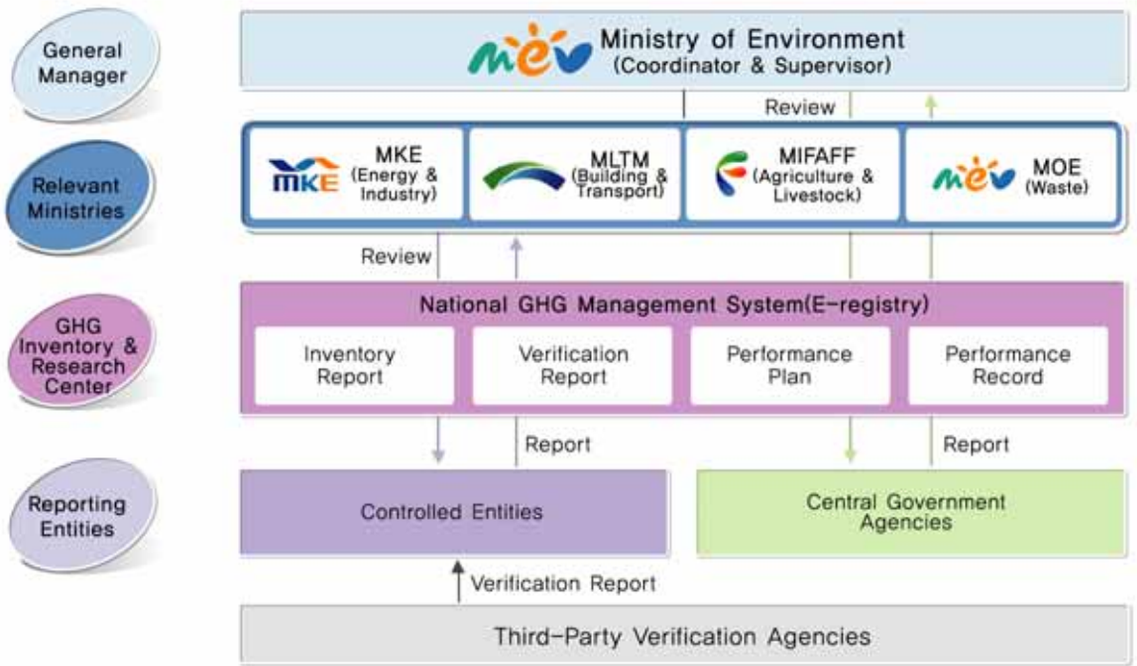
The management scheme operates on a year-basis as follows: selection of the entities (July), sectoral/industrial target setting (September), submission of implementation plan (December), and submission of inventory and implementation report (March). By the end of September each year, governing authorities in each sector have been setting targets for the following year's GHG reduction, energy-saving, and energy efficiency to inform controlled entities. The maximum allowance for annual GHG emissions by controlled entities will annually be determined in accordance with the GHG reduction goals by sectors and industries, decided in July. The goals for the entities will be finalized based on their operation rate and construction plans. Controlled entities are to submit their performance reports by December, proposing the goals assigned by the relevant ministries. By the following March, the performance plan and the inventory report should be submitted by the controlled entities.

Since GHG estimations and reports are the basis for operating the target management scheme, the government of Korea confirmed and notified *GHG and Energy Target Management System Operating Guideline* (Notification No. 2011-29, Ministry of Environment) on March 2011, to propose specific GHG estimation methods and reasonable management standards for key factors including emission factors and activity data. The guideline comprehensively includes methods for setting organizational boundaries, system development methods to monitor data on fuel and material consumption activities, and specific methods to estimate and utilize emission factors regarding 33 emission activities. It also includes formulas for writing GHG and energy receipt. Controlled entities must have these receipts certified by the GHG verifying institution and submit them to the relevant ministries.

*** GHG emissions estimation and reporting procedures**

① Set organization boundaries → ② Verify and classify emissions activities → ③ Select monitoring type and method → ④ Build estimation and reporting system → ⑤ Selection estimation method → ⑥ Estimate emissions → ⑦ Write inventory report statement

GHG verifying institutions refer to specialized agencies which objectively verify GHG and Energy statements submitted by controlled entities. In order for an organization to be qualified as a verifying institution, the organization not only must have expertise in verification, but also must have independence



[Figure 3-1] Schematic diagram of national greenhouse gas management system

and objectivity. For that purpose, the verifying institutions are separated into two categories: one takes charge of verification and the other of management. The National Institute of Environmental Research (NIER) designates, enrolls, and manages the verifying institutions and as of September 2011, there are 21 verifying institutions. The procedure to designate a verifying institution is reviewing registration, field inspection, evaluation by the screening counsel, requesting designation, gathering opinions of the overseeing government agencies, and authorizing the verifying institution. To have more strict management, the verifying institutions are screened every two years. Since January 2011, there has been intensive training for auditors to become certified through rigorous evaluation. In order to continually enhance their expertise, the sectors have been classified into seven different industries such as mineral industry, chemical industry, metal industry, electronic industry, waste, agriculture and common sector. As of September 2011, there are 211 certified verifiers.

2) National Greenhouse Gas Management System

The government of Korea established an institute named Greenhouse Gas Inventory & Research Center of Korea(GIR) in 2010 as an affiliate of Ministry of Environment to build and manage the national GHG inventory system. As a GHG inventory hub, GIR built the *National GHG Management System* as a means of reporting the *GHG & Energy Target Management*. The main functions of the system are shown in Figure 3-1.

As the relevant agencies, such as the central government and controlled entities, report their data (GHG emissions, energy consumption, etc.) through this system, the general management agency will be able to access and manage the submitted data. For example, the controlled entities are to submit the relevant data such as

performance plan, report, and inventory data to the relevant ministries. Then the general management organization will access the submitted data through the system and executes administrative tasks to supplement the data. Data confirmed by the third-parties and relevant ministries will be managed in the electronic registry.

The system also supports other functions including national GHG statistics management, general public information, setting reduction goals, and etc. The general public may receive various information on GHGs through the homepage built in the system. GIR is planning on integrating and managing the data collected from the system.

3) GHG emission trading system

The government of Korea is pursuing an implementation of the emissions trading system that will utilize the operation of *GHG & Energy Target Management Scheme*. The purpose of this trading system is to reduce GHG emissions based on market function. In April 2011, the government submitted the *Act on Allocation and Trading of GHG Emissions* to the national assembly. Upon enactment of this law, the GHG emissions trading system will be implemented as of January 1, 2015.

2. Institutional measures

A. Power and industry sectors

Based on the *five-year plan for the national strategy for Low Carbon, Green Growth*, which was announced in 2009, Korea is making efforts to achieve its reduction goals by establishing and implementing mid-term plans in specific sectors such as the *National Energy Master Plan and Energy Use Rationalization Base Plan*.

1) Enhancement of energy demand management in industrial sector

Policies on Korea's energy demand management are based on the *Energy Use Rationalization Act*, institutionalized in December 1979, and a *Energy Use Rationalization Base Plan* should be established every five years in order to promote relevant policies. In the energy demand sector, current policies are established and are proceeding to strategically foster energy-saving projects and revolutionize demand management in each sector.

(A) Voluntary agreement

The National Energy-saving Committee[10], which was established according to the *Energy Use Rationalization Act* in 1998, introduced a *Voluntary Agreement* for energy-saving and GHG reductions. Through this program, industries has been voluntarily setting and actualizing energy-saving and GHG reduction goals, and the government of Korea has been sponsoring these efforts by providing funds and tax support. This Agreement initially focused on companies using energy over 5,000 TOE per year, and the system expanded to include companies using over 2,000 TOE per year from

10) The committee was launched in 1997 to ratify *Energy Use Rationalization Base Plan* to set the basic direction and goal, and to review and revise major policies of the government or local governments regarding energy-saving. The Minister of Knowledge & Economy became the chief commissioner and 25 members including 8 government ministries undersecretaries were appointed,

<Table 3-4> Number of participating industries in voluntary agreement

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number	15	67	211	372	532	686	1,021	1,288	1,353	1,383	1,355	1,300

Source: Korea Energy Management Corporation, 2011

2004. 15 pilot projects launched the initiative in 1998, and about 1,300 workplaces had participated in this system as of 2009(Table 3-4).

(B) Energy audit system

Since 2007, in accordance with the *Energy Use Rationalization Act*, the Energy Audit System aims to conserve energy and reduce GHG emissions in the industrial and building sectors by regularly inspecting businesses with energy consumptions above 2,000 TOE per year.

In addition, to support energy in small and medium businesses that lack human resources and materials, the cost of audits will be partially supported (as much as 90%) to those businesses with energy consumption below 10,000 TOE per year. This system supported KRW 8.5 billion to a total of 536 small and medium businesses from 2007 to 2010. The system discovered that a total of 148,000 TOE of energy can be potentially saved (276 TOE per business).

From 2007 to 2010, there were 1,497 industrial sectors and 410 building sectors that underwent an energy audit. The system had

<Table 3-5> Mandatory energy audit system cycle

Category	Areas to audit	Cycle
Annual energy consumption below 200 thousand TOE	All	5 years
Annual energy consumption above 200 thousand TOE	All	5 years
	Partial[11]	3 years

Source : Korea Energy Management Corporation (2011)

<Table 3-6> Energy audit performance

Category	2007	2008	2009	2010	Total
Number of businesses	383	420	559	545	1,907
Energy consumption for audit (TOE per year)	9,373,271	6,878,185	11,090,762	8,087,743	35,429,961
Energy-saving potential (TOE per year)	429,013	549,333	710,412	479,840	2,168,598
Reduction rate (%)	4.6	8.0	6.4	5.9	6.1
Estimate saving cost (KRW million/year)	169,824	302,934	390,420	266,730	1,129,908
Investment in energy-saving facilities (KRW Million)	326,788	431,631	727,777	589,175	2,075,371
Investment payback period (year)	1.9	1.4	1.9	2.2	1.8
Potential GHG reduction amount (ton CO_2 eq. per year)	1,086,377	1,463,397	1,754,496	1,184,438	5,488,708

Source : Korea Energy Management Corporation (2011)

11) In case of partial audit, the standard level is more than 100,000 TOE usage. The audit reviews by sectors and started surveying from the sector that was not audited yet.

<Table 3-7> Energy use plan consultation system results

Year / Category	'93~'00	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Number of cases	226	19	25	41	42	71	61	94	83	100	120	882
Planned volume (1,000 TOE per year)	33,165	1,055	2,143	6,531	8,914	7,743	10,362	11,952	8,583	11,495	19,326	121,269
Reduction potential (1,000 TOE per year)	2,355	191	247	635	1,362	1,283	1,212	1,866	1,172	1,900	3,411	15,634
Estimated reduction rate(%)	7.1	18.1	11.5	9.7	15.3	16.6	11.7	15.6	13.7	16.5	15.8	12.9

Source : Korea Energy Management Corporation (2011)

discovered that a total of 2,169,000 TOE of energy could be saved, and such discovery has led to the investment in energy-saving facilities and ESCO projects. These investments have actualized energy-saving (Table 3-5, 3-6).

(C) Consultation on energy use plan

The Consultation on Energy Use Plan is a system in which industries are required to consult their plans for energy supply, efficiency enhancement, and so forth with the government when the industries want to operate businesses or install energy facilities above certain sizes.

Started in 1993, this system was designed to assist public sectors, initially, to lay the foundation for an energy-saving system, but its application has begun expanding into the private sectors as of 2002. Currently, the eight project sectors include urban development, industrial complex development, port construction, etc. Projects requiring prior consultation are public sector projects that have fuel consumption above 2,500 TOE per year and power consumption above 10,000 MWh per year; private sector projects that have fuel consumption above 5,000 TOE per year and power consumption above 20,000 MWh per year.

Through this system, a total of 882 prior agreements have been reached regarding the energy use plan. As a result, 15.6 million TOE per year of energy can be potentially saved (Table 3-7).

(D) Investment support for energy-efficient facilities

The government of Korea has been investing in energy-efficient facilities through long-term loans at low interest to replace outdated, low efficiency facilities and to increase distribution of high efficiency equipment. Since the initial investment of KRW 200 billion in 1980, the conditions and procedures for investment support have been consistently improving, including the expansion available funds and affiliated businesses. As a result, from 1980 to 2010, a total of KRW 5.9 trillion was provided to fund energy-saving facilities (Table 3-8).

The government of Korea sponsored about KRW 601.8 billion in 2011. The government also plans to expedite the efforts to increase the investment.

<Table 3-8> Energy-saving support fund

Year	2006	2007	2008	2009	2010
Funding (Million won)	429,610	454,213	539,995	518,650	511,785

Source: Korea Energy Management Corporation (2011)

(E) Energy Service Company (ESCO) business expansion

The Energy Service Company (ESCO) began with the registration of four companies in 1992 and currently a total of 182 ESCOs have been registered in 2010. Initially, ESCO's business was simply providing high-efficiency replacements for low-efficiency equipment and lighting. However, due to recent technological advancements, ESCO has expanded its business to include waste heat recovery, heating and cooling, and cogeneration facilities.

To stimulate small and medium businesses that lack the technology and capital, about 70 percent of government funding has been assigned to those businesses. Credit loan and factoring programs were also provided in order to reduce the debt made by ESCOs.

To expand and revitalize the ESCO industry more actively, the *ESCO Industry Revitalization Plan* was proposed in 2010. As such, through leveraging private funding, constructing new business models, establishing the ESCO mutual aid association, the *ESCO Industry Revitalization Plan* is expected to expand ESCO business and other related businesses (Table 3-9, 3-10).

<Table 3-9> ESCO registration status

Year	2006	2007	2008	2009	2010
Number of registered companies	158	156	143	128	182

Source: Korea Energy Management Corporation (2010)

<Table 3-10> Funding status for ESCO

Category	1993~2007	2008	2009	2010	Total
No. of case	2,958	100	100	122	3,280
Loan	10,487	1,115	1,318	1,307	14,227

Source: Korea Energy Management Corporation (2010)

(F) Cap on energy consumption for government and public sectors

The government of Korea is committed to promoting energy consumption caps for government and public sectors in order to counteract climate change and also to take the initiative in raising awareness of energy-saving. Currently, this system is being implemented under the *GHG and Energy Target Management Scheme*.

Public organizations have to present an annual energy-saving goal in an effort to reduce energy consumption. The performance of their implementation efforts also have to be checked. From 2004 to 2006, the average energy consumption was 3 percent below the level in 2003, and the 2007-2009 average energy consumption was kept below the average of the past two years.

2) New & renewable energy and clean energy expansion

The government of Korea has designated the new & renewable energy industry as its new transformational growth engine in its move to become a low energy consuming, green nation. Korea plans to achieve a new & renewable energy supply rate of 11 percent in 2030, accompanied by efforts to reduce the dependence on fossil fuel energy by increasing the supply of integrated energy supply, nuclear power generation, natural gas, etc.

(A) Expanded distribution of renewable energy and promotion of industry

In order to reduce dependence on fossil fuels and to stimulate the new & renewable energy industry by increasing the supply of available energy resources, the government of Korea is promoting various policies based on the *Act on the Promotion of the Development, Use, and Diffusion of New & Renewable Energy*, which was institutionalized in 1987 and revised in 2004.

The government of Korea is committed to the *One Million Green Homes* project to replace existing energy sources with renewable energy, such as solar and geothermal, by 2020. For residential buildings installing new & renewable energy facilities, up to 50 percent of the installation cost is being funded (within 80% for fuel cells). One neighborhood with more than ten participating homes is being encouraged to register in the effort to build green villages. For the 100,000 Solar-roof Project, which was launched in 2004, KRW 372 billion was provided and a total of 73,721 houses are currently using solar energy.

Also, since 2002, in order to increase the supply of the new & renewable energy, *Feed-in Tariffs* for the new & renewable energy have been implemented to make up the balance between the base price (by power station) and the market price to energy suppliers. As a result, KRW 772 billion was provided to a total of 1,694 new & renewable energy stations, which built a foundation to increase the supply of new & renewable energy, as of 2010. As the use of new & renewable energy is progressively adopted into society, the government of Korea is promoting Renewable Portfolio Standards (RPS), which requires the use of new & renewable energy for total power generation above certain levels. This is aimed at energy suppliers who possess over 500,000 kW capacity power plants.

Furthermore, by selecting the core technologies for the new & renewable energy and investing KRW 1.5 trillion, related technology can be developed, and facilities can be installed in schools, industrial complexes, etc. Also, based on the *Offshore wind power top-3 road map*, various policies have been implemented to develop and increase the supply of technologies. Through these policies KRW 9 trillion will be invested by 2019 and will be

<Table 3-11> One million green homes supply project details

Category		~2005	2006	2007	2008	2009	2010	Total
Private homes	No. of houses	1,217	2,452	3,033	4,143	7,066	8,831	26,742
	Fund (million)	22,064	43,163	43,249	53,644	83,462	85,941	331,523
Apartments	No. of houses	-	550	127	251	1,216	5,427	7,571
	Fund (million)	-	649	128	377	1,740	2,104	4,998
Public housing	No. of houses	-	2,962	4,307	5,627	10,911	15,601	39,408
	Fund (million)	-	5,108	7,079	6,551	8,788	8,000	35,526
Total	No. of houses	1,217	5,964	7,467	10,021	19,193	29,859	73,721
	Fund (million)	22,064	48,920	50,456	60,572	93,990	96,045	372,047

Source : Korea Energy Management Corporation (2011)

focused on the installation of new & renewable energy facilities.

(B) Expansion of integrated energy supply

The government of Korea is using the energy produced by Integrated Energy Supply systems—such as cogeneration power plants, heat of boilers, and resource recovery facilities—to supply and sell the produced energy to many consumers in the residential and commercial sectors. These policies encourage energy-saving and GHG emission reduction. The service area is ever increasing through the expansion of Integrated Energy Supply system areas and administrative and funding support. On the other hand, as part of the expansion of the Integrated Energy Supply, the waste heat from incinerators is used as a source of district heating, and a landfill gas project has been implemented (along with other initiatives) to utilize this renewable energy.

After the district heating system was first introduced in 1985, the supply rate of district heating grew to be about 13.5 percent at the end of 2010, providing heating to more than 2,006,000 out of 14,877,000 households. In industrial complexes, integrated energy is supplied to a total of 17 complexes and 25 businesses. The supply of the integrated energy was 22,229 GWh, amounting to 5.1 percent of the total national power generation (433,604 GWh).

(C) Stable supply of natural gas

Natural gas is a relatively clean source of energy and there is a comprehensive policy to manage its rational use and to secure a stable supply capacity as well as expand the nationwide supply infrastructure. According to the *10th Long-term Natural Gas Supply Plan* proposed in 2010, sources that are concentrated in the Middle East and Southeast Asia will be diversified and the stability and efficiency of supply will be secured by proper distribution of materials in the short-and long-term. In addition, due to the completion of the Samcheok facility in 2013 and the transition of the gas field in the East Sea into storage facilities by 2017, a total of 15,360,000 *kl* of storage will be secured. This will stabilize the trade cost and improve the mid to long-term supply stability until the year 2024.

<Table 3-12> Mandatory supply amount for new & renewable energy

Category	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mandatory rate(%)	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10

<Table 3-13> Integrated energy supply status (performance based)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
District heating (1,000 homes)	1,083	1,177	1,251	1,337	1,390	1,484	1,590	1,736	1,888	2,006
Industrial complexes (Number)	20	20	21	21	21	21	20	24	25	25

Source : Korea Energy Management Corporation (2011)

On the other hand, the rate of natural gas consumption has been rising rapidly since its first distribution in 1987, demonstrating a 17.3 percent annual increase between 1987 and 2002. The rate started to noticeably decrease once natural gas had been supplied to all the major cities (Showing only 5.6% annual increase between 2002 and 2009). By enlarging the major supply pipeline from 2,853km (as of 2010) to 4,200km by 2016, the supply area will be expanded from 158 to 212 cities and districts, and a total of KRW 8.0 trillion will be spent on investment from 2010 to 2017.

(D) Maintenance of appropriate level of nuclear power generation maintenance

The total annual consumption for electricity generation amounted to 423.8 billion kWh and it is expected to reach 551.6 billion kWh by 2024, as the average annual increase rate is 1.9 percent. In order to reduce CO_2 emissions while meeting the electricity demands, nuclear power generation will continue to progress and the share of nuclear power in total electricity generated will be maintained at an appropriate level.

The nuclear capacity as of 2010 amounted to 18,716 MW (representing 25% of the overall equipment), but it is expected to increase to 32 percent by 2024. The share of expected nuclear power generated increased from 31 percent in 2010 to 48.5 percent by 2024, which suggests that high carbon electric power sources, such as coal and oil, will continue to decrease.

(E) Expansion of biodiesel supply

In order to expand the supply of bio-diesel, as approved by IPCC as carbon neutral, various policies have been promoted since 2007 to establish a long-term biodiesel supply plan. The percentage of bio-diesel in the diesel and bio-diesel mixture has been increased to 2 percent in 2010 from 0.5 percent in 2007. Also, over 60 percent of waste edible oil from fast food restaurants and other businesses is being collected. After exempting bio-diesel from the fuel tax on 2011, a mandatory policy will be implemented in 2012, requiring the usage of diesel and bio-diesel mixture.

As for the related research work, a pilot rapeseed cultivation project of 1,500 ha has been implemented from 2007 to 2010. By investing KRW 63.4 billion, research has been conducted on the development of next generation bio-diesel such as that made from marine plants and animal fat. A total of 593 thousand *kl* has been supplied from 2007 to 2009.

<Table 3-14> Biodiesel supply amount

Category	2007	2008	2009	Total
Supply (1,000 kℓ)	109	196	288	593

Source: *2nd Mid-term Biodiesel Supply Plan* (2010)

3) Energy efficiency enhancement through expansion of high-efficiency products

Korean home appliance products are world class in terms of energy efficiency. This is because the government of Korea has proceeded to lead a program to strategically expand the distribution of energy efficient appliances. The details are as follows:

(A) Energy-efficiency standard & labeling program

With the increase in the distribution of energy efficient products, the government of Korea is enforcing the *Minimum Energy Performance Standard* (MEPS), which establishes the mandatory usage of energy efficiency standard labels (Level 1~5) and banning the production and sale of products that are rated below level 5. As of 2010, 19,000 models of 24 different product types were registered including refrigerators, air conditioners, washing machines, light equipment, and three-phase inductor motors. Each year, 150 million products are sold under the MEPS or energy efficiency standard program.

In 2011, TVs, window sets, and transformers were also placed under the efficiency-labeling program, taking effect in 2012. Measurement methods for refrigerators, freezers, and commercial refrigerators have been modified and improved.

<Energy Efficiency Label and Standard Program>

<Table 3-15> Refrigerator and A/C efficiency certification

Category	Unit	1996	2009	Note
Refrigerator (Annual Consumption per L)	kWh/L	1.750	0.702	60 % reduction
Air Conditioner (Cooling Efficiency : EER)	W/W	2.974	3.597	21 % increase

(B) Enforcement of e-standby program

Based on the *Standby Korea 2010* road map, the government of Korea allows producers that meet energy-saving standards to arbitrarily display the energy-saving label and requires producers that fail to meet the standards to display the *stand-by energy warning* label to promote the minimization of standby power and availability of a power-save mode while not in use. The energy-saving program affects 22 products and requires an *e-standby* label on items that fall below the standard. The e-standby program is the world's first system of this kind. Once a product is selected, two obligations must be met: the manufacturer or importer will be required to report any standby energy functions and products that fall below the e-standby standard must display the label.

As of 2010, most of the home appliances sold in Korea under this program meet the requirement to go below 1 watt.

<Products meeting the standard>
(Arbitrary)

<Products failing to meet the standard>
(Mandatory)

(C) Expansion of high-efficiency equipment certification program

In order to establish a market at an early stage and expand the supply of energy-saving products, such as insulated windows with high air-permeability, a *high-efficiency equipment certification* system was implemented in 1996. This certification is provided to products that register and have above the standard quality.

The certification approved a total of 37 items from 1996 to 2010 and 4,943 models from 803 companies as high-efficiency

equipment. These products have been granted *e Mark*, and purchases have been made in public markets initially with funding and tax support.

In addition, considering the rapid commercialization of LED lights in both domestic and international markets, the share of LED lights will increase up to 30 percent by 2015. With this outlook, more products in the LED category will be approved for certification and the number of target items will increase to 42 by 2013. Also, test fees and purchases will be funded through systematic support when making procurement purchases.

4) Promoting early action on GHG reduction

In order to encourage early action to reduce GHG emissions from the industrial sector, various policies have been implemented including the *Voluntary Emissions Reduction Program and Industrial ad hoc Working Group for addressing Climate Change*.

(A) Korea voluntary emission reduction registration program

For the promotion of voluntary corporate action on GHG reductions, the emission reduction registration program was implemented in 2006. This program provides a government subsidy to compensate for the reduction outcomes.

In accordance with methodologies approved by the government of Korea, companies willing to participate in this program should register their businesses of which estimated annual GHG reduction is above 500 t CO_2 eq., and follow through on implementation and verification of their reduction activities. From 2005 to 2010, a total of 299 businesses completed examination and registration and as much as 8.78 Mt CO_2 eq. reductions have been registered after passing 491 verification processes. Also, since 2011, the registration program has had downward adjustment that goes below 100 t CO_2 eq. in order to promote small-scale reduction programs.

(B) Industrial ad-hoc working groups for addressing climate change

The government of Korea supports GHG reduction and actions to counteract climate change by operating task forces classified by industries such as power, steel, oil and so forth. Starting with eight industries in 2004, there are 13 industries participating in the task force as of 2010. Each task force team promoted the voluntary efforts to reduce GHG emissions through data collection and analysis of GHG reduction technologies, development of guidelines for GHG inventories, and corporate internal emission trading scheme.

B. Building sector

In the building sector, policies and measures to meet the reduction goals by 2020 have been promoted through the energy efficiency of residential and commercial buildings. In the mid- and long-term, new buildings will be designed to achieve *zero carbon* goals, and existing buildings are preparing measures for effective energy-saving remodeling.

1) Continuous strengthening energy-saving design criteria for buildings

After implementing the initial regulation that prevented energy-loss in buildings in 1976, the government of Korea established standards for building insulation in 1979. Since 1985, regulations for envelope insulation and energy-*efficient design* were implemented for eight types of large, high-energy consuming buildings. By setting the regulations for building equipment and energy-saving in a 3-year cycle, the insulation standards for outer walls, rooftops, and floors for new buildings has been enhanced and the insulation level for the windows and doors increased by 20 percent in 2010. In addition to the strengthened insulation standards, the government has been requiring higher permission standards for buildings to expand their efforts in using high-efficiency lighting, boilers, freezers, etc. Starting in 2011, the *Energy-saving Building Design Standard* will be introduced in order to enforce regulations on the total energy consumption of the building sector.

After the *Low Carbon, Green Growth* strategy was declared in 2009, the GHG reduction goal has been specified for the building sector. Also, insulation policies and technological standards will be strengthened with the goal of establishing a net-zero carbon house by 2025, along with mandatory low-carbon houses by 2017.

2) Expansion of the building energy efficiency certification system

The government of Korea is continually making an effort to improve energy efficiency in buildings. As part of this effort, certificates have been issued to buildings that meet certain criteria since August 2001. This certificate is intended to encourage new apartments under construction or remodeling to implement energy-saving facilities and equipment from the beginning stage of construction. Buildings must have a grade between 1 and 3 according to this standard in order to be awarded this certificate. This certificate gives an incentive for building owners by providing them interest loans for the construction costs.

Since 2010, commercial buildings have also expanded the energy efficiency labeling program and public buildings are now required to obtain a grade above 2. The program will be further expanded for more buildings, ultimately reaching out to currently existing buildings. Expansion of this program will make a great contribution to GHG reductions by voluntarily encouraging energy-saving in the building sector, which accounts for 23 percent of the national energy expenditure.

3) Green building certification program

The Green building certification program evaluates influential environmental factors, such as resource-saving and pollution reduction, throughout the process of materials production, design, construction, maintenance, and disposal. As such, enhancement of environmental performance is the driving force for reducing energy consumption and GHG emissions. Evaluation criteria include 40 items in nine different sectors including land use, transport, energy, materials, resources, environmental pollution, water, maintenance, ecological environment, and indoor environment.

Implemented in 2002, this policy is being evaluated based upon completed buildings. Upon the request of the owner, a pre-certificate may be issued at the designing stage. Certification will be valid for five years and re-certificating will be required after that.

Initially, the program was limited to target apartments, however, it has been expanded to include offices, school facilities, accommodations, multiple unit complexes, and others. Moreover, in order to expand this certification program, the government of Korea has allowed the mitigation of construction standards such as lowering the real estate taxes on acquisition and registration, maximum floor area ratio (FAR), minimum area of garden space, and maximum building height.

<Table 3-16> Number of green buildings certificates

Year	2005	2006	2007	2008	2009	2010
Number	33	163	300	414	570	2,235

4) Green building activation plan

In order to stimulate low energy/carbon green construction, there are comprehensive and systematic plans that describe the life cycle of buildings step by step.

In regard to the construction of new buildings, the *energy-saving and eco-friendly construction standards and capabilities* of the *energy-saving standard* implemented in 2009 for the common house construction sector, will be adjusted in terms of advances in the energy-saving rate. A test-bed for green homes that aims to conserve energy in more than 60 percent of existing houses will also be established as a proposal for green building modeling.

Eco-friendliness and energy efficiency ratings will be applied to currently existing buildings and the energy efficiency of these buildings will be maintained at a higher level by mid- and long-term mandatory building requirements. Also, the energy information regarding buildings will be shared via the integrated energy management system, and an *energy consumption verification system for buildings* will be introduced and included in real estate transactions as the data becomes available.

Additionally, remodeling guidelines designed for specific purposes and applied technology for construction will be developed and distributed, promoting a greener version of existing buildings.

With the goal of *One Million Green Homes* by 2020, the new & renewable energy system will be distributed to households, and with the expansion of the mandatory new & renewable energy system, the government of Korea is systematically encouraging the use of new & renewable energy in the construction and remodeling of buildings.

C. Transport sector

Emissions from the transport sector accounted for 16.8 percent of 2008 GHG emissions. Policies and measures for the transport sector focus on major strategies; enhanced management of transport demands, more effective operation of traffic, revitalization of low pollution vehicle availability and a low carbon distribution system.

1) Enhanced management of transport demand and efficient traffic system

(A) Low-carbon smart transit system

The government of Korea is making efforts to promote more optimal management by merging the existing transport facilities with advanced IT technology and traffic information. In order to improve efficiency and safety, the Intelligent Transportation System (ITS) will be expanded resulting in 25% of paved roads by 2020. About 11 percent of paved roads use ITS as of 2010. In addition, in conjunction with the major transport systems in the metropolitan area, the Bus Information System (BIS), currently linked to 33 axes, will be expanded to 71 axes by 2020.

Since 2007, R&D work has been active to create *smart highways* to maintain smooth traffic flow and to improve safety, punctuality, and convenience by mutual integration of the high-road technology, ITS, and automotive technology. This project, expected to continue until 2016, includes *smart highway road infrastructure, traffic management skills based on smart road and IT*, and *smart road - automotive link technology*.

Also, the roundabout[12], which is a low-speed rotational intersection installed in the center of an intersection, helps prevent traffic accidents and reduces delays and congestion. Installation of traffic roundabouts showed reduction in signal wait time (by one minute), fuel efficiency, smooth traffic flow, and prevention of traffic accidents. Therefore, in 2011, pilot programs for this installation have been expanded into 103 locations in 15 different cities and provinces such as Seoul and Busan.

(B) Green public transport

For the purpose of mitigating traffic congestion in the metropolitan regions and encouraging the use of public transport, the Metropolitan Bus (MBUS) system has expanded its operation. MBUS will make only eight stops within 5 km from the starting point and destination. Currently, there are 12 lines, including Yongin-Seoul station (a pilot project begun in August 2009). Also, Bus Rapid Transit (BRT), which has low cost and high efficiency, will be expanded into major cities nationwide. As a result of BRT in Seoul, the average bus speed between stations increased by 2.0~9.0 km per hour compared to existing ones, and the deviation of traveling time was improved as ±1~2 minutes in terms of punctuality.

In order to accelerate transition to eco-friendly green transport, the early opening of the 2nd phase of the Gyeongbu Expressway between Daegu and Busan (January 2011) and early completion of the Honam Expressway between Osong and Gwangju (from 2014 to 2015) are in progress. Many efforts have been made in the marine and aviation sector. In order to establish a green seaport, wind resource research was conducted in three ports for the introduction of offshore wind power complexes. Also, geothermal and solar power facilities at Kimpo airport, geothermal energy facilities at Jeju airport, and the new & renewable energy facilities at Incheon airport have been completed or are being completed.

Since 2007, a pilot program for the

12) Facility that suppresses entrance of vehicles to the circular intersection to operate non-traffic signal intersection

pedestrian priority zone has been implemented in areas where there is a high risk of traffic accidents or difficult conditions exist for pedestrians in order to improve pedestrian and bicycle systems. A public bicycle system is also operated in Seoul, Changwon, and Goyang to encourage the use of bicycles. Also, by creating city space centered on public transport, bicycles and pedestrians, green transport will be more available and *public transport exclusive* regions are being expanded in order to relieve traffic congestion. As a result of testing this pilot program in Daegu, the number of public transport users increased by 10 percent, pedestrian traffic increased by 15 to 18 percent, and about 77 percent of citizens expressed positive responses on this program. To promote this project in a more systematic way, a new business plan and public transport exclusive areas will be defined in the *Transit Master Plan (2012~2016) and* there will be guidelines regarding the installation of major facilities and their operations.

Eco-driving (avoiding rapid acceleration, quick start, sudden stop, etc.) is an eco-friendly and cost-effective way of driving, and eco-driving contributes to energy-saving and GHG reductions. Since 2010, commercial drivers, driving instructors, and relevant public officials have received eco-driving training courses and practical tips for eco-driving are taught through traffic safety education in work places. Since 2011, eco-driving simulators have been installed at various exhibitions and public places to provide a virtual experience and the website provides information regarding eco-driving and training.

2) Revitalization of lower-emission vehicles

Infrastructure for the distribution of electric cars will be built upon assessments of the actual performance of electric cars and recharging devices developed between 2010 and 2011. From 2011 through 2012, efforts will focus on creating a stable market by supporting a fund to install charging stations and purchase electric cars for the public sector. After 2013, support for private purchases and the recharging infrastructure will be expanded to allow stable growth of consumer demand. By replacing 10 percent of domestic compact car markets by 2015 and 20 percent of mid-size car markets by 2020 with electric cars, a total of one million electric cars will be distributed by 2020 (2.2 million chargers). The requisite amount of eco-friendly vehicles in the public sector will include electric cars and the purchase rate of eco-friendly vehicles will increase gradually (20% by 2010, 30% by 2011, and 50% by 2013). Also, the requisite amount of eco-friendly vehicles produced by auto manufacturers will be adjusted upward (6.6% by 2010 and 7.5% by 2011).

3) Establishment of low carbon distribution system

For the common use and assembly of distribution facilities forming a low-cost and high-efficient green distribution system, the construction of an inland distribution warehouse and the development of distribution complexes have been planned and promoted in five major districts.

The government of Korea has been making efforts to switch from the first-party logistics

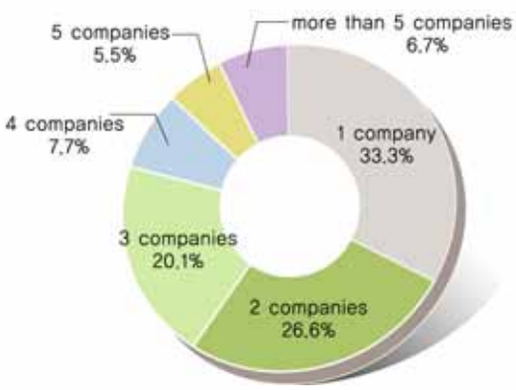
(1PL) and the second-party logistics (2PL) to third-party logistics (3PL) and to increase the share of 3PL in the licensed general logistics firms. As of 2009, the market size of domestic 3PL was assessed to be KRW 8 trillion, accounting for 7.9 percent of the overall logistics market. Improvement measures regarding tax support for 3PL have been planned based on comprehensive reviews of reduction performance on income tax and efficiency by companies that utilize 3PL.

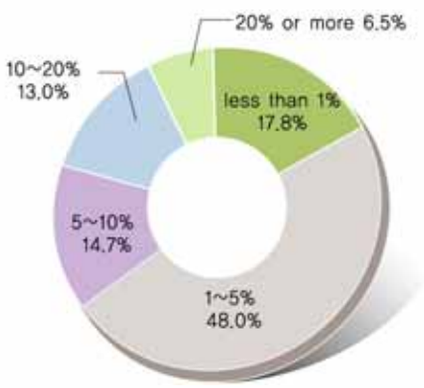
Subsidies are provided to the shippers who make contracts with logistic companies to shift from road shipping to railways or coastal shipping. The routes and potential business partners will be expanded continually. In the long-term, the indirect supports (including investment, introduction of trains with two-floor cars, reduction of charge for use of cargo ships) in modal shift is under review.

4) Greenhouse gas & energy policy for vehicles

An *average fuel efficiency* has been implemented to expand high-efficiency vehicles (except for LPG and compact vehicles). This is a system of managing fuel efficiency by giving the improvement order to car manufacturers failing to satisfy the limit set by the government of Korea. According to the system, the manufacturers that sold over 1,000 vehicles are tested to see if they satisfy the standard by calculating the average fuel efficiency.

This program was launched in 2006. Until 2011, vehicles below 1,600cc applied to





Source: Korea International Trade Association
Third-Party Logistics Research Result, Korea Transport Institute (2009)
Basic Plan for National Logistics (2011~2020), 2010

[Figure 3-2] Number of companies using 3PL **[Figure 3-3] Share of expenses for 3PL compared to Sales**

<Table 3-17> Average energy consumption efficiency trend

(Unit : km/ℓ)

Category	2005	2006	2007	2008	2009
Below 1,600cc	12.86	13.39	13.69	13.87	14.75
Above 1,600cc	10.41	10.50	10.62	10.69	11.48
Total	10.97	11.19	11.36	11.53	12.43

Source : Korea Energy Management Corporation (2011)

12.4km/ℓ average fuel consumption, and the vehicles that exceeded 1,600cc applied to 9.6km/ℓ. The share of vehicles meeting average fuel efficiency of 17.0km/ℓ will be gradually increased from 30% in 2012 to 100% in 2015. Also, the program will be expanded to vehicles with less than 10 passenger seats and below the total weight of 3.5 tons, and small car manufacturers and their importers will have separate average fuel consumption standards.

Using this system, the average fuel efficiency has been increasing by 3.2 percent annually. In 2009, there was a 7.8 percent increase due to rising sales in compact cars and replacement support for old vehicles.

D. Agricultural & livestock sector

GHG emissions from methane and nitrous oxide caused by the agricultural sector have been improved through low carbon agricultural policies and upgraded technology. The efforts to reduce GHG emissions in the agriculture & livestock sector were made through improvements to methods of farming & animal husbandry. The policies on crop sector are divided into reduction policies on CH_4 from rice paddies and those on N_2O from dry fields. In the livestock sector, GHG reduction is promoted through the improvement of ruminants' enteric fermentation and manure treatment facilities.

1) Reduction of CH_4 emissions from paddy fields

Currently, a policy to reduce CH_4 emission is conducted through the improvement of rice cultivation technology. Since the 1990s, the development of technology for CH_4 emission reduction has been fundamental, allowing systematization of agricultural management for water, rice straw, sewage, seeding/transplanting, soil amendments, and tillage. Based on the R&D[13] regarding GHG emissions from rice cultivation, a *Rice Cultivation Technology Manual for GHG Reduction* has been published to support low-carbon cultivation technology and to spread relevant techniques into the farm level. According to this manual, certain cultivation methods that reduce GHG emissions have been stimulated. For example, seeding on a dry paddy field reduces CH_4 emissions by 32 percent more than transplanting culture, and intermittent irrigation technology can reduce CH_4 emissions by 43.8 percent more than continuously flooded practice. Therefore, even if the cultivation area remains on the same level, CH_4 emissions will be expected to decline as seeding cultivation and intermittent irrigation areas increase. Also, as early rice varieties tend to have lower CH_4 emissions than mid/late season rice varieties by about 25 to 40 percent, there is a suggestion that most emissions can potentially be reduced by the encouragement of these rice varieties.

2) Reduction in N_2O emissions in rice paddy and dry field

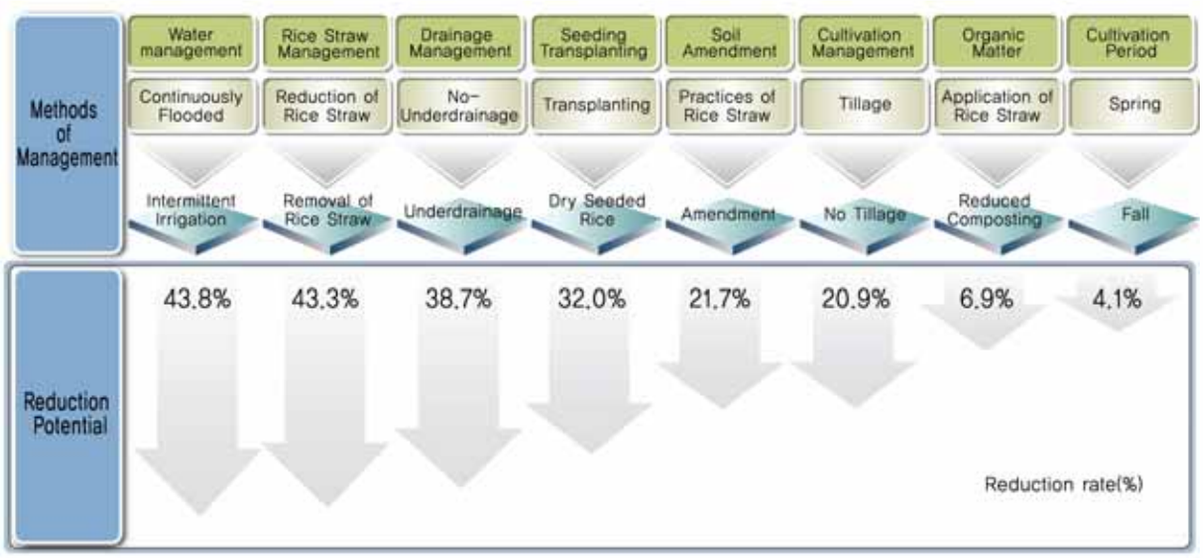
Reduction in N_2O emissions from nitrogenous fertilizers in farms has been achieved through eco-friendly agriculture reducing chemical fertilizers. The government of Korea has been promoting a *Five-Year Plan for Developing Environmentally-Friendly Agriculture* since 2001 in order to actively foster

13) Rural Development Administration, 2009

environment-friendly agriculture. Currently, the 3rd version of the five-year plan is being made. As an example of an eco-friendly project, in order to build a sustainable low-carbon resource-circulating agricultural system, eco-friendly agricultural complexes will be created on city and county levels, connecting the crop sector and livestock sector (greater than 600 ha). Also, eco-friendly agricultural districts greater than 10 ha will be created on town and village levels. An eco-friendly direct payment agricultural system, which provides subsidies per acre, is being promoted for developing eco-friendly farms. Additionally, a customized fertilizer support program has been created, which promotes the use of this fertilizer based on soil test results in order to reduce the use of chemical fertilizers.

Through the implementation of eco-friendly projects, certified eco-friendly agricultural areas have increased by more than 60 percent each year since 2000. As a result, consumption of nitrogen fertilizers (per ha) has been reduced from 423,000 tons in 2000, to 354,000 tons in 2005, and to 242,000 tons in 2010. This consumption decreased by 42.8 percent in 2010 compared to usage in 2000, significantly contributing to N_2O reductions.

Since 2000, nationwide surveys have been implemented to assess N_2O emissions,



Source : National Academy of Agricultural Science (2009)

[Figure 3-4] Comparison of GHG reduction effects in rice cultivation

<Table 3-18> Eco-friendly agricultural area and nitrogen fertilizer consumption

Year	2000	2005	2007	2008	2009	2010
Certified eco-friendly agricultural area(ha)	2,039	49,807	122,882	174,107	201,688	194,006
Total consumption of nitrogen fertilizer(thousand tons)	423	354	335	302	262	242

Source: MIFAFF (2011)

successfully establishing the basic measurement system. Controling the use of nitrogen fertilizer has expanded farming management leading to a reduction in N_2O emissions. On the other hand, to implement *Integrated Nutrient Management (INM)* for eco-friendly agriculture, the information on proper handling of fertilizers and fertilization based on soil test has been provided. Also, research on N_2O emissions in the upland and the development of reduction technology continue to be promoted. In addition, based on the research results from 2002 to 2010, in relation to field crops such as peppers, beans, and cabbage, a *Manual Guide for Cultivation Technology* will be published. This manual will promote low carbon agricultural skills such as organic trials, tillage management, water management, use of nitric acid suppressant, and improvement of cropping systems.

3) Improvement of Ruminant Enteric Fermentation

In order to reduce CH_4 emissions from ruminant enteric fermentation, various plans have been considered such as livestock improvement and feed management (high-quality feed and feed supplement).

(A) Support expansion for the animal improvement project

This project promotes animal improvement, which can reduce GHG emissions through proper maintenance of breeding while increasing livestock productions on ruminants such as Korean cows and dairy cattle. The government of Korea is promoting programs for supporting high quality Korean cow breeding and assessing the abilities of dairy cattle in order to improve productivity through these genetic modifications. Dairy farm breeding projects have been advanced by introducing high-quality fertilized eggs and providing these to clean breeding farms. Furthermore, focusing on leading farms, a technical training program has been introduced to increase productivity and to reduce GHG emissions.

(B) Expansion of high-quality forage

In order to promote the foundation for production of good quality secondary feed, utilization of domestic natural resources, and expansion of production, the government of Korea has been promoting the establishment of an infrastructure for roughage production. This project includes the improvement of forage machinery, utilization of natural resources such as rice straw, grass composition, processing facilities, and the support for silage production, and transportation. To secure high-quality feed, the government of Korea plans to increase the ratio of forage to concentrated fodder from 4:6 to 6:4.

(C) Rumen fermentation modifiers and forage additives

The current researches include feed formulations that can better conditions for rumen fermentation, feed additives through enhancement of feed ingredients and processing methods, and CH_4 reduction by microbial treatment agents. Research investment will be increased for practical purposes.

4) Utilization of livestock manure as resources

Large amounts of livestock manure are generated from the production process of domestic livestock from specialized and customized farms (such as cattle, pigs, poultry, etc.). Livestock manure is an organic material that contains fertilizer ingredients and demands high biological oxygen. CH_4 occurs in the decomposition process. By composting, liquefying, and energizing livestock manure, GHG emissions in the livestock sector will be reduced. In order to promote the recycling of animal manure, *Livestock Manure Management and Regulations* have been enacted as of September 2007. There is also a support program for animal manure disposal provided for the facilities and equipment in the livestock farms. This project seeks to promote resource-circulating agriculture by integrating the crop sector with the livestock sector. According to this project, loans are available for composting facilities, common disposal facilities, liquid fertilizer systems, and energy facilities installation. For the effective operation of livestock manure recycling, there are civic organizations such as livestock manure recycling centers and liquid fertilizer distribution centers. These organizations have signed an official agreement to operate recycling systems for crop and livestock farms. Also, consulting services from experts and educational programs on recycling for livestock farms will be strengthened. In addition, in order to meet the demands from crop farms, research funding for developing practical skills regarding odor control and microbiological culture techniques will be increased and cost reductions for recycling livestock manure will be made.

E. Forestry

In the 1950s, forests were severely devastated due to excessive harvesting for fuel wood as well as the deforestation during the Korean War. However, thanks to successful reforestation through conversion of household wood fuel to various energy sources and the implementation of forest rehabilitation projects, the acreage of unstocked forests has decreased from 2.8 million ha, or 42 percent in 1960 to 2 percent in 2005 of the total forest area. Korea made tremendous progress of forest rehabilitation in a short period. This is recognized as a successful reforestation case by the Food and Agriculture Organization (FAO) of the United Nations.

Policies for the protection and expansion of forest carbon sinks and promotion of the use of wood bio-energy are being implemented according to the *Forest Sector's Comprehensive Plan Responding to Climate Change* (2008~2012), established in 2008 to implement sustainable forest management and to enhance carbon sequestration potential based on this reforestation history. Forest Carbon Sink Promotion Law will be enacted in order to properly manage the carbon sinks on national, local, and civic levels.

1) Protection and expansion of forest carbon sinks

(A) Maintenance and enhancement of carbon sequestration potential

Species conversion reforestation projects have been implemented in the forests that may have been damaged by pests or significantly lack the capacity to absorb carbon. From 2006

<Table 3-19> Achievement of forest tending project

(Unit: thousand ha)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Area	104	89	118	172	179	184	179	176	216	304	251

Source: Korea Forest Service

to 2009, *species conversion reforestation* was implemented in pitch pine forests above 21,000 ha and will be gradually applied to other forest.

Forest tending projects have also been implemented not only to maintain and enhance the capacity of forest carbon sinks, but also to improve environmental services from forests such as watershed conservation and wildlife habitats.

Launched in 2004, the *Five-year Forest Tending Plan (2004~2008)* started operations in 934,000 ha of forest areas. The 2nd phase for the forest- tending project (2009~2013), involving a total of 1.25 million ha, will improve the economic and environmental value of the forest and proactively respond to climate change by expanding carbon sinks.

Since 2009, approximately 3.5 percent of the total forest area (225 thousand ha) has been damaged by various diseases and pests. About 62 percent of the damage has been caused by diseases and pests affecting pine trees, including pine wilt disease, pine needle gall midge, and black pine bast scale. Therefore, between 2001 and 2010, the government of Korea implemented forest disaster management projects to protect forest carbon sinks. On average, these projects have controlled 67 percent of damaged areas, annually. By strengthening prevention activity and early detection of harmful insects, the area of vulnerable forest will be reduced. The forest will be protected by intensive pest control, especially in pine trees.

Over the past 10 years (2001~2010), 478 forest fires have occurred per year on average, and a total of 1.2 thousand ha of forests have suffered from fire damage. However, since the basic plan for mid-term forest fire prevention and suppression was established, the damaged areas have been decreased by hiring professional staff and by obtaining rescue equipment. In the future, forest fires and fire-related damages will be minimized by increasing the number of rescue teams and available equipment, improving operational efficiency, and continuously enforcing fire prevention activities (Table 3-20).

<Table 3-20> Forest fires and damages

Year	No. of Cases	Area (ha)	Volume (m^3)
2001	785	963	33,753
2002	599	4,467	324,120
2003	271	133	2,444
2004	544	1,588	52,787
2005	516	2,067	113,830
2006	405	254	7,808
2007	418	230	6,467
2008	389	227	4,580
2009	570	1,381	91,626
2010	282	297	11,168

Source: Korea Forest Service

(B) Prevention of deforestation

Between 2001 and 2010, an annual average of 10,000 ha of forest has been converted to other uses. Forests were traditionally converted to agricultural lands, while recently forests have

been converted into private land developments, factory construction, roads, and leisure areas such as golf courses or ski resorts. As forests account for about 64.5 percent in the relatively small national land, it is inevitable that forests would make up at least some portions of these land demands. However, in order to prevent excessive forest conversion, the following policies have been implemented: a consultation system for forest land conversion permits, forest resources replacement charge scheme, as well as a feasibility survey for forest conversion. Also in 2002, by enacting the forest land management act, permit standards for forest conversion were established and enhanced through a pre-hearing system by the forest land management committee.

(C) Forest Carbon Sinks

For the purpose of expanding forest carbon sinks, a *Five-Year Unused Land Afforestation Plan* has been established to promote afforestation in vacant areas. Also, economic incentives have been provided to those willing to promote the plan. In 2007 (the first year of the plan), afforestation was conducted on 1,051 ha of idle land. Since 2008, annual afforestation of 2,000 ha has been implemented and 6,084 ha has been afforested as of 2010. Annually, 1,000 ha of idle land will continue to be afforested.

After the integration of cities and agricultural areas in 1995, urban areas have dramatically increased and forested land within urban areas has also increased. Reforestation and vegetation recovery in the urban areas means expansion of carbon sinks. Therefore, in accordance with the progress of urbanization, local governments and civic organizations have actively been performing urban afforestation projects to ensure the expansion of carbon sinks as well as the improvement of life quality in cities. The central government is creating urban forests by purchasing private lands, previously public institution areas, and little pieces of land in city centers. The first urban forest establishment project was launched in 2003 and a total of 589 ha of urban forest was created by 2008. Also, local governments have actively been working on urban forest creation. 1,617 ha of urban forest has been created as of 2010 and urban afforestation projects are on-going. Meanwhile, partnership between enterprise and government will be promoted for urban forest creation by establishing enterprise-sponsored urban forest creation and management guidelines.

2) Implementation of forest carbon offset projects

The forest carbon offset program was introduced to establish a basis to participate in *GHG and Energy Target Management and Emission Trading Schemes*. As of 2010, by establishing a pilot project for a forest carbon offset program, a reliable verification/ certification system is being built while considering the ways to connect the program to emission trading which is possible to be introduced in Korea. *The Regulation on Pilot Projects of Forest Carbon Offset Program* has been enacted to establish a legal basis for the initiative and an operating system for future pilot projects has been developed. In 2010, an MOU among three domestic companies was signed for participation in the pilot project. In

2011, two companies completed afforestation projects covering more than 16.8 ha and an additional company is currently preparing its own project plan.

3) Promotion of use of wood bio-energy

To achieve the supply goal of new & renewable energy (11% by 2030), supply and demand expansion policies for wood bio-energy have been implemented through various support programs. To this end, installation of wood pellet manufacturing facilities have been subsidized. As of 2010, 13 facilities have been supported by the government of Korea and five other facilities have been funded by private sector investors. A total of 18 facilities have reached production capacities of over 200,000 tons per year. However, the production of wood pellets amounted to only 9,000 tons in 2009 and 13,000 tons in 2010. Therefore, to increase demand for wood pellets, small wood pellet boilers have been distributed to agricultural and mountainous villages since 2009, and the horticultural heaters have been replaced with wood pellet heaters, as of 2010.

Policies for stable wood pellet supply have been implemented through maximizing collection of by-products from forest tending operations and creating short rotation forests for biomass production. The collection rate (the ratio of collection to production) of wood products from forest tending practices will be increased from 11 percent in 2008 to 20 percent in 2012 via collectivization of forest tending projects, expansion of by-product collection by machines and establishment of more working roads necessary for machinery operation. For the purpose of creating short rotation forests for biomass production over 100,000 ha by 2020, the *Establishment Plan of Short Rotation Forests for Biomass Production* was established in 2009. About 6,116 ha of short rotation forests for biomass production have been established through fast growing species such as the tulip tree and various other types of poplars as of 2009.

F. Waste

Waste that is inevitably generated by

<Table 3-21> Permitted forest conversion area

	Agricultural (ha)	Non-agricultural (ha)						Total
		Housing	Factory	Road	Golf	Others	Subtotal	
2001	925	952	944	1,755	452	2,358	6,461	7,386
2002	582	1,216	1,196	1,879	321	2,351	6,963	7,545
2003	516	1,416	1,166	1,763	455	2,210	7,010	7,526
2004	357	1,751	1,158	1,539	330	2,817	7,595	7,952
2005	472	1,804	1,211	1,238	1,006	3,282	8,541	9,013
2006	431	1,281	1,147	964	1,485	3,593	8,470	8,901
2007	647	1,753	1,370	1,117	1,460	4,197	9,897	10,544
2008	571	1,707	2,253	1,181	2,130	5,897	13,168	13,739
2009	535	1,207	3,308	1,497	2,181	7,149	15,342	15,877
2010	450	1,355	2,240	1,115	1,223	5,468	11,401	11,851

Source: Korea Forest Service

everyday life not only damages the natural environment, but also emits CH_4 and N_2O from greenhouse gases during the disposal process. Therefore, waste reduction and recycling policies have been promoted to proactively marginalize GHG emissions. Through these policies, unavoidable wastes will be used as energy resources.

Also, the government of Korea is promoting saving and reusing water, establishing water demand management policies to save energy for tap-water production and making efforts to reduce GHG emissions from sewage treatment. The share of sewage treatment water reused for industry and agriculture is gradually expanding. And after 2012, sewage sludge treatment facilities, energy recovery using sewage sludge, and bio-gasification using food waste leachate will also be expanded to prepare for the *Ocean Dumping Regulation*.

1) Reduction of waste

Specific policies to minimize waste generation, which is one of the key sources for CO_2 and CH_4 emissions, have been enforced in the stage of production, distribution and consumption. Minimization of waste from the production stage led to the establishment of the *Industrial Waste Reduction System* in 1996. This system provides regulations on emitters in work places. The fundamental purpose of the system is to reduce the base unit of waste generation, waste reduction and recycling from production process. The base unit of waste generation had increased before 2005 and started to decrease thereafter. In 2009, the reduction rate decreased by 4.7 kg per ton compared to 2005 levels.

In the distribution stage, packaging methods and materials have been regulated in order to reduce waste from packaging (Table 3-23).

Since 2008, the government of Korea has assigned a voluntary agreement with 64 distribution and manufacturing companies and achieved the reduction of packing materials by 780 tons and returned the money from saving costs as green mileage (about KRW 1 billion) by encouraging minimized use of unnecessary packing materials.

Additionally, to address the final stage of consumption, a *Volume-Based Waste Fee System* was implemented in 1995, which requires the waste emitter to pay for disposal costs. As of 2008, the system has been in effect for 99.7 percent of administrative areas, covering 18,938

<Table 3-22> Reductions in waste from workplaces

Category / Year	No. of businesses	Production amount (thousand ton)	Sales (billion won)	Waste amount (thousand ton)	Waste generation* (kg/ton)
2001	681	351,585	-	17,921	51.0
2003	703	363,258	-	18,308	50.4
2005	1,229	540,834	442,222	29,954	55.4
2007	1,350	644,918	597,512	34,954	54.2
2008	1,297	593,890	676,619	31,832	53.6
2009	1,334	604,135	731,360	30,622	50.7

* Waste generation: Amount of waste per ton (kg/ton)
Source: 2010 Environmental White Paper, Ministry of Environment

households (out of 19,005). To avoid the use of disposable items such as paper cups, plastic bags, etc., a total of 17 restaurant brands in 2009 and 22 large retailers in 2010 entered a voluntary agreement. Also, *comprehensive policy measures* were released in 2010 to reduce food waste and seven local governments have implemented a standard pilot project. In addition, *Waste Disposal Charge*, implemented in 1993, covers products that contain toxic and hazardous substances for air and water or are difficult to recycle and manage. The system also suppresses production of waste by charging the polluter, manufacturer or importer for disposal. As of 2009, six products (i.e. chewing gum, diapers, cigarettes, plastic products, and packing materials) face charges on waste.

Regarding water resources, the government of Korea established a comprehensive national measure for water management in September 2007. The comprehensive policy measure for saving water led to a reduction of running water by 868 million tons by 2009. The policy also covers overall measures and policies such as the expansion of water-saving devices and reclaimed water systems, introduction of low-flow water systems, and replacing old water pipes. The economic effect of this achievement was KRW 559.6 billion for tap water production (KRW 760 per ton by 2009 average water production costs), KRW 617.1 billion for sewage treatment costs (KRW 711 per ton by 2009 standard), amounting to a total of KRW 1,276.7 billion. According to the comprehensive national water demand management measures, about 206 million tons of tap water were saved between 2007 and 2009 by supplying consumer-oriented water saving devices, decreasing water leakage rates, and reusing sewage water.

2) Expanding reuse and recycling of waste

GHG emissions caused by production, consumption, and disposal of certain products can be reduced through recycling. For this

<Table 3-23> Regulations for packaging materials and wrapping methods

Category	Regulation standards
Packaging materials	▪ No use of Polyvinyl Chloride (PVC) to connect or coat the packing materials (Lamination) ▪ No synthetic resin packing materials, or reduce it annually
Packaging methods	▪ 23 products including processed food should be packed for manufacturer, importer and buyer within 10~35 % of packing space, and no more than two packages

Source: 2010 Environmental White Paper, Ministry of Environment

<Table 3-24> Results for calculation of water saving

(Unit: million ton)

Category	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	867.9	92.4	61.8	151.4	104.5	124.9	64.8	61.8	91.6	60.3	54.4
Water saving device	434.4	54.6	33.4	116.0	67.5	88.2	38.4	33.9	-	1.8	0.6
Reclaimed water facilities	87.3	12.1	1.7	5.5	7.9	8.1	1.6	7.2	6.8	33.5	2.9
Pipe replacement	346.2	25.7	26.7	29.9	29.1	28.6	24.8	20.7	84.8	25	50.9

Source: 2010 Environmental White Paper, Ministry of Environment

purpose, producers will make sure that items can be improved with recyclable materials and discarded products and packing materials will be collected in order to maximize the recycling system that the producer will assume sole responsibility for. The government of Korea is promoting expansion of infrastructure suitable for local and regional conditions, development of related technology, and the consumption of recycling products.

To stimulate the recycling industry, KRW 796 billion in long-term loans at low interest rates were made between 1994 and 2009 for the installation of facilities and funds for technology development. Since 2009, the recycling industry development fund provided KRW 65 billion for projects. As the collected amount of recycling resources has increased due to expansion of reusable items and public awareness, the expansion project for public recycling facilities has been implemented to modernize the currently existing recycling and recollection facilities. From 2000 until 2009, a total of KRW 102.5 billion was invested to support installation and improvement of more than 300 waste selection facilities.

Since 2008, regarding electronic products and vehicles, recycling capacity has been enhanced and hazardous substances are being limited from the design stage. The government of Korea published the *Act on the resource circulation of electrical and electronic equipment and vehicles*, which was implemented in order to protect the environment through proper management of the entire process of disposal after use. Since 2009, the circulation assessment system, which the manufacturer and importer operate, is promoting the recycling of waste.

In regard to food waste management policy, recycling of organic resources will be actively promoted along with reduction of waste. As a result of long-term comprehensive measures on food wastes created in 2004, 92.2 percent of the food waste (14,452 ton per day) has been reused for forage/compost as of 2007. Also, in order to accelerate the reuse of food waste by 2009, the government of Korea supported installation of public food waste recycling facilities and vehicles in 286 locations. Also, a total of 2,125 centers have been installed via a KRW 796 billion loan for a *recycling industry training fund* to develop technology and install facilities. When it comes to construction waste from activation of reconstruction/redevelopment, the waste amount continued to increase from 43

<Table 3-25> Food-processing waste management

(Unit: ton per day)

Category	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Amount generated	11,797	11,577	11,434	11,237	11,397	11,398	11,464	12,977	13,372	14,452
Per person (kg)	0.25	0.25	0.24	0.23	0.24	0.24	0.24	0.27	0.28	0.29
Recycled	2,566	3,928	5,161	6,378	7,130	7,718	9,316	12,105	12,603	13,327
	21.8%	33.9%	45.1%	56.8%	62.6%	67.7%	81.3%	93.2%	94.2%	92.2%

Source: Environmental Whitepaper 2010, Ministry of Environment

million tons in 2002 to 64 million tons in 2008, accounting for more than half of the overall amount of business waste. Based on the construction waste recycling policy, the recycling rate increased to 97.5 percent as of 2008. However, most of the recycling of construction waste gets used for simple purposes, such as embankment, and the actual recycling rate for high- value added sectors (such as concrete) was only 27 percent.

By enacting the *Construction waste recycling promotion Act* and its corresponding legislation, which went in effect in January 2005, systematic structures to dispose and reuse construction waste were established. Likewise, recycled aggregate has become mandatory for road construction, industrial parks and residential lands, sewer installation, basic environmental facilities, and parking lot installation.

To accelerate the demand for other recycled products, 838 public institutions as of 2009 enacted the *Act on encouragement to purchase environment-friendly products*. As a result, although the overall purchase of recycling products by public institutions was only about KRW 1.2 billion in 2004, it increased to KRW 26.4 billion by 2008, showing significant growth.

<Table 3-26> Current status of construction waste management

(Unit: ton per day)

Category / Year	Total	Landfill (%)	Incineration (%)	Recycled (%)
2002	120,141	14.5	2.1	83.4
2003	145,420	9.4	1.5	89.0
2004	148,489	7.3	2.0	90.7
2005	134,906	2.6	0.6	96.7
2006	168,985	2.3	0.7	97.0
2007	172,005	1.8	0.7	97.5
2008	176,447	1.7	0.8	97.5

Source: Environmental Whitepaper 2010, Ministry of Environment

The annual sewage treatment water, from continuing expansion of wastewater treatment plants, reached about KRW 6.7 billion as of 2009. The *Sewerage Act* in 2006 required reuse of the wastewater from public sewer treatment plants that process more than 5,000 tons of sewage per day. Since 2005, project funds for local agencies have been partly supported by the government subsidy for reuse of wastewater through the *Pilot project plan for promotion of the reuse of sewage treatment waste*. In addition, the water quality standards for reusing wastewater from landscaping, cleaning, agriculture, and industrial water was imposed in order to safely reuse sewage treated water.

By establishing *the water recycling basic plan* in February of 2007, reuse of sewage treated water in the future is intended to provide high-quality water for reasonable prices. In order to focus on the reuse of sewage treated water as *the new water industry*, about 1.24 billion tons of wastewater will be reused annually by 2016. To expand the reuse market, the financial business of the local government and reuse of industrial water led to the establishment of *private investment in reusing wastewater*, providing 440 hundred million tons of industrial water by investing KRW 1.4 trillion by 2016 with private capital and technology.

By reusing wastewater for industrial, agricultural, and daily use, the *Promotion of and support for water reuse act* was enacted (in June 2010), to build a systematic basis to proactively cope with water scarcity. The market for water recycling will be expanded and new

jobs will be created through building water recycling facilities and new contractors.

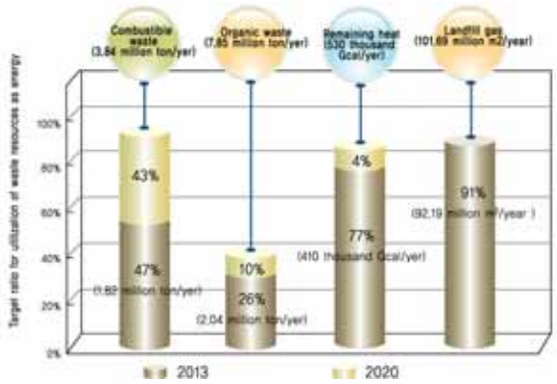
3) Utilization of waste resources as energy

The 2009 standard indicated that the total production of new & renewable energy compared to the primary energy accounted for only 2.50 percent (6.09 million TOE) of the total 243,311 thousand TOE. Energy from waste was about 4.56 million TOE, which is about 42 percent of the total production of the new & renewable energy (excluding the waste gas, which is 2.54 million TOE).

For more active use of waste resources, the government of Korea is promoting expansion of facilities for production of Refuse Derived Fuel (RDF) and power generation using combustible waste. It also expands energy facilities using waste resources bio-gasification of organic waste including food waste, sewage sludge, and livestock manure. Also, establishing energy production facilities, low-carbon green villages, and R&D programs are promoting development of technology and expert training.

In October 2008, a *waste resources and biomass energy countermeasure* was enacted, followed by its implementation in 2009. This countermeasure was enacted in order to focus on measures for using waste resources. By 2013, 47 percent of combustible waste and 26 percent of organic wastes will be reused for energy. Also, 77 percent of remaining heat, occurred from large incineration plants, and 91 percent of landfill gas will be collected for recycling purposes.

Since 2007, the public funds to install facilities for waste resources have been



[Figure 3-5] Waste utilization plan

gradually increased and in 2010, approximately KRW 73.2 billion were provided to support the municipal-scale facilities.

Also, through urban redevelopment and concentration of waste resource energy facilities, environment/energy towns will be created to relieve side-effects from individual facilities in the regions as well as securing economic stability. The country will be divided into eight regions to create 13 environmental and energy towns, centered on metropolitan landfill sites, and areas designated for new cities. By 2010, 15 waste resource energy facilities will be established in nine different towns throughout the nation.

As ocean dumping of organic waste will be prohibited as of 2012, measures of energy recovery using sewage sludge will be actively promoted. For that purpose, the *Enforcement Rules of the Wastes Control Act* has been enacted to be able to use sewage sludge as a fuel in coal-fired power plants. To accelerate manufacturing and the use of combustible waste fuel products, the quality standard for fluff RDF and management practices were implemented in July 2007. In addition, the information management system for RDF is being operated

<Table 3-27> Energy generated from waste

(Unit: thousand TOE)

Category	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
New & renewable Energy	1,897	2,127	2,453	2,917	4,437	4,582	4,879	5,225	5,609	5,858	6,086
Energy from waste	1,761	1,978	2,308	2,733	3,039	3,313	3,706	3,975	4,319	4,569	4,558
	93%	93%	94%	94%	68%	72%	76%	76%	77%	78%	75%

Source: 2009 new & renewable energy distribution, Korea Energy Management Corporation

to effectively share the information on the manufacturing and use of RDF as well as information sharing between manufacturers and users.

Although there are great potential energy opportunities in rural and small towns, such as combustible and organic waste resources, forest resources, and agricultural by-products, the actual utilization of energy is extremely low due to the regional dispersions or low amount of generation. Therefore, the government of Korea has implemented a pilot project to create low-carbon green villages in 2010. In order to create the best practice model in the early stage, benchmark practices will be established for each category prior to the pilot project based on statistical data and treatment of biomass occurrence: urban, agricultural, mountainous, oceans, etc.

Chapter 4

Projected Greenhouse Gas Emissions and Reductions by Sector

Chapter 4 Projected Greenhouse Gas Emissions and Reductions by Sector

1. Overview

This chapter presents *Aggregate Emissions Projection* and *Projected Emissions after GHG Reductions by Sector*, the former is a projection against BAU emissions, and the latter is a projection of emissions upon accomplishment of the mid-term GHG reduction goal (30 percent reduction below BAU by 2020). Implemented and adopted policies and measures are applied to phases of BAU emission projections, the former falls into the *with measures* category and the latter falls into the *with additional measures* category[14].

The Korean economy is anticipated to have a steady growth rate of 4-5 percent during the forecast period (2005-2020). The high technology, IT, and service industries are expected to lead economic growth. Although BAU projections of GHG emissions show a continued annual increase, successful implementation of the mid-term national GHG reduction plan will reflect a decreasing trend after 2015.

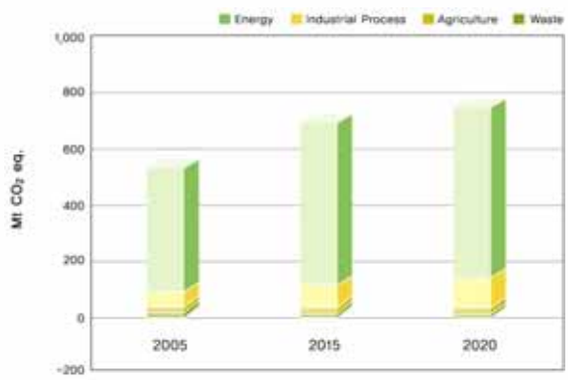
The activity data on emissions and sinks has been reported in consideration of the economic growth rate, oil price, and national policies. For the estimations of GHG emissions from fuel combustion and industrial processes, which comprise most of the GHG emissions, projection data from Korea Energy Economic Institute was used. As for the emissions in agriculture and waste, the National Academy of Agricultural Science and Korean Environment Corporation made the projections, respectively. The LULUCF sector was monitored by the Korea Forest Research Institute.

2. Aggregate emissions projection

If the current trends of industry structure remain unchanged and no additional effort is made to reduce GHG, the emissions during the forecast period are anticipated to increase by 24.3 percent in 10 years and by 36.1 percent in 15 years (against 2005 levels). The projected emissions from 2005 to 2020 by sector are estimated as follows: energy sector will increase by 33.5 percent and industrial processes will increase by 81.8 percent. On the other hand, the agriculture sector will decrease by 7.5 percent and waste sector will decrease by 14.9 percent. For the energy sector, the share of total emissions is estimated to decrease from 82.3 percent (2005) to 80.8 percent (2020), while the amount for the industrial process will increase from 11.2 percent (2005) to 15.0 percent (2020). The agricultural sector will decrease from 3.6 percent (2005) to 2.4 percent (2020), and the waste sector will decrease from 2.9 percent (2005) to 1.8 percent (2020).

By GHG type, it is estimated that CO_2 will increase by 24.3 percent in 2015 and 32.0 percent in 2020 from 2005 levels and F-gases (including HFCs, PFCs, SF_6) is projected to

14) According to the *Guidelines for National Communication*, parties shall report a with measure projection which encompasses currently implemented and adopted policies and measures and may report *without measure* and *with additional measure* projections.



[Figure 4-1] Projected national GHG emissions by sector

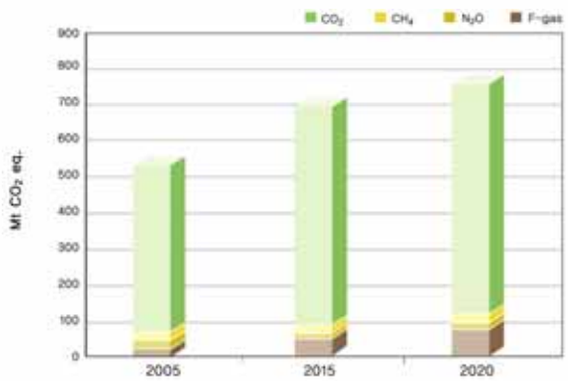
<Table 4-1> Projected GHG emissions by sector and increase rate by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
Energy	469.6 (82.3%)	588.0 (82.9%)	626.9 (80.8%)	25.2%	33.5%
Industrial processes	64.1 (11.2%)	86.7 (12.2%)	116.6 (15.0%)	35.2%	81.8%
Agriculture	20.3 (3.6%)	19.5 (2.7%)	18.8 (2.4%)	-4.2%	-7.5%
Waste	16.3 (2.9%)	14.8 (2.1%)	13.8 (1.8%)	-9.0%	-14.9%
Total emissions (excluding LULUCF)	570.3 (100%)	709.0 (100%)	776.1* (100%)	24.3%	36.1%

*This emissions level is the result of a recalculation based on the 2009 emissions estimation methodology; at the time of the national mid-term GHG reduction goal establishment, the BAU projection reflected an 813 Mt CO_2 eq. level of emissions in the year 2020. This recalculation does not change the 30% reduction goal rate.

increase from 118.6 percent (2015) to 235.0 percent (2020) from 2005 levels. CH_4 will likely maintain a similar volume until 2020. N_2O will decrease by 48.2 percent (2015) against 2005 levels, and it will maintain a similar volume of emissions.

The overall projections indicate that emission share of CO_2 will decrease from 86.7 percent to 84.1 percent between 2005 and 2020. CH_4 will also decrease from 5.0 percent to 3.7 percent and N_2O will decrease from 3.9 percent to 1.5 percent. However, emission share of F-gases will likely increase from 4.3 percent to 10.7 percent.



[Figure 4-2] Projected GHG emissions by types of GHG

<Table 4-2> Projected GHG emissions by types of GHG and increase rate by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
CO_2	494.6 (86.7%)	614.6 (86.7%)	652.8 (84.1%)	24.3%	32.0%
CH_4	28.8 (5.0%)	28.8 (4.1%)	28.9 (3.7%)	0.1%	0.4%
N_2O	22.2 (3.9%)	11.5 (1.6%)	11.5 (1.5%)	-48.2%	-48.1%
F-gas	24.8 (4.3%)	54.1 (7.6%)	82.9 (10.7%)	118.6%	235.0%
Total	570.3 (100%)	709.0 (100%)	776.1 (100%)	24.3%	36.1%

3. Projected emissions by source and sink

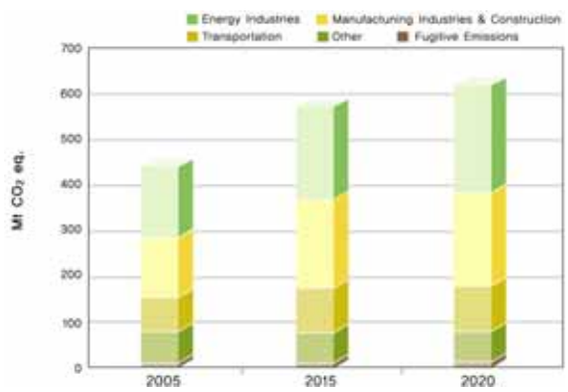
A. Energy

GHG emissions in the energy sector in 2020 are estimated to increase by 33.5 percent compared to 2005 levels. By sector, the increase rate is estimated to be 37.1 percent for the

energy industry, 54.2 percent for the manufacturing industry, 20.1 percent for transport, and 0.4 percent for the remaining.

When looking into emission shares of specific sub-sectors, the energy industry, which accounts for the largest share of energy-related emissions, will increase from 37.8 percent to 38.8 percent between 2005 and 2020 due to continuously increasing power consumption. Manufacturing and construction will also increase from 28.7 percent to 33.1 percent during the same period.

On the other hand, due to improved fuel efficiency and slowdown in car registration rates, emission share of transport sector are expected to decrease from 17.4 percent to 15.7 percent, and other sectors will also decrease from 14.8 percent to 11.1 percent due to a slowdown in population growth and improvement of energy efficiency.



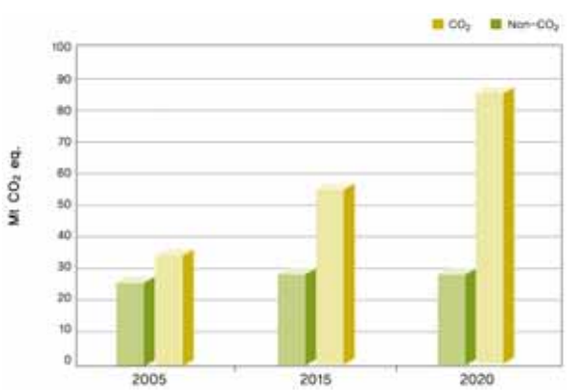
[Figure 4-3] Projected GHG emissions by sub-sector in the energy sector

<Table 4-3> Projected GHG emissions by sub-sector in the energy sector and increase rate by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
Energy industries	177.5 (37.8%)	218.2 (37.1%)	243.4 (38.8%)	22.9%	37.1%
Manufacturing industries & construction	134.6 (28.7%)	200.0 (34.0%)	207.6 (33.1%)	48.5%	54.2%
Transport	81.9 (17.4%)	94.8 (16.1%)	98.4 (15.7%)	15.7%	20.1%
Other	69.6 (14.8%)	67.8 (11.5%)	69.8 (11.1%)	-2.6%	0.4%
Fugitive emissions	5.9 (1.3%)	7.4 (1.3%)	7.6 (1.2%)	24.5%	29.5%
Total	469.6 (100%)	588.0 (100%)	626.9 (100%)	25.2%	33.5%

B. Industrial Processes

GHG emissions in industrial processes are projected to increase to 81.8 percent by 2020 against 2005 levels as the petrochemical, electronics, semiconductors and display industries are expected to continue growing. By GHG sources, CO_2 emissions is estimated to increase by 6.9 percent from 2005 to 2020. Non-CO_2 emissions are projected to increase by 140.2 percent from 2005 to 2020. This is due to the outlook that F-gas emissions from the growth of the display and semiconductor industries will rapidly increase, despite decreasing N_2O emissions, as projects for decomposing N_2O are being pipelined into the



[Figure 4-4] Projected GHG emissions by types of GHG in the industrial processes sector

<Table 4-4> Projected GHG emissions by types of GHG in the industrial processes sector and increase rate by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
CO_2	28.1 (43.8%)	29.8 (34.4%)	30.0 (25.8%)	6.1%	6.9%
Non-CO_2	36.0 (56.2%)	56.9 (65.6%)	86.5 (74.2%)	58.0%	140.2%
Total	64.1 (100%)	86.7 (100%)	116.6 (100%)	35.2%	81.8%

Clean Development Mechanism (CDM).

C. Agriculture

After 2005, GHG emissions from agriculture are projected to decrease 7.5 percent by 2020. During the forecast period, emissions from the livestock and agronomy sectors are estimated to decrease by 2.1 percent and 10.1 percent, respectively. By GHG type, CH_4 will decrease by 9.9 percent as emissions from rice cultivation and N_2O is projected to decrease by 4.1 percent.

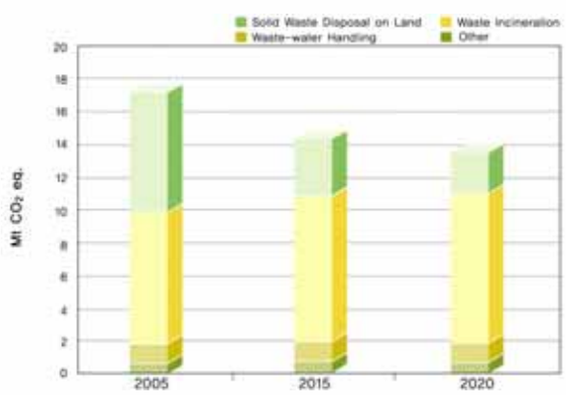
[Figure 4-5] Projected GHG emissions by sub-sectors in the agriculture sector

<Table 4-5> Projected GHG emissions by sub-sectors in the agriculture sector and increase rate by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
Enteric fermentation	3.2 (15.9%)	3.9 (19.8%)	3.6 (18.9%)	19.4%	10.2%
Manure management	3.3 (16.2%)	2.9 (15.1%)	2.8 (15.0%)	-10.9%	-14.2%
Rice cultivation	7.6 (37.3%)	6.1 (31.1%)	6.0 (32.0%)	-20.2%	-20.8%
Agricultural soils	6.1 (30.2%)	6.6 (33.7%)	6.3 (33.7%)	6.9%	3.4%
Field burning of residues	0.1 (0.4%)	0.1 (0.3%)	0.1 (0.3%)	-22.1%	-23.9%
Total	20.3 (100%)	19.5 (100%)	18.8 (100%)	-4.2%	-7.5%

D. Waste

GHG emissions from waste sector will be reduced by 14.9 percent during the forecast period. This is due to government policies regarding the increase in recycled waste products and reduction of landfills.



[Figure 4-6] Projected GHG emissions by sub-sectors in the waste sector

<Table 4-6> Projected GHG emissions by sub-sectors in the waste sector and increase by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
Solid waste disposal on land	8.5 (52.5%)	3.9 (26.4%)	2.8 (20.3%)	-54.4%	-67.2%
Waste incineration	6.0 (37.0%)	9.2 (61.9%)	9.3 (67.3%)	52.3%	54.9%
Other	0.4 (2.3%)	0.6 (3.9%)	0.6 (4.1%)	54.1%	50.8%
Waste-water handling	1.3 (8.2%)	1.2 (7.9%)	1.2 (8.4%)	-12.3%	-13.2%
Total	16.3 (100%)	14.8 (100%)	13.8 (100%)	-9.0%	-14.9%

E. Land Use, Land-use Change and Forestry (LULUCF)

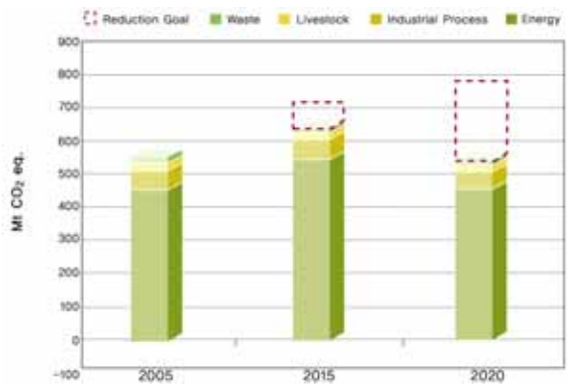
CO_2 removal levels in LULUCF are projected to decrease by 26.0 percent between 2005 and 2020. This is because total emissions from forest and grassland conversion and soil carbon emissions will maintain a similar level while the total sinks of forestry and other woody biomass stock are projected to decrease.

<Table 4-7> Projected GHG emissions in the LULUCF sector and increase by period (Mt CO_2 eq., %)

	2005	2015	2020	Increase Rate in 2005~2015	Increase Rate in 2005~2020
Sinks	-32.4	-29.7	-24.0	-8.1%	-26.0%

4. Projected emissions after GHG reductions by sector

The government of Korea declared the national mid-term GHG reduction goal in November 2009 and, as a follow-up, detailed reduction goals by sector and industry were recommended in July 2011.



[Figure 4-7] Projected national GHG emissions by sector after the national reduction plan

<Table 4-8> Projected GHG emissions by sector(after reduction) and reduction rate below BAU projections in 2020 (Mt CO_2 eq., %)

	2005	2015	2020	Reduction rate in 2020
Energy	469.6 (82.3%)	542.4 (85.1%)	454.9 (83.9%)	27%
Industrial process	64.1 (11.2%)	62.5 (9.8%)	57.5 (10.6%)	51%
Agriculture	20.3 (3.6%)	19.0 (3.0%)	17.5 (3.2%)	7%
Waste	16.3 (2.9%)	13.5 (2.1%)	12.1 (2.2%)	12%
Total emissions	570.3 (100%)	637.4 (100%)	542.1 (100%)	30%

If the reduction goal is successfully achieved, the total GHG emission of Korea in 2020 is expected to be decreased by 30 percent compared to BAU projection. Projected emissions by sources indicate that all sectors would achieve a decreasing trend. The reduction rates of GHG emissions in 2020 by sector are estimated as follows: 27 percent decrease in energy sector, 51 percent decrease in industrial processes sector, 7 percent decrease in agriculture sector, and 12 percent decrease in

waste sector. Looking at the projected emissions sources, the emissions share of the energy sector will increase from 82.3 percent to 83.9 percent and industrial processes share will decrease from 11.2 percent to 10.6 percent. Emissions share will decrease only a small amount in agriculture, from 3.6 percent to 3.2 percent, and the emissions share in the waste sector will decrease to from 2.9 percent to 2.2 percent during the forecast period.

Chapter 5

Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures

Chapter 5 Vulnerability Assessment, Climate Change Impacts, and Adaptation Measures

The influence of the climate change on Korea has included increases in deaths due to tropical diseases and heat waves, northward movement of croplands, a decrease in polar fish catches, and an increase in flood damage (an increase of 3.2 times every 10 years). Based on the vulnerability assessment on climate change, the government of Korea established the *National Climate Change Adaptation Master Plan* in association with 13 relevant ministries in 2010. The measures are comprised of 87 major tasks in ten fields and emphasize cost-effectiveness and protection of vulnerable members of society. Also, the municipal adaptation measures have been integrated with the existing national plan to establish coordinated adaptation measures to counteract climate change.

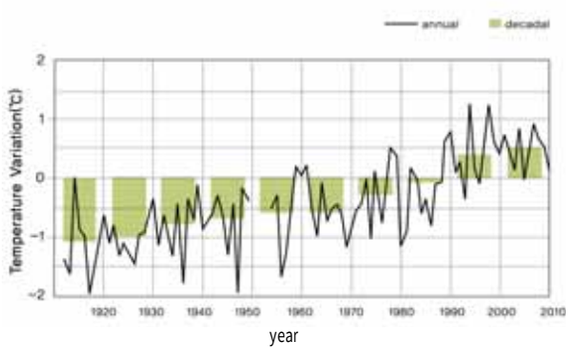
1. Observed and projected climate change in Korea

A. Change based on observations data

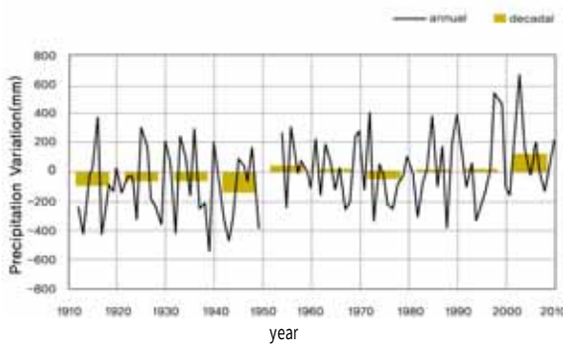
1) Annual mean temperature and precipitation

The annual mean temperature for Korea has increased by about 0.18℃/decade over the past 99 years (1912-2010), which has been linked to global warming and partially related to urbanization. Precipitation has large variability and increase rate of 21 mm per a decade, recording a 17% increase over the past 99 years (Figure 5-1).

(a) mean temperature



(b) precipitation anomalies



[Figure 5-1] Annual and decadal (a) mean temperature and (b) precipitation anomalies (1912-2010) for Korea (Anomalies are calculated with respect to the 1971-2000 base period)

2) Climate extreme

Based on the trend analysis using the climate extreme index of CCI/WCRP-ETCCDI, extreme temperature index were consistent with the idea of a general warming with greater warm extremes and less cold extremes for the past 99 years.

The summer days with a daily maximum temperature above 25℃ increased at a rate of 0.86 days per decade and tropical nights with a daily minimum temperature above 25℃ increased by 0.72 day per decade. However, frost days, that the daily minimum temperature is below 0℃, decreased at a rate of 3.5 days per decade and ice days, that the daily maximum

temperature is below 0℃, decreased at a rate of 0.96 day per decade.

In Table 5-2, the extremely wet day precipitation (R99p) and the max 5-day precipitation amount (RX5day) in August increase by 8.5mm per decade and 5.17mm per decade respectively. More specifically, during the last 99 years the simple daily intensity index increased by 18 percent and days with more than 80 mm precipitation more than doubled compared to the 1970's.

<Table 5-1> Trends in temperature extreme index for the period 1912~2010

Index	Term	Change rate per 10 years
SU	Summer days	+0.862*
ID	Ice days	-0.958*
TR	Tropical nights	+0.722*
FD	Frost days	-3.501*
GSL	Growing season length	+3.511*
TXx	Max Tmax	+0.093*
TXn	Max Tmin	+0.202*
TNx	Min Tmax	+0.120*
TNn	Min Tmin	+0.264*
TN10p	Cool nights	-0.741*
TN90p	Warm nights	+0.214*
TX10p	Cool days	-0.565*
TX90p	Warm days	-0.052
WSDI	Warm spell duration indicator	-0.260
CSDI	Cold spell duration indicator	-1.822*
DTR	Diumal temperature range	-0.116*

Note: * refers to significance level of about 5%.
Index unit is day per decade except for txx, txn, tnx and tnn(℃/decade)

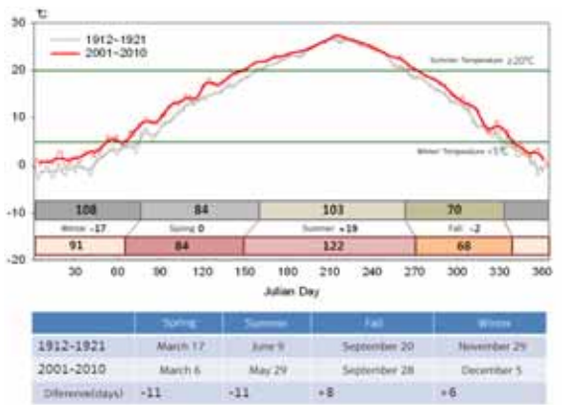
<Table 5-2> Trends in precipitation extreme index for the period 1912~2010

Index	Term	Change rate per 10 years
RX1day	Max 1-day precipitation amount	+2.330*August
RX5day	Max 5-day precipitation amount	+5.166*August
SDII	Simple daily intensity index	+0.223*
R10mm	Number of 10mm, 20mm, 30mm precipitation days	+0.345*
R20mm		+0.289*
R30mm		+0.257*
CDD	Consecutive dry days	0.056
CWD	Consecutive wet days	0.003
R95p	Very wet day precipitation	+17.674*
R99p	Extremely wet day precipitation	+8.501*
RTOT	Annual total wet-day precipitation	21.376*

Note: * refers to significance level about 5%
Unit is mm per decade. However, the unit for R10mm, R20mm, R30mm, CDD and CWD is days per decade.

3) Season length

For the past 99 years (2000's compared to 1910's), the end of fall has come later and start of spring has come sooner, making the length of winter 17 days shorter. In contrast, the length of summer increased by 19 days as the end of spring came sooner and the start of fall later (Figure 5-2).



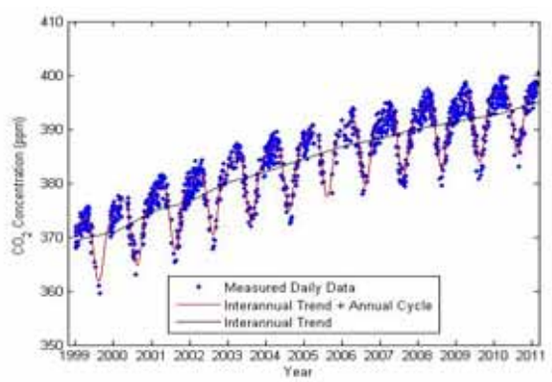
	Spring	Summer	Fall	Winter
1912-1921	March 17	June 9	September 20	November 29
2001-2010	March 6	May 29	September 28	December 5
Difference(days)	-11	-11	+8	+6

Note: The table refers to the beginning days of season and differences between two seasons

[Figure 5-2] Changes in the lengths and the starting and ending dates of seasons for the period 2001-2010 compared to 1912-1921

4) Change of GHGs concentration

According to the observation data of the Korean Global Atmosphere Watch (GAW) Center in Anmyeon-do (World Meteorological Organization Regional GAW Station), CO_2 concentration was 394.5ppm in 2010, which was higher than the global average of 388.6ppm. For the past 12 years (1999~2010), the annual average increase rate was 2.12ppm per year, which was relatively higher than the global annual increase rate of 1.90ppm per year (Figure 5-3). However, the increase rate in 2010 was only 2.0ppm per year, which is lower than the increase rate of the global CO_2 concentration average of 2.4ppm per year.



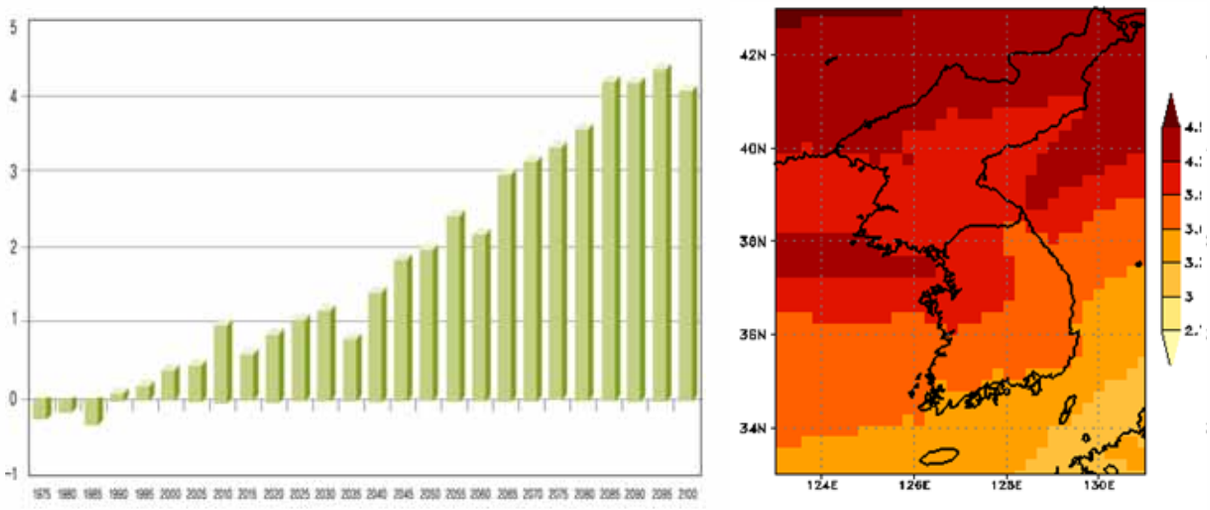
[Figure 5-3] Trends in CO_2 concentration change in Anmyeondo

The annual average rate of change in the concentration of CH_4, N_2O, SF_6 for 12 years between 1999 and 2010 were 3.20ppb per year, 0.96ppb per year, and 0.64ppt per year, respectively, showing an increase every year. However, chlorofluorocarbon levels (CFC-11, CFC-12, CFC-113) all decreased by 2.30ppt per year, 0.84ppt per year, and 0.09ppt per year respectively for the same period (Table 5-3).

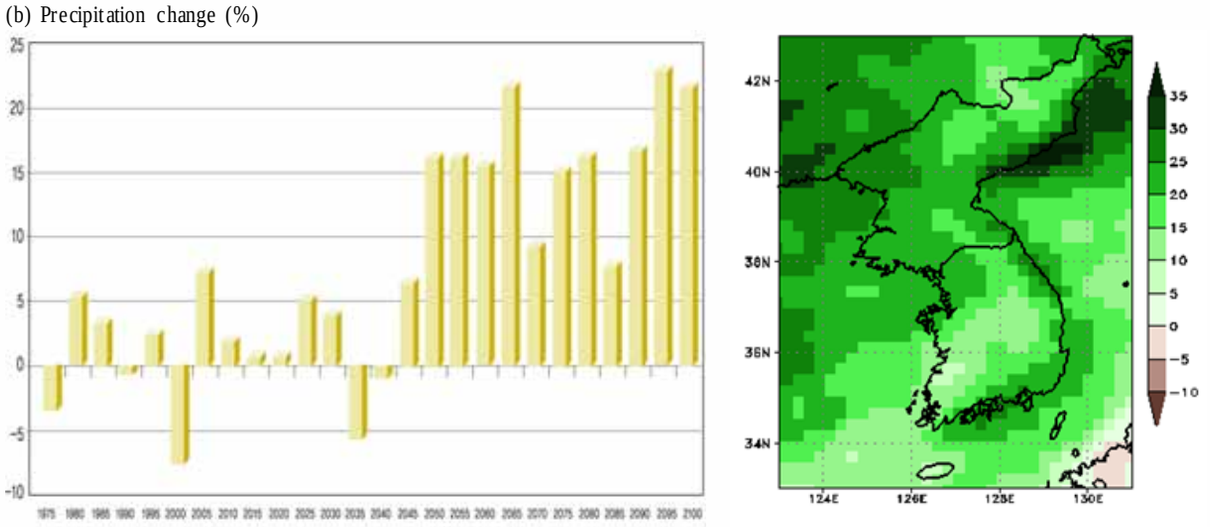
<Table 5-3> Average concentrations of the ambient air GHG and rate of change between 1999 and 2010

GHG	CO_2	CH_4	N_2O	CFC-11	CFC-12	CFC-113	SF_6
2010 Average Concentrations	394.5 (ppm)	1914 (ppb)	325.2 (ppb)	244.7 (ppt)	524.2 (ppt)	76.8 (ppt)	7.8 (ppt)
Annual Increase Rate	+2.12 (ppm/year)	+3.20 (ppb/year)	+0.96 (ppb/year)	-2.30 (ppt/year)	-0.84 (ppt/year)	-0.09 (ppt/year)	+0.64 (ppt/year)

(a) Temperature change(℃)



(b) Precipitation change (%)



[Figure 5-4] The simulated and projected 5-year averaged (a) temperature (top panel) and (b) precipitation (bottom panel) changes and horizontal distribution of future (2071~2100) temperature and precipitation change of the Korean Peninsula based on the A1B scenario between 1971~2100 (left)

B. Future climate change projections

In order to project possible consequences of climate change at a regional scale, dynamic downscaling using MM5 regional climate model at 27 km horizontal resolution was applied to the large-scale climate information from global climate models(GCMs) under IPCC SRES A1B scenario. The regional climate projection showed that the annual mean temperature of Korea will increase by 4℃ at the end of 21st century (2071-2100) relative to reference period 1971-2000. This increase in temperature is projected to be more prominent during the winter. Also, because the increase in the daily minimum temperature will be more prominent than the increase in the daily maximum temperature, the daily temperature range is

expected to decrease.

Precipitation is projected to increase by 17 percent at the end of 21st century. In particular, since space-time variability of precipitation is expected to increase, a high probability of extreme conditions, such as droughts and torrential rain is predicted to increase in some areas (Figure 5-4).

Due to global warming, the number of days with temperature below 0℃ is expected to decrease while the number of hot days is expected to increase. In addition, an increasing frequency of heavy rainfall (over 50 mm per day) is also expected.

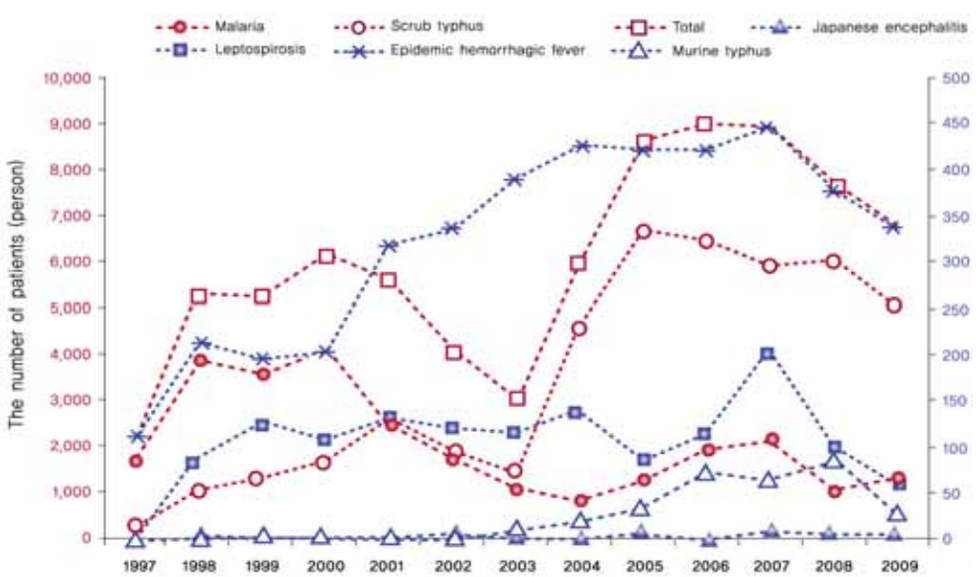
2. Impact and vulnerability

A. Human Health

Climate change affects human health in particularly vulnerable groups such as the elderly and chronically ill.

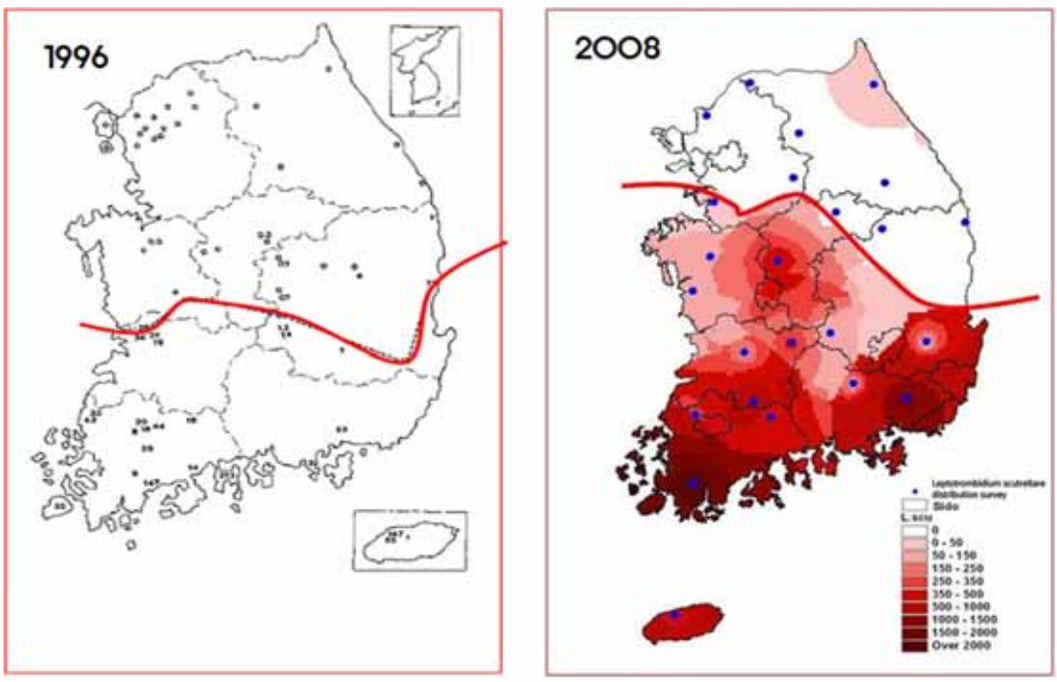
Based on the analysis of the correlation between summer temperature (July and August) and mortality in Korea between 1991 and 2005, there was a significant statistical relationship between the daily maximum temperature and mortality. An analysis of the mortality rate of people 65 or older and heat waves in six major metropolitan cities between 1991 and 2008 revealed that the mortality rate increased by 3~13 percent with each 1℃ increase in the temperature. The mortality rate in Seoul increased by 10.6 percent each time the temperature increased by 1℃ (12.8% for the elderly above 65). Taking into account the current trend of frequent heat waves during the summer, it is assessed that there is a greater probability of an increase in deaths due to the heat waves.

Climate change also affects the outbreak of infectious diseases and the inhabitation of vectors. Infectious diseases have been decreasing in Korea due to the intensive measures taken by



Source: Korea Centers for Disease Control and Prevention

[Figure 5-5] Occurrences of major carrier-borne infectious diseases by year



Source: Korea Centers for Disease Control and Prevention

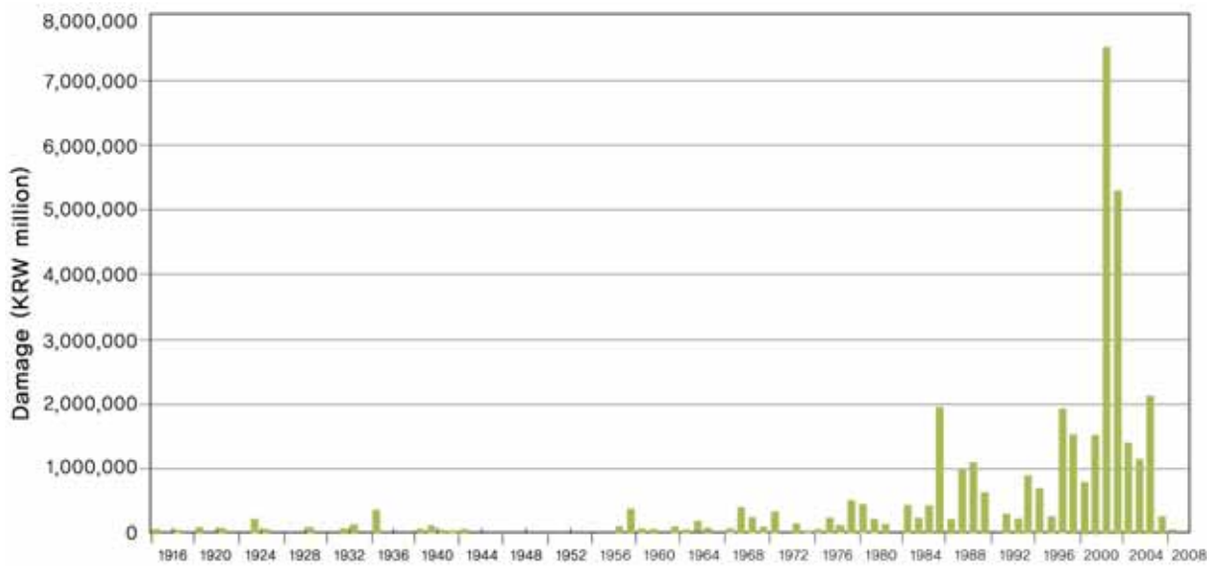
[Figure 5-6] Leptotrombidium scutrellare distribution expansion

health authorities. However, diseases such as malaria, tsuisugamushi, leptospira, and hemorrhagic fever with renal syndrome, which are affected by climate change, are continuing to increase (Figure 5-5). As leptotrombidium (*Leptotrombidium scutellare*), which transmits tsuisugamushi disease, have migrated north, their presence is expected to expand and therefore more people will be affected by tsuisugamushi disease (Figure 5-6).

Climate change has affected air pollutants such as the ozone, which in turn creates changes in the atmospheric environment. This type of atmospheric environment change is known to affect human health. Related diseases, such as asthma or allergic rhinitis, have been continuously increasing and asthmatic risk was 7.7 percent higher among the socioeconomically lower class.

B. Calamity and disaster

The opinion that the frequency of abnormal weather is connected to global warming is increasing. Abnormal weather is directly related to meteorological disasters, which can lead to significant damage. Using the statistics from annals of disasters in Figure 5-7, the cost of damages incurred between 1916 and 2008 are shown in 2008 index price. Six of the ten greatest meteorological disasters, in terms of property damage, between 1916 and 2008 occurred after 2001. In particular, the national annual damage cost rose to KRW 2.3 trillion between 2001 and 2008, more than three times greater than the cost of damage in 1990s (about KRW 700 billion). Among them, Typhoon Rusa and other typhoons in 2002 caused drastic property damage totally KRW 7.5 trillion.



Source: National Emergency Management, 2008

[Figure 5-7] Total cost of natural disasters between 1916 and 2008

Recently, with various abnormal weather phenomena taking place throughout all seasons, there have been significant socioeconomic impacts. For example, a cold wave continued for three weeks in late December 2009, and the amount of snowfall in Seoul was 25.8 centimeters on January 4, 2010 signifying the highest observed value since 1937. However, the national average temperature was higher than that of normal years for 81 days out of 92 days during the summer, summer minimum temperature was the highest observed, and there were seven more tropical nights than usual. Also, typhoons occurred three times during August and September and the daily amount of precipitation was recorded to be 259.5 mm in Seoul.

C. Agriculture

As agriculture is highly dependent on the weather, climate change will lead to large-scale changes in the current agricultural production system. In accordance with the climate change scenario, frequent occurrences of precipitation and temperature increases, and abnormal weather patterns will cause deterioration of agricultural infrastructure, changes in cultivation sites, increased frequency of disease and insectoid pests and weeds, and the decline of quantity and quality of agricultural products.

In addition, rising temperatures are changing the current crop sites. Tangerines, figs, grapes, apple, green tea, garlic, wheat, and rice are agricultural products that adapt well to warm conditions. However, if the current product types and harvest periods are maintained, the growing period shortens, the percent of fertile grain deteriorates, and the crop yield will decrease due to the worsening respiration from warm night temperatures.

Due to trade liberalization, it is expected that invasive foreign rice species will be introduced into the nation. Furthermore, climate

change will create warmer habitats that may enhance the invasion and growth of the introduced species. In particular, areas affected by rice stripe virus have been moving north and expanding due to the increase in temperature during the winter. The *Lycorma Delicatula White*, which lives in subtropical climates, were difficult to find during the winter but the increase in temperature has recently led to their settlement in Korea. Outbreaks of *Cnaphalocrocis medinalis* in Korea are known to occur normally three times a year; however, it is expected to increase to four times a year before harvest season if the annual average temperature increases 2~3℃.

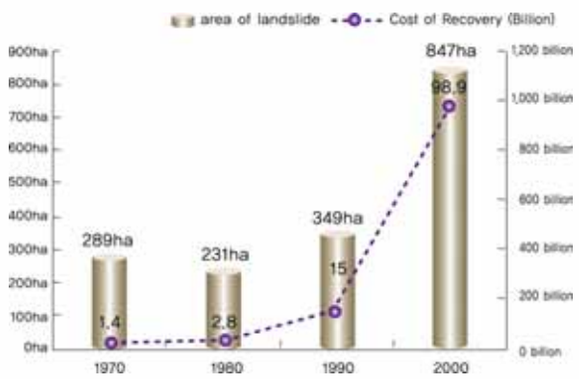
D. Forestry

Most of the forests in Korea were left devastated after the Japanese Colonial Era (1910~1945) and the Korean War (1950~1953). The average growing stock was no more than 10~30㎥ per ha in the 1960's. Since then, with the success of national-level afforestation projects and the transition of fuel supply sources, its average stand value increased to 125.6㎥ per ha as of 2010. Recently, the forest ecosystem service functions and biodiversity have been gradually increasing.

The forest area in 2010 was measured to be 6,369,000 ha, comprising 63.7 percent of the whole land area. This is the fourth highest forest ratio among OECD countries, following Finland (72.9%), Japan (68.5%), and Sweden (68.7%). However, recently, large-scale landslides have been occurring at Mt. Jiri National Park, which is located at the summit of Baekdudaegan Mountains, due to climate change. Frequent heavy rainfall in summer has been responsible for annual 1,000 ha landslide occurrences, and after 2008, huge landslides occurred in six high mountains including Mt. Sorak and Daeduk (Figure 5-8).

Since the 1990s, because of high temperatures and drought in the winter season, the withering of evergreen needle-leaf trees such as pine trees have been increased. In the spring of 2009, 1 million trees in the southern region near Gyeongnam Province withered due to the drought that began in the fall of 2008 and high winter temperatures.

Also, global warming and climate change have increased the inflow of new forest insect pests and disease and the spread of outbreak pests. This is a key factor that threatens forest health. The damage by forest pests in 2001 was 336,528 ha and had decreased until 2004. Pest damage increased again between 2005 and 2006 because of the expansion of the damage area from pine gall midge, black pine bast scale and pine wilt disease. Since then, effective prevention efforts reduced the damage annually and the damage region decreased to 225,345 ha in 2010. Other sporadic pest damage areas were



[Figure 5-8] Trend of landslide occurrence

the greatest in 2001, but started to decrease after 2008. But because subtropical sporadic pests such as *Pitch canker*, *Lycormadelicatula* and *Baculumelongtum* appeared, the damage trend started to increase again.

Due to the forest development effort in Korea, potential stock causing forest fire has increased. The climate change in the future will lead to the temperature rising and the forest fire period brought forward, while precipitation of winter and spring will not increase particularly during forest fire warning period. In case of occasional drought, concerns have risen over extreme fire events. The average number of forest fire occurrences in the past 10 years (2001~2010) was 478, the damage area was 1,161 ha, the volume of trees lost was 64,858㎥, while casualties and injuries were eight and two, respectively.

Forest fire occurrence continuously decreased from 785 incidents in 2001 to 282 incidents in 2010. In 2009, it increased to 1,381 ha with 570 occurrences and the research revealed the cause to be the continuous drought and abnormally high temperature between the Fall 2008 and Spring 2009.

Korea has relatively complex geographical features, comprised of a mostly cool temperate forest sub-zone and, in part, a warm temperate forest sub-zone and sub-alpine forest zone. It is estimated that rises in temperature due to climate change will cause the forest climate zone to move northward and toward hilly areas. Furthermore, when average temperatures rise by 4℃, the warm temperate forest sub-zone belonging to some parts of the southern areas is forecasted to change into a sub-tropical climate zone. Currently, the evergreen broad-leaved tree forest in the warm temperate forest sub-zone, whose growing distribution is limited to the southern coast and island areas, is estimated to expand and gradually move northward. In contrast, the range of vegetation in sub-alpine zones could become drastically reduced. The country's lower regions are comprised of mostly agricultural land or urban areas. Therefore, it is presumed that accelerated climate change may cause the fast distribution of tree species' migration, which brings about the rising latitude and not the rising altitude. Upon the forecasting of the forest distribution, one report indicated that about 25 percent of the sub-alpine and cool temperate zones will be reduced, and about 66 percent of sub-tropical and warm temperate zones will be expanded in the future (2071~2100).

E. Oceans and fisheries

For the past 41 years (1968~2008), the sea surface temperature (Sea Surface Temperature, SST) of the waters around the country rose by 1.31℃ (0.032℃ per year). Specifically, the East Sea rose by 1.39℃ (0.034℃ per year), the South Sea rose by 1.27℃ (0.031℃ per year), and the West Sea rose by 1.23℃ (0.030℃ per year). By season, the winter (February) surface water temperature rise was 1.39℃, which was higher than the summer (August) surface water temperature rise of 0.74℃. This demonstrates significant ocean warming in the winter season. Rather than the coastal sea, the open sea has displayed a greater increase in water temperature.

Changes in relative sea levels of adjacent

seas showed an average increase rate at 2.5mm per year for the past 41 years (1969~2009). The South Coast had a relatively high rate, 3.2mm per year, compared to 1.3mm per year in the West Coast and 2.2mm per year in the East Coast. In particular, sea areas near Jeju have a noticeably high rate, 5.7mm per year. In addition to rising sea levels, tidal waves from typhoons and high tides are also on the rise.

A variety of social and economic activities of coastal zone are disrupted by flooding, coastal erosion, sea water percolated to the underground water due to meteorological disasters such as high tides, high waves and tidal waves. When the aforementioned shoreline damages are combined by external factors, such as an increase of sea levels and typhoons, high tides, and precipitation changes resulted from the global warming, it will have a significant effect on the social and economic activities of the coastal region.

Climate change is expected to cause acidification of seawater, de-oxygenation of deep sea water, and costal eutrophication as well as deoxygenation. The increase of CO_2 in the global average surface has been 1.5 ppm per year since 1990. However, in the Ulleung Basin in the East Sea, it was 3.3 ppm per year and the reduction rate of pH (0.02 units per 10 years) has been growing twice as fast as the global average (0.04 units per 10 years). When the CO_2 cycles in deep water are compared, the Japanese basin in the East Sea was 70~80 mol-C/㎡, showing a higher level than that of the North Atlantic and North Pacific, which were 66~72 mol-C/㎡ and 20~30 mol-C/㎡ respectively. With respect to changes in ocean oxygen, dissolved oxygen data of the northern area of the Japan Basin in the East Sea deep waters (>2000m) indicated that the change, which was above 250 μmol/kg in the early 1950s, was reduced to 220 μmol/kg in 2007. Due to salinization from land and increased stratification from rising water temperatures, deoxygenation could increase in the coastal zone. Deoxygenation started to emerge in Cheonsu bay in the Yellow Sea, Jinhae bay region, near Yeosu area, and Goseong. Stratification due to rapid global warming has been assessed as a deteriorating factor in water quality.

It is observed in marine ecology that there are various changes, such as an increase in zooplankton and red tides, jellyfish bloom, the emergence of tropical and subtropical species, and the increase of albinism due to the global warming. Also, various changes in jellyfish bloom have been observed and reported. Looking back at 37 years in the recent past (1965~2002), the average biomass of zooplankton displayed an increasing trend in the 1990s, as the average was above 300mg/m^3 after 1997. Furthermore, every summer red tides have caused damages to the fishing industry. It is known that red tides have occurred in the ocean as well as coastal water since 1995. In particular, since *Cochlodinium polykrikoides* (a type of Dinophyta in subtropical zones), caused large-scale red tides in 1995, it has been expected to occur periodically between July and September every year. In recent years, the appearance of large jellyfish is increasing rapidly. *Nemopilema nomurai*, which are subtropical jellyfish that generally inhabit the

South and East China Seas, have increasingly appeared in the Korea since 2000, causing damage to commercial fisheries through the destruction of fishing nets and deterioration of the fish population.

Influenced by the recent changes in the major fishery resource around the coasts of Korea, coastal areas with warm current fish are moving north and fishing season is being extended. For the past 30 years (1981~2010), the ratio of small pelagic fish to the Korean total fish population has gradually increased and warm current fish such as squid, mackerel, and anchovies occupies 60 percent of the entire fish population.

Meanwhile, rising water temperatures in the long-term could cause a negative impact on production of cold-water fish. Costal fisheries may suffer extensive damages as tropical and subtropical pathogens such as cholera, vibrio, and blood poisoning become naturalized. Also, due to the inflow of plankton, which is the cause of Paralytic Shellfish Poisoning (PSP), around Korea, there is a possibility of sporadic occurrences of PSP.

F. Water management

Climate change has direct and indirect impacts on the water quality and water ecology, by influencing the increase in water temperature, as well as causing changes in the level of evaporation, flow, and rainfall efflux in the water system. High water temperature aggravate the quality of drinking water with malodors and toxins by facilitating the growth of algae and germ. When the stream influx decreases during the dry season, streams and rivers can be aggravated by eutrophication. When the evaporation rate becomes too high, the salt concentration in the river and the river mouth may increase.

As the acceleration of global warming causes an increase of yearly average temperature, it is predicted that the demand for drinking water and other uses of water (including livelihood, environmental, and industrial use) will be increased. Because of the growth in the standard of living, the amount of water used by each person will increase and the demand for water in river maintenance and environmental improvement will increase as well.

The frequency and scale of floods has continually increased and the damage caused by flooding has also correspondingly increased. Even though the yearly precipitation is increasing, days of precipitation are decreasing and precipitation intensity is increasing, making heavy rainfall a serious issue. Heavy rainfall not only causes damages to riverbanks and facilities, it also increases the losses of both life and property. For the past ten years (2000~2009), there have been 385 cases of flood, which reflected a frequency increase of 70 percent compared to previous yearly averages. The risk index regarding flood is 6.9, substantially higher than that of UK and Japan, which recorded 0.2 and 2.3, respectively.

Droughts are frequently occurring due to the increase in temperature and the amount of evapo-transpiration from climate change. Furthermore, water shortage is expected to continue to worsen in the future. Korea uses

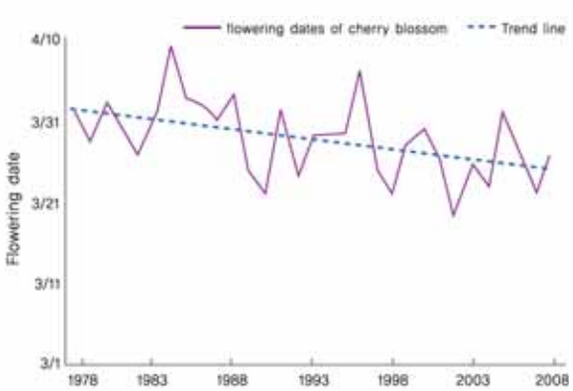
more than half of all usable water for agriculture, so the water shortage is directly linked to lower agricultural productivity. Rice cultivation had been difficult in many areas due to severe drought between 2008 and 2009. The duration of drought increased every year and the damage to crops has kept increasing. Land use change caused by recent urbanization and a change of crop production area due to the climate change has a negative influence on agriculture water management. Between 2000 and 2008, about 140,130 ha of arable land has been diverted for other purposes and this phenomenon is becoming more serious each year.

G. Ecosystem

Due to global warming, the blooming season has come earlier in the mainland ecosystem of the Korean Peninsula. The blooming seasons for *Quercus serrata and Quercus mongolica* are occurring five days earlier than usual and the spring seasons for most of the plants are similarly affected (Figure 5-9). Growth of plants in northern areas are declining due to the physiological stress from rising temperatures. Animals are changing their habitats and migration cycles, and biodiversity is expected to decrease. In particular, the effect of climate change on alpine belts and sub-alpine zones, as well as vulnerable ecosystems such as coastal areas and islands throughout the Korean Peninsula, will be significant.

Due to the recent rise in temperatures, the period for spring phenology (such as flowering and defoliation) is clearly occurring earlier than before. The period of the flowering of a Mongolian Oak and a Queritron, the major forest species of domestic temperate forest, appears 5~7 days earlier if 1℃ of the temperature increases and that of most plants except some forest species also appears earlier than the past. Such changes in phenology affect the herbs that grow on the forest floor and algae that eat phytophagous insects. It is also expected to affect the ecological food and biodiversity.

Climate change due to global warming has also had various impacts on birds. As many as 69 kinds of foreign species of birds have come into Korea since 2000 and some subtropical birds have already settled in Korea. Also, summer birds that typically stay in subtropical regions during winter, have given up migrating and increasingly pass the winter in Korea. New unrecorded tropical species[15] (such as black petrel) have appeared in Korea, and common Korean winter birds (such as wild geese, egrets, herons, etc.) have become non-migrant birds[16] and their numbers have increased.



[Figure 5-9] Change in flowering dates of cherry blossom

15) 10 species such as light thrush, verditer flycatcher, and black drongo
16) Throughout past 10 years, the number of herons that migrate in winter has increased 80%.

Due to recent climate change, a decrease in northern insects and increase in southern insects, transformation of common insects into pests, influx of southern insects, and changes in insect life cycles have been occurring. Based on the reviews of unrecorded and new species in Korea over the past 10 years (2000~2009), there has been an increase in both northern and southern insects (although the increase in southern insects has been clearer).

3. Adaptation measures

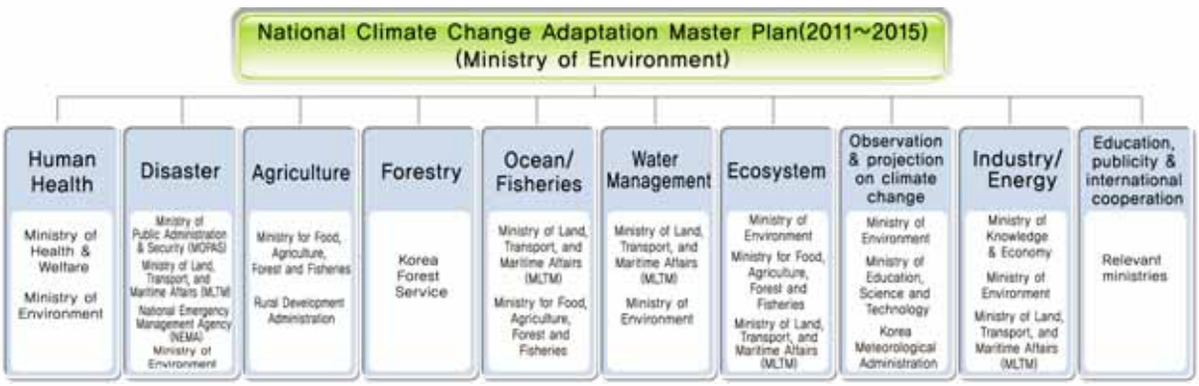
In accordance with *Framework Act on Low Carbon, Green Growth*, the government of Korea established the *National Climate Change Adaptation Master Plan* (2011~2015). In June 2010, government agencies held a working level meeting to establish adaptation measures and key agenda points and formed an expert advisory council. Conferences and symposiums were conducted thereafter and the opinions of experts regarding climate change adaptation measures were collected. These measures, which take into account the uncertainty of climate change, are continuing 5-year plans. 13 relevant ministries and 70 experts in the field are participating in the measure. Ten new visions and plans were released in June 2011 (Table 5-4).

The vision for the national adaptation measure is to build a stable society through climate change adaptation and to support the vision of green growth. The measures are categorized into seven sub-sectors: public health, disasters, agriculture, forestry, ocean/fisheries, water management, and ecosystem.

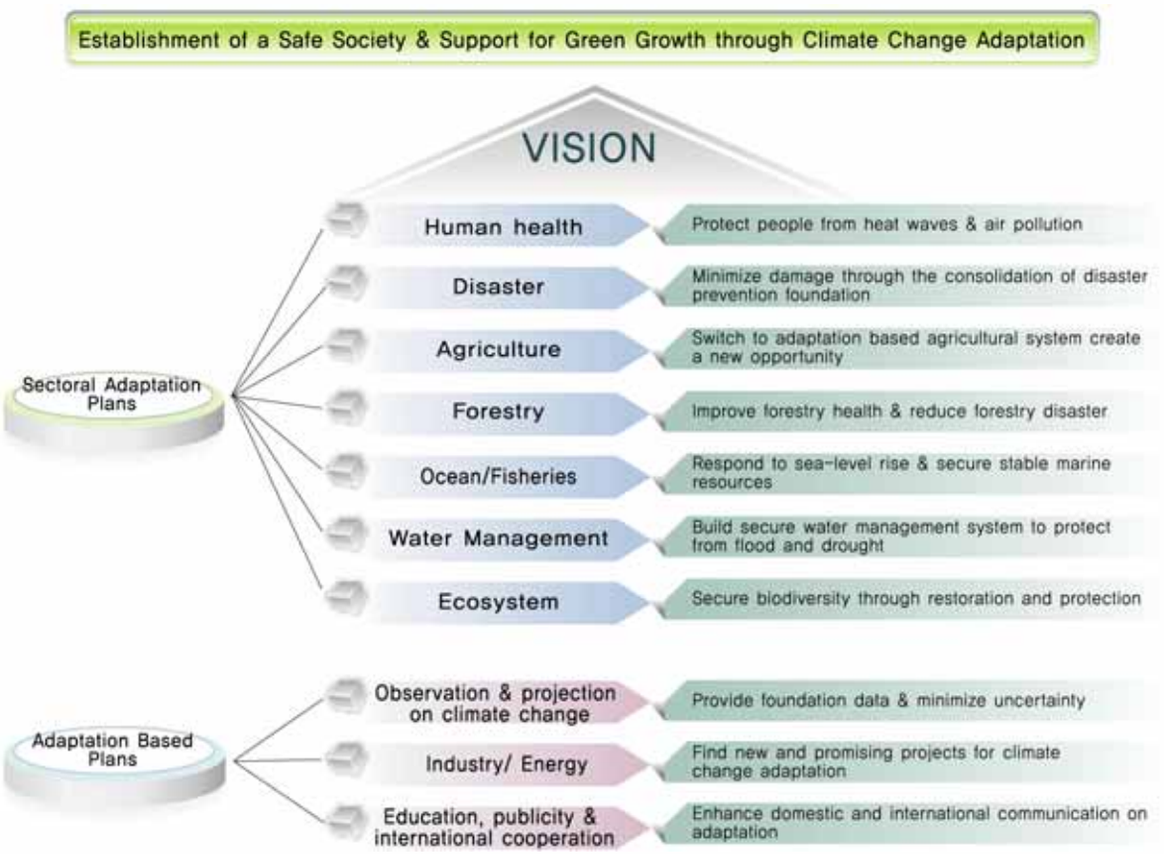
In order to effectively promote the adaptation measures, the government of Korea has made it possible for central agencies, local governments, and the general public to participate and the role of each body has been clearly established. For the practical effect of the adaptation measures, specific implementation plans regarding the measures have been established under central and municipal governments. Implementation assessment regarding these plans will be performed every year and a comprehensive assessment report will be published in the 3rd and 5th years to show the overall assessment regarding the implementation results.

A. Human health

Korea's adaptation measures for human health are focused on protecting public health from climate change. In April 2010, the government of Korea established *National Climate Change and Health Adaptation Action Plan*(2010~2014). Its measures are being pursued with a complete readiness system for extreme weather events, strengthening prevention of epidemics related to climate change and the general health of vulnerable groups against heat waves and air pollution, enhancement of R&D on adaptations and adaptation infrastructure to address climate change. Korea's major pursuit, at the time, is a project to build public health monitoring systems against endemics as this type of system has become crucial to scientifically assess the effect of climate change on public health. Additionally, the government of Korea has



[Figure 5-10] National climate change adaptation measure system



[Figure 5-11] National vision and goal: Adaptation measures for climate change

[Figure 5-12] The role of central government, municipal governments, and general public for the adaptation measures

<Table 5-4> Action plan of national climate change adaptation measures

Field	Measures	Specific Assignment	Branch	Current Status
Health	Adaptation to heat waves and UV rays	Establishment of system that observes and analyzes the effects of heat waves and UV rays on health	Ministry of Health and Welfare, Korea Meteorological Administration	New
		Providing countermeasures to reduce the damages caused by heat waves and UV rays	Ministry of Health and Welfare, Ministry of Environment Korea Meteorological Administration, Korea Forest Service	New/ Implemented
	Adaptation to meteorological disasters	Providing observation and countermeasures to reduce the impact of meteorological disasters on health	Ministry of Health and Welfare	Implemented
	Adaptation to infectious diseases	Establishment of system that observes and analyzes the effects of changes in natural ecosystem on health	Ministry of Environment	Implemented
		Enhanced observation and management on the infectious disease survey	Ministry of Health and Welfare	Implemented
		Enhanced R&D on adaptation to the vector of infectious disease	Ministry of Health and Welfare	Implemented
	Adaptation to air pollution & chemicals	Establishment of system that observes and analyzes the effects of air pollution on health	Ministry of Environment, Ministry of Health and Welfare	New
		Reduction of damage by air pollution on the vulnerable group against air pollution	Ministry of Environment	New
		Establishment of system that observes and analyzes the effects of chemical movement on health	Ministry of Environment	New
	Adaptation to allergies	Enhanced management of the environmental factors that causes allergic diseases	Ministry of Environment, Korea Meteorological Administration	Implemented
		Prevention management of allergic diseases affected by climate change	Ministry of Environment, Ministry of Health and Welfare	Implemented
Natural disaster	Disaster prevention system	Analysis the possible danger of natural disasters affected by climate change	National Emergency Management	Implemented
		Enhanced standard for disaster prevention system to counteract climate change	National Emergency Management	Implemented
		Revitalization of the disaster insurance	National Emergency Management	Implemented
	Disaster prevention infrastructure	Implementation of the disaster prevention projects to prepare secure territory	National Emergency Management	Implemented
		Establishment of the pre-emptive disaster prevention system	National Emergency Management	Implemented
		Improved disaster recovery system to prevent repeated damage	National Emergency Management	Implemented
		Setup of facility that reduces the efflux of rain water to counteract climate change	National Emergency Management, Ministry of Land, Transport and Maritime Affairs	Implemented
		Establishment of waste treatment system that safely manages and counteracts disasters	Ministry of Environment	Implemented
		Development of technology to control the weather to actively counteract the meteorological disasters caused by climate change	Korea Meteorological Administration	Implemented
		Improvement of sewage facility to prepare for heavy rainfall	Ministry of Environment	Implemented

Field	Measures	Specific Assignment	Branch	Current Status
Natural disaster	Facility infrastructure	Providing analysis on the vulnerable areas affected by climate change and establishment of adaptation plan	Ministry of Land, Transport and Maritime Affairs	New
		Establishment of plan for climate-friendly land use and its management system	Ministry of Land, Transport and Maritime Affairs, Ministry of Environment	New
		Improvement of the urban adaptation capability to counteract climate change	Ministry of Land, Transport and Maritime Affairs	New
		Implementation of the disaster prevention city to adapt to climate change	Ministry of Land, Transport and Maritime Affairs	New
Agriculture	Implementation of climate-friendly agriculture & livestock industry	Analysis & projection on the effect of climate change on crop productivity	Rural Development Administration	Implemented
		Development of species and new crops adapted to climate change	Rural Development Administration	Implemented
		Development of cultivation technology adapted to climate change	Rural Development Administration	Implemented
		Development of livestock improvement and management technologies adapted to climate change	Rural Development Administration	Implemented
		Development of the forage supply system adapted to climate change	Rural Development Administration	New
		Development of efficient water use in agriculture and technology to conserve water for agricultural use	Rural Development Administration	Implemented
		Providing plan to securely supply water for agricultural use to adapt for climate change	Ministry for Food, Agriculture, Forestry and Fisheries	New
	Damage prevention measures in agricultural & livestock industry	Analysis on the vulnerability caused climate change in the agriculture	Rural Development Administration	Implemented
		Development of the adaptation technology to reduce the damage caused by meteorological disaster in the agriculture	Rural Development Administration	New
		Expansion of the agricultural facility to prevent damage caused by storm and flood	Ministry for Food, Agriculture, Forestry and Fisheries	New
		Establishment of system to prevent the spread of pests caused by climate change	Rural Development Administration	Implemented
		Establishment of system to predict to the foreign pest occurrence	Ministry for Food, Agriculture, Forestry and Fisheries	New
		Providing plan to prevent the livestock diseases caused by the global warming	Ministry for Food, Agriculture, Forestry and Fisheries	New
Forestry	Maintenance & improvement of the function and recovery of forest	Management and protection on the forest bioresources vulnerable to climate change	Korea Forest Service	Implemented
		Management on the forest water resource adapted to climate change	Korea Forest Service	Implemented
	Improvement of forestry productivity	Evaluation on the influence and vulnerability of the forestry	Korea Forest Service	Implemented
		Maintenance and improvement of the forestry productivity adapted to climate change	Korea Forest Service	Implemented

Field	Measures	Specific Assignment	Branch	Current Status
Forestry	Forestry damage prevention	Evaluation on the vulnerability of forestry disasters by climate change	Korea Forest Service	Implemented
		Improvement of the disaster prevention and damage reduction system in forestry	Korea Forest Service	Implemented
		Establishment of system to forecast and prevent of forest pests	Korea Forest Service	Implemented
		Implemenation, evaluation and feedback of the adaption practice management to climate change in forest	Korea Forest Service	New
Ocean/ Fisheries	Adaptation to the rising of the and water surface	Analysis on the vulnerability of the coast by rising water surfaces	Ministry of Land, Transport and Maritime Affairs	Implemented
		Establishment of the scientific management system to counteract the changes of external forces in coast	Ministry of Land, Transport and Maritime Affairs	New
		Providing countermeasures to adapt to the change of coastal land by climate change	Ministry of Land, Transport and Maritime Affairs	New
	Improvement of the productivity in fisheries	Providing the management plan to control the change of fish species and fishery resources	Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
		Providing plan for securing future fishery resources	Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
		Enhanced management of the construction of observatory infrastructure and the management of the fish species in coast	Ministry for Food, Agriculture, Forestry and Fisheries	New
	Prevention of the damage in fisheries	Development of countermeasures against infectious disease in marine species	Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
		Implementation of the measure to reduce the impact of ocean acidification on fish species	Ministry for Food, Agriculture, Forestry and Fisheries, Ministry of Land, Transport and Maritime Affairs	Implemented
		Introduction of measures to reduce the damage on fisheries	Ministry for Food, Agriculture, Forestry and Fisheries	New
Water manage-ment	Analysis on impact & vulnerability	Improvement of the monitoring on water management affected by climate change	Ministry of Land, Transport and Maritime Affairs, Ministry of Environment	Implemented
		Analysis of the impact and vulnerability of water management affected by climate change	Ministry of Environment, Ministry of Land, Transport and Maritime Affairs	Implemented
	Countermeasures against flood & drought	Establishment of strong land infrastructure to counteract flood	Ministry of Land, Transport and Maritime Affairs	New
		Management of water demand by the efficient use of water	Ministry of Land, Transport and Maritime Affairs, Ministry of Environment	Implemented
		Plan for securing water resources	Ministry of Land, Transport and Maritime Affairs	Implemented
		Development of alternate technology and expansion of facilities for water resources	Ministry of Land, Transport and Maritime Affairs, Ministry of Environment	Implemented

Field	Measures	Specific Assignment	Branch	Current Status
Water management	Countermeasures against flood & drought	Plan for maximization of the adaptation ability of rivers on climate change	Ministry of Land, Transport and Maritime Affairs	New
		Advancement and overseas market expansion of water management to counteract climate change	Ministry of Land, Transport and Maritime Affairs, Ministry of Environment	New
	Measures on the management of water quality & water ecosystem	Measures on the management of the deteriorated quality of river and streams caused by climate change	Ministry of Environment, Ministry of Land, Transport and Maritime Affairs, Rural Development Administration	Implemented
		Maintenance and restoration of river water quality and water ecosystem to counteract climate change	Ministry of Environment	Implemented
Ecosystem	Monitoring & evaluation on impact and vulnerability	Monitoring on the vulnerable ecosystem and the indicator species affected by climate change	Ministry of Environment, Rural Development Administration, Korea Forest Service, Ministry of Land, Transport and Maritime Affairs, Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
		Analysis on the impact and vulnerability of ecosystem on climate change	Ministry of Environment, Rural Development Administration, Korea Forest Service, Ministry of Land, Transport and Maritime Affairs, Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
	Adaptation measures	Preservation and restoration of species, biodiversity and ecosystem	Ministry of Environment, Rural Development Administration, Korea Forest Service, Ministry of Land, Transport and Maritime Affairs, Ministry for Food, Agriculture, Forestry and Fisheries, Ministry of Health	Implemented
		Restoration of deteriorated ecosystem and extinct species	Ministry of Environment, Korea Forest Service	Implemented
		Establishment of the management system to prevent the damage caused by sudden appearance or massive occurrence of foreign species	Ministry of Environment, Ministry of Land, Transport and Maritime Affairs, Ministry for Food, Agriculture, Forestry and Fisheries	Implemented
		Establishment of governance to manage the ecosystem and enhancement of its publicity	Ministry of Environment, Rural Development Administration, Korea Forest Service, Ministry of Land, Transport and Maritime Affairs, Ministry for Food, Agriculture, Forestry and Fisheries	Implemented

Field	Measures	Specific Assignment	Branch	Current Status
Observation & projection on climate change	Observation of the climate change	Establishment of the observatory system to monitor climate change in three-dimensions	Korea Meteorological Administration, Ministry of Environment, Ministry of Education, Science and Technology, Ministry of Land, Transport and Maritime Affairs	Implemented
		Observation and data utilization to counteract the climate and weather in locality	Korea Meteorological Administration	New
	Climate change projection	Development of national climate change scenario for Korea	Korea Meteorological Administration	Implemented
		Production of information on regional climate and climate extreme	Korea Meteorological Administration	Implemented
	Development of the forecast model	Earth System Model development	Korea Meteorological Administration, Ministry of Environment, Ministry of Education, Science and Technology, Ministry of Land, Transport and Maritime Affairs	Implemented
		Regional Climate model development for Korea	Korea Meteorological Administration	Implemented
	Establishment of the system utilizing the climate information	Improvement of technology to pre-emptively alert citizens of extreme climate	Korea Meteorological Administration	Implemented
		Establishment and operation of the forecast modeling system that integrates the climate and atmospheric conditions	Ministry of Environment	Implemented
		Improvement of observation and alerting service on climate change	Meteorological Administration, Ministry of Environment	Implemented
		Establishment of the system utilizing the prediction technique on climate change for marine ecosystem	Ministry of Land	Implemented
Industry/ Energy	Analysis on the impact and vulnerability	Forecast of the impact of climate change on the industries and energy and analysis on the impact on vulnerability	Ministry of Knowledge Economy, Ministry of Environment	Implemented
	Climate change crisis management & utilization of the opportunity	Inducement of the establishment of adaptation measures in the industries	Ministry of Knowledge Economy, Ministry of Culture, Ministry of Environment	Implemented
		Discovering and supporting new potential projects on adaptation to climate change	Ministry of Knowledge Economy, Ministry of Environment, Ministry of Land, Transport and Maritime Affairs	Implemented
		Securing the energy supply to counteract climate change	Ministry of Knowledge Economy	Implemented
Education, publicity & international cooperation	Education and publicity	Education and publicity to improve the understanding of climate change	Ministry of Environment	Implemented
		Establishment of the infrastructure to improve the adaptation capability to counteract climate change	Related Branch	New/ Implemented
	International cooperation	Establishment of the international cooperation to adapt to climate change	Related Branch	Implemented

organized and run the *Korean Forum for Climate Change and Health*, which consists of government agencies and academic experts since 2008, and has reflected its work to human health policies. It has been making efforts to establish adaptation measures to reflect public opinion and civil society by providing its roster of experts to and communicating with municipal governments, to support municipal governments' adaptation measures.

The government of Korea since 2004 has enhanced medical support projects in order to monitor and respond to health impact from weather-related natural disaster. In 2010, disaster area health management program was developed, and it will be widely applied after the operation pilot project.

To monitor the impact of heat waves on health, the government of Korea launched a monitoring system in 2011, based on 470 emergency medical authorities. And, to reduce the damage caused by the heat waves and UV rays, the government of Korea is making efforts to expand the urban green area and, in 2011, is planning to invest more than KRW 11.4 billion for establishing the urban biotope and urban eco-forest. Also, the government of Korea is in process to provide countermeasures and policy revisions to institutionalize the urban environmental plan, which takes into account its vulnerability to heat waves. Since 2003, the government of Korea has also been proceeding with urban forest creation in government-owned land and plans to invest KRW 81 billion for the creation of urban forests, street trees, and school forests in 2011 in order to reduce the damage caused by UV rays and heat waves.

The government of Korea has been conducting research on climate-related health impact assessment. The government of Korea established an monitoring system for the infectious disease vector (Vector-Net, VibrioNet, EnterNet, PulseNet, etc.) and plans to enhance these systems more in the future. The comprehensive monitoring system of infectious disease vector will be managed by region (3 regions in 2011) and the number of regions will be expanded to 6 in 2012. In addition to operating the monitoring system, Korea is also conducting a study of infectious diseases and developing treatment and vaccine and an early diagnosis kit of infectious diseases.

The research on the impact of air pollution on human health caused by climate change has been conducted by collecting the monitoring data and analyzing the relationships between key factors. In 2011, surveys on the health impacts of air pollution as well as the health impact assessment of vulnerable social class will be conducted. Also, the alert system for fine dust operated, thus far, only around the capital city is expected to expand to five other metropolitan cities. The response system for yellow dust is in the progress of improvement as well.

In order to prevent and manage the allergic diseases exacerbated by climate change, the government of Korea has operated the Allergic Disease Standard Research Center since 2009 and many related research projects are in progress. Also KRW 3.95 billion will be allocated for the enhancement of education and publicity, and operation of information center.

For municipal governments to establish specific implementation plans for climate change

adaptations, consulting services are provided to support for technical skills needed. Likewise, education and training programs for civil servants are offered in order to improve the capability of municipal governments for climate change adaptation.

B. Disasters

Concerning the climate change adaptation measures in regard to disasters, the government of Korea has set goals to strengthen the disaster prevention infrastructure.

To achieve these goals, the government of Korea has established a vulnerability evaluation system through R&D and the framework for regional safety assessment. Also, in 2011 the government of Korea plans to conduct a disaster vulnerability analysis around the Nakdong River and assess the regional safety of 230 cities, counties, and districts. This will be extended to other regions and be conducted every year to improve the regional alerting effort to minimize the effect of disasters in each region.

Also, the government of Korea is actively revising disaster prevention standards, establishing flood defense standards, expanding pre-emptive disaster impact evaluation, and strengthening the integrated plan to reduce the damage from storms and floods (2011~2012).

Since 2006, insurance reform against storm and flood damages has been being implemented. In 2011, KRW 9 billion was invested to improve insurance policies. A project to improve and expand the insurance policy against storms and floods (insurance for small business owners, national reinsurance was introduced) has also been implemented as of 2006.

As the frequency of natural disasters increase due to climate change, the maintenance of disaster risk areas has become a major adaptation policy. From 1998 to 2010, about KRW 2.7 trillion was invested to improve 840 risk areas. In 2011, government funding of KRW 308.3 billion and local funding of KRW 205.5 billion have been made available to improve 72 risk areas. Also in order to reduce the flood damage in cities, the government of Korea will continue to invest in stormwater detention facilities (KRW 61.8 billion in 2011), and pursue the improvement and establishment of sewer system and stormwater pumping stations (KRW 2.824 trillion in 2011).

Improvements on an alert system for natural disasters is still in progress. In 2011, KRW 311 million was invested to build a disaster precursor monitoring system, improving the localized torrential downpours alert, and developing transmission technology based on IT. The adaptation manual categorized by major disasters will be developed and distributed throughout the nation. Promotion and education initiatives for the general public and for civil servants are also being planned.

The government of Korea has established a land policy that can adapt well to climate change and has been actively pursuing projects to create a disaster prevention city. Since 2011, the government of Korea has been establishing the methodology to assess the vulnerability of cities to climate change and has supplemented the guidelines for urban planning and urban management planning. These have been developed to be reflected in every step of urban

planning. The government of Korea is promoting a pilot project to improve urban adaptation capabilities to counteract climate change. It also plans to provide this model to different areas. Furthermore, Korea plans to establish land policies that take into account vulnerability of land to climate change impacts, by conducting land sensitivity analysis on climate exposure, vulnerability of areas, and infrastructure needs, etc. to adapt these areas to climate change effects and to enhance the safety of national infrastructure.

The government of Korea is preparing the standards for land usage and installation of national facilities by analyzing the weaknesses of the land's current and future vulnerabilities and taking into account the risk of disaster caused by climate change which is growing and intensifying. It will enable Korea to create comprehensive national adaptation measures for land usage and its development.

C. Agriculture

Regarding climate change adaptation measures in agriculture, the government of Korea has set goals to develop and disseminate climate change resistant cultivation and breeding technologies, develop climate change resistant livestock that improves livestock productivity, and modernize measures against meteorological disasters and pet and livestock diseases in order to minimize the impact from meteorological disasters.

In order to develop and disseminate new crops and cultivation technology of crops that can adapt to climate change, the government of Korea carried out advanced environmental impact assessments. Also, adaptability to high-temperature, disaster tolerance and pest-resistant breeds are under development and the research is in progress to introduce and naturalize tropical and subtropical crops. The government of Korea will also provide the map for changes in biotic seasons, the guide for optimum planting management, and crop production systems.

In order to develop a livestock management system for climate change adaptation, the government of Korea has been assessing fertility and physiological reactions of livestock due to temperature increases. Productivity research has also been conducted through the development of temperature regulated water facilities and ventilation technologies. In addition, the government of Korea plans to provide standardized guidelines to select livestock that are resistant to high temperatures and will continue to improve them.

For the stable supply of animal feed, the government of Korea plans to develop environmental adaptability in new kinds of forage and establish a seed production system. Furthermore, to deal with the increased activity of disease carriers due to the climate change, Korea plans to conduct a study on resistance and prevention of livestock disease.

For the efficient use and stable supply of agricultural water, which is easily affected by climate change, the government of Korea is developing the management skills required for high efficiency usage of water, such as the enhancement of IT based irrigation systems in cultivation facilities (2011~2012) and drought

forecasting techniques, the development of cultivation technology and water recycling technology to conserve water. There is also an ongoing project to enhance the facilities that re-examine the water-supply capacity of existing facilities.

The government of Korea is conducting vulnerability assessments to analyze the vulnerable areas in the agricultural and livestock industries according to disaster type. The nation also has plans to reset cultivation boundaries according to crop type, develop technologies to minimize the effect of meteorological disasters, and upgrade facilities in order to develop and implement adaptation measures for agricultural infrastructures.

To prevent breakout of pest caused by the climate change, the government of Korea plans to provide early pest outbreak prevention technology, weather charts for foreign pest occurrences, and web-based real-time foreign pest occurrence forecasts.

To build a long-term civilian and government joint R&D system to address climate change, the government of Korea plans to establish a comprehensive agriculture research system focused on climate change that is comprised of civilian and government agencies. Through a stable and structured system, the efficiency of research will be ensured.

In addition, the government of Korea plans to conduct campaigns to enhance the public capacity to handle climate change, thereby preventing various social problems such as sharp increases in the prices of agricultural and livestock products resulting from speculative transactions following meteorological disasters.

D. Forestry

Adaptation measures for forestry are focusing on the reduction of forest disasters, enhancement of forest health and recovery, and improvement of forestry productivity. To this end, several strategies for forestry have been established, such as conservation of forest ecosystems and biodiversity, the maintenance and enhancement of forest productivity, the prevention and response to forest disasters, and the promotion of forest functions to the public.

The government of Korea enhanced monitoring systems on long-term changes in forestry to conserve forest ecosystems and biodiversity. For in-situ conservation, it plans to expand forest genetic resource preservation areas for species vulnerable to climate change and to enhance their management. For ex situ conservation, it is planning to expand the national arboretum by vegetation and climate. In 2010, 112,000 ha were designated as forest genetic resource preservation areas and, starting in 2011, these areas are forecasted to increase by 10,000ha per year.

In securing water resources in the forest, a project to manage the forest near the 27 dam basins in Korea is being pursued. Consequently, the number of dams will be increased to 38, and 34,000 ha of land will have been afforested by 2011.

In order to forecast productivity of forest and assess its vulnerability and to establish adaptation measures, the government of Korea developed growth models for major tree species and forecasted changes in productivity for chestnuts and mushrooms. The government of

Korea also plans to improve soil quality to maintain their productivity and supply species that can adapt to climate change.

In 2010, after taking climatic factors into account, the government of Korea laid the foundation to create customized forest maps regarding ideal forestation period and suitable forestation areas. Starting in 2011, the forest maps were enhanced and their distribution was expanded. In addition, the provision of useful tree species from the southern temperature climate region, the warm temperature zone and subtropical region will be expanded to counteract climate change.

In 2010, the government of Korea developed the forest fire risk assessment and landslide forecast model. The government of Korea is planning to develop the forest disaster vulnerability rating model between 2011 and 2015, to forecast forest fire risk and landslide disaster risk and to create and distribute a risk map. Also, in order to enhance prevention and minimize damage of meteorological disasters, the number of available helicopter extinguishers and extinguishing teams will be increased, the accuracy of landslide risk rating will be improved, and debris barriers and coastal disaster prevention forests will be expanded. By 2010, the number of debris barriers was 4,279 and the area of coastal disaster prevention forest was 49ha. In 2011, about 735 additional debris barriers and 10 more ha of the coastal disaster prevention forest are planned. Starting in 2012, more than 500 debris barriers and more than 200 ha of the coastal disaster prevention forest are also expected to be established.

In addition, forecasting and prevention systems will be developed due to the increased possibility of the inflow and spreading of foreign and unexpected pests and disease.

E. Ocean and fisheries

The climate change adaptation measures for oceans and fisheries aim to counter rising sea levels and to secure stable fishery resources. The strategy to achieve these goals are as follows: establish a management system for changes in the coastline due to rising sea levels and provide adaptation measures, monitor and forecast changes to fisheries due to climate change, secure the future fishery resources, minimize the impact of contagious disease and acidity on marine life, and establish fishery disaster relief measures.

In order to build systems to manage and assess vulnerability in the coastal areas, a coastal submerging projection will be taken and a map of predicted coastal submerging areas will be published. In 2010, maps for 17 out of 141 areas of predicted coastline were made and this will be increased to 30 by 2011 and 30 by 2012. Also a coastal disaster vulnerability evaluation system customized for Korea and a customized adaptation portfolio categorized by coast, municipal governments, and projects will be established. The coastal management plan and the marine environment impact evaluation is planned to be revised and supplemented so that it will take into account the impact of climate change. Also, precise observation and assessment on external forces in the coasts will be performed and a new concept for restoring and organizing pilot projects suitable for climate

change will be pursued. In addition, costal terrain changes due to climate change will have predictive measures and a management strategy as costal topography will be prepared.

The government of Korea plans to develop the monitoring and predictive technology and model for changes in fishery resources in the coast and tidal flats and to develop a fishery predictive system. Based on these, the government of Korea will assess the strategies on coastal management measures and introduce environmental impact assessments. Also, by improving forecasting capabilities, the migratory path of the main commercial fish species and the changes in their population will be quantitatively forecasted and re-calculated for future cultivation areas. In order to secure future fishery resources, the government of Korea is planning to develop an optimum aquaculture technology for new fish breeds and the best fishing technologies for breeds of fish that are permanently migrating to the coasts of Korea. It will also develop technology for ocean forests and ranches, technology for artificial grounds for fish breeding, technology for the production of artificial seedlings, and technology for open sea cultivation.

In order to minimize damages from contagious diseases, the government of Korea plans to develop methodologies to monitor coastal waters and diagnose disease outbreaks, diagnose new pathogens, and to develop vaccines against contagious disease for farmed fishes. Additionally, to cope with acidification of the oceans, prediction and damage assessment countermeasures will be established and there will be proper training for the fishing communities.

The government of Korea is also planning to develop the technology to alleviate the damages from hazardous organisms (jellyfish, etc.), to reduce disasters in fisheries, to heighten safety for fishery facilities in the event of natural disasters and develop sanitation management skills for fishing techniques and new fisheries, in order to reduce disasters in fisheries which are sensitive to climate change.

F. Water management

The adaptation measures in water management against flood and drought focus on building a safe water management system. The government of Korea has established restoration and conservation measures for river ecosystems, enhanced water quality, secured water resource alternatives, built its capacity to cope with floods through the *Four Rivers Restoration*, and built and improved its infrastructure and facilities to mitigate its vulnerability in water management.

For vulnerability assessment in the water management, the infrastructure for a monitoring and IT system will be built. And its effects and vulnerability regarding floodgates by basin will be assessed and mapped (flood, drought, and other risks). To build a strong land infrastructure to counteract flood, an alert system has been built which will strengthen the facilities that better control flood. To secure water resources, the existing dams have been re-examined in terms of their water supply capacity (2009~2011) and by 2014 five mid-size dams will continue to be constructed for flood control

and water security.

Projects on ground water resource management and water supply facilities in case of drought have been pursued. The government of Korea is continuing its research on rainfall management in urban areas and seawater desalination. The research will continue even after 2011 in order to advance and apply these technologies in practical ways. Also, projects that provide drinking water and develop drinking water resources for rural areas and islands are being conducted. As a part of the adaptation measure for climate change, the government of Korea will continue to develop and supply water-saving equipment and facilities. It will also strengthen its water demand management through water-saving promotions and education.

The *Master Plan for the 4 Major River Restoration* was able to secure the irrigation and water control capabilities of the rivers through the construction of banks, dredge and reservoirs since its implementation. It has restructured the river management system by creating an eco-friendly area as well as developing a real-time river management system. After the completion of key facilities in 2011, branch rivers from the 4 rivers will be repaired, regulations will be revised, and river monitoring will continue.

To strengthen the management of river and lake water environments (water quality and ecology of water) against the effects of climate change, the government of Korea is strengthening its pre-emptive management of non-point pollution sources. Also, it plans to strengthen the management of pollution sources around river basins such as waterborne pathogenic microorganisms, micropollutants, and sedimentary materials. Plans are also being made to restore the quality of river water, ensure ecologically sustainable river maintenance flow, and develop water circulation systems.

G. Ecosystem

Adaptation measures in the ecosystem are focusing on providing biological diversity through preservation and restoration of the ecosystem of Korea. Strategies to achieve this are: improvement of monitoring on the ecosystem and indicator species, analysis on ecosystem vulnerability, preservation and restoration of species and genetic resources, projects linking Korea's ecosystem, and damage prevention and management to prevent the outbreak of emigration species.

To strengthen climate change monitoring of ecosystems, a total of 19 Long Term Ecological Research Centers were selected and these Centers aim to improve the monitoring of changes to the terrestrial, fresh water, coastal and animal ecosystems. The number of indicator species monitored will increase from the current level of 100 to 130 species. In addition, there will be vulnerability assessments for regional effects of climate change by building a database of surveys and the monitoring of outstanding ecological areas, wetlands, desert islands, and other areas.

In order to secure the ecological connection and restore the diversity of species, the government of Korea is pursuing measures to

protect and restore species that are vulnerable to climate change. It is developing regional genetic resource banks and information networks, and expanding the area of protected ecosystems. It is also pursuing an ecological connection project of three major ecological networks (the Baekdudaegan mountains, the Civilian Control Line, and the costal forest) in Korea through the restoration of damaged areas and installation of ecological corridors. It is planned to repair the damaged habitats of major wild plants and strengthen the management of ecological corridors of wild animals.

In order to develop measures to prevent and manage exotic and unexpected biological outbreaks, the government of Korea plans to monitor the changes to and spreading of exotic species as well as analyze the ecological environment of areas with an outbreak of unexpected organisms. The government of Korea is also planning to develop an early warning and prevention system for unexpected organisms. Furthermore, in 2011, the government of Korea established measures including a pilot project to observe a *biological diversity network*, and produced and promoted adaptation guidelines on vulnerability. Moreover, the government of Korea plans to operate an intergovernmental council for efficient ecological management in order to build governance and better implement ecological management.

Chapter 6

Financial Assistance and Technology Transfer

Chapter 6 Financial Assistance and Technology Transfer

The Republic of Korea is a leading country in green growth among Non-Annex I countries actively making efforts to combat climate change. Through the *East Asia Climate Partnership (EACP)*, the nation supports the improvement of adaptation measures in Asia. The Korea International Cooperation Agency (KOICA) is providing financial assistance and technology transfer for other countries in the form of bilateral and multilateral Assistance. Korea also founded the *Global Green Growth Institute (GGGI)* to offer solutions for green growth to Non-Annex I countries and to encourage global development cooperation.

1. Financial assistance

A. East Asia Climate Partnership

In July 2008, Korea proposed the EACP at the G8 meeting in Tōyako, Japan in order to encourage cooperation among Asian countries in tackling the climate change issue. As a result, from 2008 to 2012, Korea has committed USD 200 million to finance related projects, training, and forums. EACP is dedicated to bringing 31 countries together for collaborative efforts among not only East Asia but also Central Asia, South Asia, Southeast Asia, and the Pacific Islands.

In 2008, the Korea Energy Management Corporation (KEMCO), an implementing agency of EACP, gave KRW 20 billion in financing to 17 projects in seven different countries and four international organizations. The projects are aimed to reduce GHG emissions through technological means. Since 2009, KOICA has been carrying out EACP programs. Through this partnership, KOICA has selected five different sectors to support (water, low-carbon city, low-carbon energy, forest, and waste) by analyzing the green growth demands of Non-Annex I countries in Asia and comparative advantages in Korea. Because water related issues require significant recognition and support in the Asian region, EACP has emphasized flooding, drought, and water sanitation issues.

Between 2009 and 2011, Korea conducted 20 projects in 10 different countries (Table 6-1) and also a total of nine projects for various international organizations (Table 6-2): Asian Development Bank (ADB), United Nations Economic and Social Commission for Asian and the Pacific (UNESCAP), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), World Health Organization (WHO), World Bank (International Finance Corporation), and International Maritime Organization (IMO). The major EACP projects are the Landmark Water Projects (LWP), which include water-related projects for Water Resource Development in, Azerbaijan (2010~2015, USD 26.2 million); Improvement of Water Resource Management and Water Supply System in the Yarmag District of Ulaanbaatar, Mongolia (2010~2013, USD 22.6 million); and Construction of Small-scale Reservoirs for Agricultural Water Supply and Flood Prevention in the Philippines (2010~2014, USD 21.8 million).

<Table 6-1> Current status of EACP bilateral projects since 2009

(unit: USD ten thousand)

Country	Project Name	Period	Amount Aided
Vietnam	Expansion and improvement of water supply system in Buon Ho Town	2009~2012	450
Vietnam	Feasibility study on the establishment of the Bus Rapid Transit (BRT) System in Ho Chi Minh City	2009~2011	200
Indonesia	Demonstration project for constructing fuel cell power plant for the local water supply system in Ancol, Jakarta	2009~2011	300
Mongolia	Establishment of heating and hot tap water supply station in Baruun-Urt Town	2009~2011	500
Cambodia	Construction of hybrid power system facilities with PV	2009~2011	220
Sri Lanka	Construction of 500kW grid-connected PV power plant	2009~2010	300
Bangladesh	Establishment of solar powered irrigation pump and solar home systems	2009~2011	250
The Pacific Islands	Renewable energy development project	2009~2012	200
Tajikistan	Feasibility study and demonstration of flow-type hydroelectric power plant	2009~2011	280
Indonesia	Korea-Indonesia forest biomass development model	2009~2011	400
Mongolia	Afforestation and water resource development using solar power system in Byannuur	2009~2011	150
Vietnam	Establishment of the electronic manifest system for the integrated management of hazardous waste	2009-2011	250
Mongolia	Construction project for municipal waste-recycling facility in Ulaanbaatar	2009~2011	350
Indonesia	Production of bio-energy through the reuse of palm oil and other waste	2009~2010	250
Azerbaijan	[LWP] Water Resource Development in Absheron	2010~2015	2,618
Mongolia	[LWP] Improvement of water resource management and water supply system in Yarmag district in Ulaanbaatar	2010~2013	2,260
The Philippines	[LWP] Construction of small-scale reservoir for agricultural water supply and flood prevention	2010~2014	2,176
Mongolia	Construction of survey and data report on mine damage	2010~2013	300
Sri Lanka	Development of COMS (Communication, Ocean, Meteorological Satellite) data reception and analysis system	2010~2012	200
The Philippines	Development of wood pallet production and sustainable commercial forestation	2010~2012	340

LWP = Landmark Water Projects
Source: eacp.koica.go.kr (EACP official website)

<Table 6-2> Current status of EACP multilateral projects since 2009

(unit: USD ten thousand)

Organization	Project Name	Period	Amount Aided
ADB	Economics of climate change and low carbon growth strategies in Northeast Asia	2009~2011	180
UNESCAP	Development of the Low Carbon, Green Growth roadmap for East Asia	2009~2010	120
UNEP	Water management and resource efficiency for green growth in East Asia	2009~2010	150
UNIDO	Transfer of environmentally sound technologies in Cambodia	2011~2013	90
WHO	Strengthening control of vector-borne diseases to lessen the impact of climate change in the Western Pacific region	2010~2011	120
World Bank	Low-carbon/Green Special Economic Zone (SEZ) development	2011~2012	50
UNEP	Capacity development for a policy framework of low-carbon societies in Central Asia	2011~2013	84
IMO	Capacity building to address GHG emissions from ships in East Asian countries	2011~2013	70
UNESCAP	Application of community-based integrated water supply and wastewater treatment systems	2011~2012	63

Source: eacp.koica.go.kr (EACP official website)

B. Global Green Growth Institute

In 2009, during the 15th UNFCCC Conference of the Parties (COP15) held in Copenhagen, Korea announced a plan to found the GGGI. Officially launched in June 2010, GGGI is an independent non-profit organization dedicated to pioneering and distributing a new model of economic growth, called *green growth*. While the GGGI headquarter is located in Seoul, Korea, the organization is aiming to become an international organization with many regional branches around the world.

GGGI, founded on the belief that economic growth and environmental sustainability should be pursued simultaneously, supports program development and implementation, capacity building, sharing benchmark practices, and giving assistance to other partner organizations. In particular, GGGI is trying to theorize a green growth concept to enhance bi- and multi-lateral cooperation, country-specific projects, and to build an international network related to climate change. Also, GGGI is actively disseminating the value of green growth as a new paradigm that will simultaneously accomplish sustainable growth and greenhouse gas reduction through the development of green technology and the new & renewable energy. In addition, GGGI is promoting R&D projects for developing countries regarding macroeconomics, industrial structure and productivity, labor supply and employment, building a human resource database, and economic development models.

Since its establishment, GGGI has carefully assessed the status of many developing countries and launched country-customized projects in Brazil, Ethiopia, and Indonesia. New country programs will expand to Middle Asia and Africa.

Through the agreement of Memorandum of Understanding, GGGI has partnered with other developed countries, developing countries, international organizations, and research institutions, with an effort to create an international cooperation network and establish GGGI as an international organization.

In 2011, GGGI opened the first regional office in Copenhagen, Denmark and a second regional office in Abu Dhabi's Masdar City, UAE.

GGGI is also expanding partnerships to the corporate private sector. GGGI signed an agreement with the Denmark-based Danfoss Group which is a global producer of components and solutions for refrigeration, air conditioning, heating and water, and motion controls.

C. Bilateral assistance

1) Korea international cooperation agency

Korea’s Official Development Assistance (ODA) is classified into bilateral or multilateral assistance grants or softs loans depending on capital repayment. The cooperative development grant programs operated exclusively by KOICA include the following types of assistance: project-type cooperation, feasibility study, invitation of trainees, dispatch of experts, and support for Non-Profit Organizations (NPOs). Recently, the focus of KOICA’s cooperative development programs has been on promoting sustainable development and on strengthening

partnerships with developing countries. Other emerging focuses of cooperative development include global challenges such as environmental issues, poverty eradication, gender equality, and overpopulation.

Table 6-3 specifies KOICA's financial contributions to developing countries for environmental and climate change projects, feasibility studies, and invitations to trainees. KOICA's financial contribution to addressing the environmental and climate change issues can be largely classified into the following sectors: environment, health, rural development, industry and energy, and disaster management. The focus of each sector is as follows: environment sector - on forest management and environmental improvements in water, air, and soil quality; health sector - on raising the quality of drinking water and sewage systems; rural development sector - on improving capacity to respond to climate change in agriculture; industry and energy sector - on improving electricity distribution, water resource management, and new & renewable energy projects such as construction of small hydroelectric power plants; and disaster management - on developing early warning systems and climate forecast systems.

In the past, programs for environment and climate change problems were only limited to human resource development. However, since 2000, an increase in the number of related projects has led to a significant increase in the scale of contribution. Especially since the mid-2000s, KOICA has been providing larger-scaled assistance to developing countries by means of constructing small hydroelectric power plants and water/sewage systems.

(A) Projects and feasibility study

The grant aid program in KOICA is roughly divided into the following types of assistance: project-type cooperation, feasibility studies, human resource training sessions, dispatch of experts and volunteers, and grant supply. Project-type cooperation has been consistently providing assistance to developing countries, such as providing buildings and equipment for achieving specific developmental goals in the areas of education, public health, IT, environment, and the like. Project-type

<Table 6-3> KOICA financial contribution to environment and climate change

(unit: USD one thousand)

Classification	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Environment	406	743	2,073	2,170	2,855	2,886	3,172	4,434	10,429	9,801
Health	60	53	71	584	1,062	6,546	2,971	6,170	4,237	3,639
Rural development	2	56	586	595	850	335	833	1,878	3,874	4,974
Industry & energy	569	449	698	934	4,092	1,565	2,333	15,979	6,941	6,299
Disaster management	67	69	106	83	136	135	1,734	1,795	337	221
Other							95	73	946	1,278
Total	1,104	1,370	3,534	4,366	8,995	11,467	11,138	30,329	26,764	26,212

Source: stat.koica.go.kr

cooperation has also aided in personnel cooperation by dispatching experts and holding personnel training sessions. Project-type cooperation provides a comprehensive method for systematically covering the process of research, planning, implementation, and review and assessment in a project's development. Feasibility study is used to support such project-type cooperation by providing a comprehensive ex ante study and executive plan, offering both technology and research service. More than 40 percent of the entire project budget is contributed to the project-type cooperation and less than 3 percent is contributed to the feasibility study.

The collaborative programs for climate change are being conducted in various fields such as environmental reformation, forestry, energy, water, agriculture, and disaster prevention. Project-type cooperation from the late 1990s to early 2000s for environment and climate change was focused on the forestry sector in forestation and reforestation projects. Through the mid-2000s, as many water-related projects became the center of attention, the scope of projects enlarged to include other kinds of environmental reformation projects. Since the late 2000s, with the implementation of EACP, support for new & renewable energy projects has significantly increased. Most feasibility studies have been about water and electric distribution with a focus on the development of hydroelectric plants, dam construction, water supply systems, and drinking water. From 2000 to 2009, about 125 million USD in funding was contributed to such feasibility studies. Also during those years, the scope of annual environmental projects steadily increased along with an increase in the total amount of contributions. In 2009, 9 percent, or USD 24 million, of the total amount of contributions has been solely dedicated to environmental projects. Within the environmental projects, environment, forestry, energy, and water are the largest sub-sectors.

① Environment sector

The establishment of the *Industrial Pollution Prevention Supporting Project in Vietnam in 2003*, was the start of steady financial aid, and in particular, starting in 2007 a rapid increase took place. The pollution monitoring and purification, waste treatment, environmental capacity building and other varieties of projects have been conducted according to the demand in developing countries such as China, Mongolia, Vietnam, Indonesia, and Uzbekistan in Asia as well as Egypt and Tunisia in North Africa.

② Forestry sector

From the start of the forestation project of China in 2000, the support for forestry projects has tremendously increased. In the early 2000s, the majority of forestry projects in China and Myanmar focused on forestation and desertification prevention. As the forestry improvement and management projects in Indonesia increased after the mid-2000s, Indonesia became the major target country for forestry projects.

③ Energy sector

Until early 2000, support of energy sector

projects had been limited only to the feasibility study and final design of hydroelectric power plants and electricity distribution projects. However, in the mid-2000s, the construction of hydroelectric power plants in Afghanistan and Iraq helped to ignite the scale of this sector. Since the late 2000s, large projects such as providing heat and hot tap water in Mongolia and Uzbekistan have been conducted. In addition, as part of EACP, KOICA supported the new & renewable energy projects such as photovoltaic, bio, and small hydro power, increasing the scale of the supporting projects in the energy sector.

④ Water sector

The early supporting project in the water sector concentrated on the development of drinking water. The majority of these efforts were conducted in the Sub-Saharan desert, where water supply and sanity were inadequate.

However coming into the mid-2000s, the project diversified with increased financing into areas such as modernization of water sewage, installation of drainage facilities, and flood control systems. KOICA projects in the water sector stepped ahead in scale and method by promoting large-scale water landmark projects. Water landmark projects have been promoted in Azerbaijan, Mongolia and the Philippines since 2010.

(B) Invitation of trainees for personnel training

Korea's nationally sponsored training programs seek to transfer the experiences and technology that Korea has acquired during the course of its economic and social development to the developing countries that have yet to make the connection between human resources and economic-social development. Human resource development is an important factor in bridging the knowledge gap that exists between developed and developing countries. From 1991 until 2009, KOICA has invited a total of 35,755 public officials, researchers, technicians, teachers, and others from 168 different countries in order to share Korea's development experiences. By disseminating experiences of development in the seven fields of Korea's comparative advantage (i.e. administrative system, rural development, telecommunications, and industry and energy), Korea hopes to increase the adaptive capacity of developing countries and also hopes to strengthen the partnership with those countries in dealing with global issues. The number of training courses for environment and climate change has increased in all fields, especially in the environmental sector.

① Energy saving, energy efficiency, and eco-friendly energy development program

Since 1995, KOICA has been inviting energy policy representatives from developing countries like China, Vietnam, Nepal and Kazakhstan to introduce Korea's energy-saving policies and programs and to provide a tour of the energy industry through KEMCO (Table 6-4). Using Korea's system as a model, this project was conducted to assist developing countries in reducing GHG emissions by helping them establish a system for energy-saving and eco-friendly energy policies. Through this project, Korea intends to lay groundwork for

<Table 6-4> Overview of the training program for professionals in energy-saving, energy efficiency, and eco-friendly energy development

Type	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Countries	11	9	10	9	14	14	14	11	10	10	14	7	12	15	11	54
Trainee	21	18	18	17	20	19	19	31	11	14	18	13	14	18	13	264

Source: stat.koica.go.kr(KOICA Statistics)

<Table 6-5> Overview of the training program for professionals in forest administration and desertification prevention

Type	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Countries	13	11	8	11	12	11	21	17	12	15	12	15	1	2	46
Trainee	13	19	15	19	17	27	32	31	17	25	16	17	15	19	282

Source: stat.koica.go.kr(KOICA Statistics)

future international cooperation regarding energy. Since 1995, a three-week training program for experts has been held annually and from 1995 until 2009, a total of 264 energy-policy makers from 54 countries were involved in the training program.

From 1995 until 2005, the on-the-job training of *energy-saving and efficiency programs* dealt with Korea's energy-saving policies, climate change strategies and energy-saving related technology. The industry tour by KEMCO includes visiting Korea's energy supply systems in the related industries, cogeneration plants, gas receiving terminals, and so forth. From 2006, through the *capacity building cultivation of experts on Asian environment-friendly energy development program*, Korea has contributed to the establishment of systematic energy policies and technology development for developing countries in areas of energy-saving, energy efficiency, new & renewable energy, and climate change plans. Although Korea is not subject to the obligation prescribed in UNFCCC Article 4.5, Korea will continue to promote this program as a tool for transferring technology to developing countries to help them combat climate change.

② Forest Administration and Desertification Prevention Program

Since 1996, KOICA has been conducting training programs on forest administration for personnel from developing countries such as Indonesia, Malaysia, Peru, and Ethiopia. Based on accumulated experience on forest management, Korea helped enrich the knowledge of foreign personnel by introducing the latest information on forest management. Through this program, experiences and technology regarding forestation, forest recreation, urban forest management, and forest preservation are being shared.

Moreover, since 2001, KOICA has been inviting relevant officials from developing Asian countries that have seriously suffered from desertification like China, Mongolia, Uzbekistan, and Pakistan. KOICA's goal is to provide training based on Korea's experience with forestation projects on desertification prevention.

In particular, beginning in 2004, 15 to 20 Indonesian forestry administration personnel have participated in an annual program to be trained to combat their forest-related major issues regarding restoration of desolated land, management of tree nurseries, and restoration of mangrove woods. In the above two projects, a total of 282 forestry administration personnel from 46 countries were trained between 1996 and 2009 and the size of this program is expected to grow.

2) Economic development cooperation fund

The Economic Development Cooperation Fund (EDCF) was established in 1987 with the purpose of promoting economic cooperation with developing countries by providing aid for their industrial development and economic stability. Through this fund, Korea supports developing countries for projects in the environment related industry, health, sanitation, engineering, electricity and telecommunications networks, and infrastructures.

(A) Asian Development Bank Future Carbon Fund

The ADB Future Carbon Fund, established in July 2008, is ADB's second carbon fund to support projects for energy efficiency, new and renewable energy, and greenhouse gas reduction in developing countries. The Korean, Swedish, Finnish, and Belgian governments along with private enterprises like POSCO and Eneco are participating as major financiers. So far, these financiers have provided a total of USD 115 million. Korea itself made a commitment to contribute a total of USD 20 million through EDCF. Since 2010, Korea has annually contributed USD 5 million to this fund. Through the ADB Future Carbon Fund, Korea also hopes to actively support developing countries in the Asia-Pacific area to help build their resilience to climate change impacts. The support for the ADB Future Carbon Fund will contribute the development of the domestic carbon market by acquiring advanced carbon-related financing techniques.

(B) Photovoltaic power plant construction in Mozambique

Based on Korea's construction and operational experience of photovoltaic power plants, Korea has been providing financial assistance in construction of stand-alone photovoltaic power plants in areas of northern Niassa, Mozambique like Mavago, Mecula, and Muembe where electric power shortages have been occurring.

Mozambique stretches for more than 2,000 km from north to south, so it is difficult to establish a nationwide electric supply. Mozambique may be able to supply electricity to different regions by establishing photovoltaic power plants without the use of long-distance electricity transmitters.

The resulting cooperation may improve the quality of life and economic activities of those who were lacking electricity. This project is a large-scale project operating based on a loan system of USD 35 million. The loan was made with no interest over a 5-year unredeemed term and a 40-year redemption period. This project establishes three 400-500kW size photovoltaic power plants and control systems in the northern rural region of Mozambique. The plan also

includes the 2km long electric supplier between the power generator and receiver and is expected to supply 60 percent of entire electricity demand. Also a 1-year guarantee, service, education, training, and consulting service are provided.

(C) Mekong integrated management project, Laos

Frequent flooding is a serious problem in Vientiane, Laos which is a city located along the Mekong River. This EDCF project was undertaken to prevent large losses of life and property caused by flooding. EDCF had built a dike along the Mekong River and created parks that not only prevent loss of land, but also secure the lives of local residents and provide a recreation area. During the monsoon seasons, heavy downpours of rain caused by an abnormal climate have been hindering this project in 2008 and 2009. However, the first phase of this project has been completed and so far more than 50 percent of this project is near completion. After the completion of this project, Vientiane will be equipped to adapt to climate change. This project started after the feasibility study provided by KOICA and was supported by the EDCF loan system of USD 37.2 million to provide the construction and improvement of dikes, establishment of riverside roads, and construction of riverside parks.

(D) Tian Tan water service project, Vietnam

Vietnam Tian Tan water service supplies water over 100,000 ton per day after purifying the water secured from Dong Nai river.

This project is a major success story of aid assistance from the Export-Import bank since diplomatic relations with Vietnam were established in 1993. Tien Tan water service office handles over 75 percent of the total capacity since its completion in June 2004.

(E) Korea Africa Economic Cooperation

In 2006, Korea Africa Economic Cooperation (KOAFEC) was founded by the government of Korea and African Development Bank (AfDB). Korea and AfDB biennially host ministerial-level dialogues together. KOAFEC seeks and promotes economic cooperation projects in four major areas as USD 5 million trust fund was established at the AfDB at the end of 2007. During the third ministerial-dialogue in September 2010, *Masterplan for water management projects* and *Korea-Africa Joint Forum for adaptations* have been selected as the major action plans for the green growth cooperation.

D. Multilateral assistance

Korea has been providing funds, technology, and human resources to several international organizations and intergovernmental panels on climate change such as: the Global Environment Facility (GEF), United Nations Environment Programme (UNEP), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), and International Tropical Timber Organization (ITTO) (Table 6-6). After joining the GEF in 1994, the Korean government has donated USD 5.5 million per annum for each

<Table 6-6> Support to international organizations on climate change

(unit: USD one thousand)

Supporting Ministries	Name of Contribution	2005	2006	2007	2008	2009	2010
Environment	Biodiversity International	-	-	-	200	260	-
Forest Service	Center for International Forestry Research (CIFOR)	150	-	150	150	150	150
Environment	Global Environment Facility (GEF)	770	1,130	1,300	1,600	1,600	1,666
Foreign Affairs and Trade, Land, Transport, and Maritime Affairs	UN Human Settlements Programme (HABITAT)	10	-	30	30	100	100
Environment	Intergovernmental Panel on Climate Change (IPCC)	-	30	30	-	-	-
Forest Service	International Tropical Timber Organization (ITTO)	-	240	280	260	280	258
Environment	International Union for Conservation of Nature (IUCN)	50	25	-	-	-	281
Foreign Affairs and Trade	Montreal Protocol	40	100	80	80	90	93
Foreign Affairs and Trade, Forest Service	United Nations Convention to Combat Desertification (UNCCD)	140	230	180	190	250	221
Foreign Affairs and Trade, Environment	United Nations Framework Convention on Climate Change (UNFCCC)	290	270	460	950	723	282
Foreign Affairs and Trade, Environment	United Nations Environment Programme (UNEP)	590	370	880	520	250	591
Korea Meteorological Administration	World Meteorological Organization (WMO)	10	50	50	40	50	45

*: Development Assistance Committee (DAC) of the OECD covers the Official Development Assistance (ODA), which is 4 percent share of the payment

Source: Export Import Bank of Korea "ODA Statistics Views"

replenishment period. July 1994 to June 1997, the 2nd period was from July 1998 to June 2002, the 3rd period was from July 2002 to June 2006, and the 4th period was from July 2006 to June 2010. Since April 2011, Korea has been participating in the Transitional Committee for the design of the Green Climate Fund established by the UNFCCC COP 16 decision. In October 2011, the tenth session of the Conference of the Parties to the UNCCD took place in Changwon, Korea.

The major accomplishments of the Conference of the Parties include the 10-year strategic plan (2008~2018) for solving *desertification, land degradation, and drought* (DLDD) problems, establishing assessment indicators, handling financing problems, and etc. Changwon Initiative, as adopted by the COP, will serve as a framework to set the criteria and function as an implementation system for solving DLDD problems. Over the next two years, Korea will perform its role as the chair country and assume a leading role in solving DLDD problems.

2. Technology transfer

A. Bilateral cooperation

Korea has been promoting various collaborative efforts in sharing energy technology with the countries of the Association

of Southeast Asian Nations (ASEAN) and East Asia. The focuses of these collaborative efforts are on the technologies for new & renewable energy, energy efficiency improvement, and clean fossil fuels. In addition, in order to develop and distribute technology for eco-friendly and sustainable agriculture, Korea has agreed to conduct collaborative pilot projects with the countries in Asia, Africa, and Latin America.

1) Korea-Mongolia technology cooperation

Since the early 2000s, Korea has been promoting cooperation with the neighboring developing nation of Mongolia in various energy technology fields such as new & renewable energy and clean fossil fuels. In December 2002, Korea's *Ministry of Commerce, Industry and Energy* and Mongolia's *Ministry of Infrastructure* pursued bilateral cooperation by agreeing to install an eight kW photovoltaic-wind hybrid electric system in Mongolia. The demonstration project was successfully completed in two years from June 2003 to May 2005 in Naran, an area near the Gobi Desert. In June 2007, Korea's *Ministry of Knowledge and Economy* and Mongolia's *Department of Fuel Energy* agreed to promote a demonstration project to establish system for *prevention of desertification in Mongolia using new & renewable Energy*. The goal of this project was to demonstrate desertification prevention by constructing a PV-wind hybrid electrical system for groundwater pumping that would be used for farm and forest irrigation. The PV-wind hybrid electrical system was constructed in the Province of Nalaikh, 50 kilometers east of Ulaanbaatar.

The total size of the construction reaches 110 kilowatts (80kW for PV and 30kW for wind), and the groundwater pumping system hoists 75 tons of water per day for forest and farm irrigation.

Additionally, in order to prevent air pollution caused by low-grade coal which is the main source of energy in Ulaanbaatar, the Korean and Mongolian governments have been discussing technology cooperation for clean coal since 2009. Both governments also conducted a feasibility study through Korea's Institute of Energy Technology. In order to further these technology cooperation projects, Korea and Mongolia signed a MOU on *Cooperation in Clean Coal Technology and Resource Development* in March 2011.

Furthermore, as a part of *Masterplan for development of water and sewage in Ulaanbaatar*, the government of Korea promoted a pilot project that install and operate wastewater recycling equipment on a pilot scale in order to test the local applicability. Reuse of wastewater involves reuse of highly treated effluence as industrial water. Using this system, it is expected that Mongolia will be able to prepare for an increase in demands for water in a long-term while saving water.

2) Korea-China technology cooperation

For technology cooperation with China, the Korean Ministry of Energy and Resources and Chinese National Science and Technology Council signed the "Korea-China Memorandum of Cooperation for New & Renewable Energy" in November 1992.

In August 2004, the fifth working committee was held in Kunming, China. The committee discussed promoting joint projects in photovoltaic power, wind power, solar energy usage, and bio-energy power. In December 2004, the Ministry of Commerce, Industry and Energy collaborated with China's Ministry of Science and Technology to initiate 100kW Photovoltaic Power Plant Demonstration Project in Tibet, China. This project was launched in December 2004 and was successfully completed in December 2007. In this project, Korea demonstrated the reliability of its products as the major equipment manufactured in the country, such as PV cells and inverters, were able to withstand the extreme conditions of Tibet. For the same project, China was responsible for producing PV modules, as well as constructing, operating, and monitoring the power plant.

During the sixth working committee held in Jeju in June 2005, Korea and China agreed to collaborate in two joint projects - *Study of 1MW Concentrated Solar Power Plant Development and Demonstration* (ending in 2011), and *Korea-China Joint Research for Production of Biodiesel Module in China* (ended in 2010).

As of December 2003, Korean Ministry of Environment and Ministry of Environment Protection of China reached an agreement on environmental technology cooperation between the two countries and started promoting a joint research project for environmental technology since 2004.

The government of Korea committed about KRW 20 billion to support this joint research project for 64 cases in eight different areas including air, water, and sewage treatments, waste recycling, restoration of soil and groundwater, and etc. As a result, the amount of money paid off for the local outcomes is about KRW 100 billion.

3) Korea-Malaysia technology cooperation

To celebrate the 50th anniversary of bilateral diplomatic relations in the year 2010, Korea and Malaysia started sharing green energy technology such as bio-fuel and electric automobiles. In September 2010, Korea's Ministry of Knowledge & Economy and Malaysia's Ministry of Energy, Green Technology and Water signed a *MOU on Green Energy Technology Partnership*. Since then, both countries have held two working group meetings, including private sectors, and have discussed specific measures for technology cooperation.

4) Korea-Ghana technology cooperation

The government of Korea is promoting a collaborative partnership with Ghana to be able to provide a small-village type waterworks facility that includes purification system to African countries with water shortage. Through this project, Korea and Ghana together are pursuing practical cooperation to accomplish sustainable supply of safe drinking water as defined by UN Millenium Development Goals (MDGs). As safe drinking water facilities get installed in underserved communities, Korea is supporting the people in Africa for climate change adaptation.

5) International technology development project for agriculture

With soaring grain prices, reducing

agricultural land, and bio-energy production, and energy price increase, global food prices are ever increasing and in consequence is causing the food market to be unstable. Because of this phenomenon, many developing countries have requested Korea to share its agricultural technology. As a result, Korea has established Korea Project on International Agriculture (KOPIA) centers in ten different countries in Asia, Africa, and South America, in order to help these countries develop their own customized technology and resources. By 2010, KOPIA centers have been established in the following ten places: Vietnam Academy of Agricultural Science (VAAS), Myanmar Department of Agricultural Research (DAR), Cambodian Agricultural Research Development Institute (CARDI), Philippine Rice Research Institute (PhiliRice), Uzbek Scientific-Production Center of Agriculture (UzSPCA), Kenya Agricultural Research Institute (KARI), University of Kinshasa (UNIKIN) in DP Congo, National Institute of Agricultural Research of Algeria (INRAA), Paraguay Institute of Agricultural Technology (IPTA), and Brazilian Agricultural Research Corporation (Embrapa). KOPIA plans to expand its centers to other countries.

Through this project, Korea signed agreement of sharing technology regarding genetic resources for sustainable agricultural development. The genetic resources were collected from bio-energy crops, tropical crops, legume crops, and vegetables. Moreover, Korea is contributing to the dissemination of agricultural technology for local climate change adaptation by developing eco-friendly cultivation technology and by developing new plant variety for forage crops and other crops like tomatoes, cucumber, cabbage, cantaloupes, and watermelons.

B. Multilateral cooperation

Korea is participating in various programs to share technology with both developed and developing countries by engaging in various partnerships with international energy organizations. In Korea's early years of multilateral cooperation, most projects focused on cooperation for information sharing. However in recent years, Korea has been an active participant and a host in various projects like collaborative research and various workshops, seminars, and staff dispatches. Moreover, in order to prepare for the ever-increasing natural disasters caused by climate change, Korea has been working on various projects to construct a regional network for cooperation in agricultural technology, and thereby help the developing countries in Asia and Africa to increase their adaptive capacity for climate change through crop productivity improvement and food security attainment.

1) International Energy Agency cooperation

Korea recognizes the importance of energy technology in acquiring effective solutions for climate change. Therefore, Korea has been actively participating in technology cooperation programs through IEA, an agency for multilateral energy cooperation. The Ministry of Knowledge Economy is in charge of Korea's activities in IEA Committee on Energy Research

and Technology (CERT). Korea is also participating in 23 implementation agreements through the Korea Institute of Energy Technology Evaluation and Planning (KETEP), KEMCO, and Korea Electric Power Research Institute (KEPRI).

2) Asia-Pacific Economic Cooperation program

By participating in the Asia Pacific Economic Cooperation(APEC) Energy Working Group (EWG), Korea has been active in cooperation programs in such ways as establishing technology strategies to solve mid- and long-term energy issues within APEC and by creating the Energy Trade and Investment Task Force (ETITF) within APEC. Korea has exchanged policy information and has hosted seminars to promote cooperation in energy technology development through participating Expert Group on New & Renewable Energy Technologies (EGNRET), the Experts Group on Clean Fossil Energy (EGCFE), and the Expert Group on Energy Efficiency & Conservation (EGEEC).

3) Asia-Pacific Partnership on Clean Development and Climate

Korea was actively involved in the Asia-Pacific Partnership on clean development and climate (APP) in which seven countries participated: Korea, USA, Australia, Japan, China, India, and Canada. This partnership was established to achieve GHG reduction by attaining a sustainable energy system between the participating countries through the development, supply, and diffusion of clean energy.

The APP was able to bring about voluntary cooperation for effective countermeasures in regard to climate change from countries standing at various economic levels and developmental stages. The member countries were all able to work in collaboration until the official conclusion of activities in 2011. Among the eight APP task forces (new & renewable energy and distributed generation, buildings and appliances, power generation and transmission, steel, cement, cleaner fossil energy, coal mining, and aluminum), Korea participated in six task forces, excluding coal mining and aluminum, and has led forces in buildings/appliances and new & renewable energy.

4) Carbon Sequestration Leadership Forum

The Carbon Sequestration Leadership Forum (CSLF) was established in June 2003 to attain national policies and R&D cooperation within the member countries to encourage international cooperation in carbon reclamation and storage. Korea became a member in September 2005 and has participated in the Policy Group and the Technical Group to promote technology cooperation. Moreover, by participating in the *CSLF's CO_2CRC Otway Project*, Korea is conducting a joint study on underground carbon dioxide storage technology.

5) ASEAN+3 environment and energy cooperation project

There also has been active cooperation between the ASEAN+3 (ASEAN Plus Korea, China, and Japan) countries regarding energy. The ASEAN+3 new & renewable energy and energy efficiency forum began in August 2003

and delegated Korea, Malaysia, and Myanmar as administrators in the forums. These three administrating countries will also host the forums in rotation. During the forum, new & renewable energy policies of the host country and various ways of cooperation will be introduced and discussed between the member countries. The specific areas of cooperation are technical cooperation with the ASEAN countries that possess bio-energy and joint research in Clean Development Mechanism (CDM).

Also, during the Korea-ASEAN Commemorative Summit hosted in November 2011, ways to strengthen cooperation in climate change actions and green growth were discussed. Cooperations between Korea and ASEAN countries in the areas of climate change and green growth are expected to expand through this summit.

6) International Renewable Energy Agency Cooperation

Korea is a founding member of the International Renewable Energy Agency (IRENA). IRENA's inaugural meeting was held in April 2011, with an aim to strengthen international cooperation for the development and distribution of energy. In order to encourage collaboration in the Asia-Pacific area, Korea has been facilitating the beginning movement of IRENA by hosting the IRENA-Korea Joint Workshop on Asia-Pacific Renewable Energy Policy in October 2010, and by dispatching representative experts to the IRENA Secretariat. Korea also has been an active member in such ways as serving as Chair of the Committee for the Selection of the Interim Headquarters and Vice Chair of the Preparatory Commission.

7) Regional cooperation on agricultural technology

In November 2009, Korea led the creation of a channel for multilateral cooperation, the Asian Food and Agriculture Cooperation Initiative (AFACI), to promote international collaboration for development of agricultural technology and productivity in Asia. The 12 countries involved in the AFACI cooperation are Korea, Bangladesh, Cambodia, Indonesia, Laos, Mongolia, Nepal, the Philippines, Sri Lanka, Thailand, Uzbekistan, and Vietnam. In April 2010, AFACI had its first general meeting in the Philippines and has agreed to conduct 14 progressive projects. The activities of AFACI can be categorized into the following three types: 1) Pan-Asia projects, in which all member countries participate, 2) regional projects, in which some member countries come together to deal with agricultural issues specific to certain regions in Asia, and 3) national projects, in which some member countries come together to develop agricultural technology that can be applied to issues specific to each nation.

In regard to Pan-Asia projects, currently there are two projects being carried out, including a project for building an information network for agricultural technology in Asia. For the regional project, there is an *establishment of collaboration network for the management of migratory pests and associated diseases in Asia*, in which seven countries are participating. There are nine national projects being carried out such as Mongolia's vegetable cultivation technology development project, Nepal's genetic resources

conservation and technology utilization project, and the Philippines' bio-fertilizer manufacturing technology for climate change adaptation project. In 2010 and 2011, there were a total of five workshops including an event for the high level officials for rural development, a workshop for organic farming technology development, and a workshop for project managers. Through these workshops, member countries have discussed and shared information to bring about collaborative efforts in Asia.

In order to distribute Korea's experience with cooperation for sustainable technology development in agriculture, the Green Revolution and the New Community Movement, the Korea-Africa Food & Agriculture Cooperation Initiative (KAFACI) was launched in July 2010. With Korea assuming leadership, the 16 countries from Africa (Angola, Cameroon, DR Congo, Cote d'Ivoire, Ethiopia, Gabon, Ghana, Kenya, Malawi, Morocco, Nigeria, Senegal, Sudan, Tunisia, Uganda, and Zimbabwe) have gained membership in KAFACI. KAFACI had its first general meeting in Ethiopia on March 2011. KAFACI selected Korea as the location to invite experts from the member countries to receive on-the-job training. There were two training sessions held between June and November of 2011 for 43 trainees from each member country in Africa. Based on the results of the training, KAFACI plans to build Africa's resilience to climate change by increasing agricultural productivity and develop both regional and national projects for such technology transfer and capacity building.

Chapter 7

Research and Systematic Observation

Chapter 7 Research and Systematic Observation

The government of Korea has developed a long-term roadmap for research and technology development which reflects the vision of the Low Carbon, Green Growth. Also Korea has increased the investment on climate science research and development of climate response technology with emphasis on commercialization. The government of Korea is actively running climate change related observation in atmosphere, ocean, and land. Recently, Korea successfully launched a geostationary orbit satellite (*The Cheonlian Satellite*), which enables routine observation.

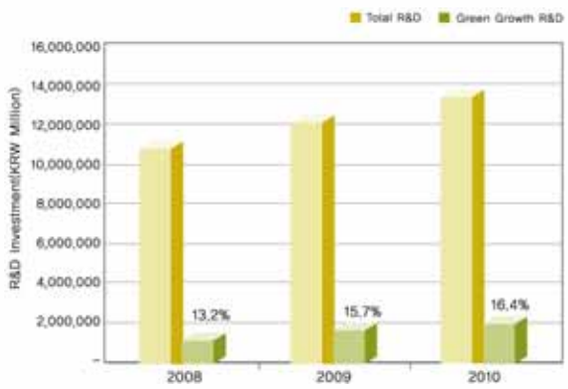
1. Research and technology development

The government of Korea has been consistently committed to building capacity to address climate change through scientific research and technology development. Given that the resource scarcity and climate change are recognized as real global threats, many countries begin to recognize the development of green technology as a key factor for the future national competitiveness. The Research and Development (R&D) area of Korea is comprehensive including a range of climate-change science, energy, transportation, agriculture, forestry, fishery, marine, and ecology topics. The government of Korea has developed long-term roadmap and has expanded the investment in science of climate change and R&D on sectoral climate change response.

In order to proactively respond to climate change issues, green technology is also recognized as a critical component of *Low Carbon, Green Growth*, a new paradigm for environmentally sustainable economic growth. Accordingly, the government of Korea seeks to establish flexible climate change mitigation strategies such as the *Comprehensive Plan on Green Technology Research and Development* (2008~2012), which functions as a gateway for sharing the results of inter-governmental green technology R&D. Korea also has been annually establishing action plans to adequately achieve the R&D investment objectives. The PCGG reviews green growth implementation plans with the concept of integrating technology and industry for *Low Carbon, Green Growth*. The PCGG is also allocating investments of green technology through the results of inspection of feasibility and importance. And the PCGG is annually analysing the industrial impact of the implemented plan. Finally, the government of Korea finds issues related to green technology as national research themes and provides guidelines for such investments. The nation also strives to commercialize technology to achieve GHG reduction goals.

A. Investment plan for research and technology development

The government of Korea is pushing for balanced investment between scientific climate change research for the purpose of prediction and adaptation, and green technology development used for GHG reduction. In 2010,



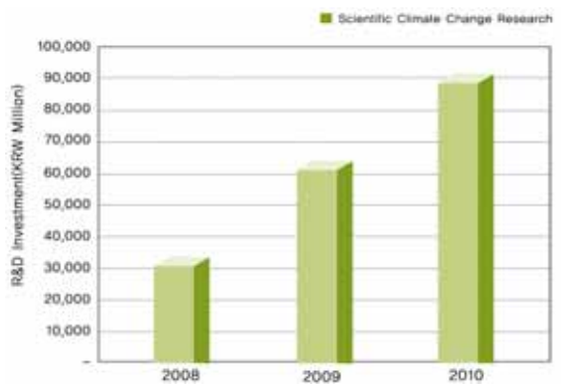
Source : PCGG, Green Technology Development research and analysis data (2011)

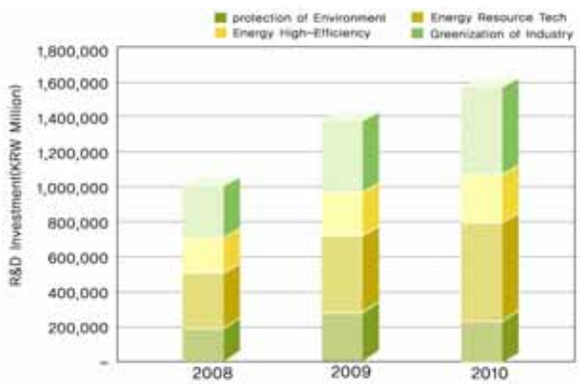
[Figure 7-1] Green technology R&D investment out of the total R&D investment

the total amount of investment in national R&D programs (Figure 7-1) was about KRW 13.7 trillion, a 23.7 percent increase since 2008. Amongst these, the total amount of investment in green technology, including scientific climate change research for prediction and adaptation, was about KRW 2.2 trillion, which was a 53.9 percent increase since 2008. The share of green technology investment in total national R&D budget increased from 13.2 percent in 2008 to 16.4 percent in 2010, showing a gradual increase every year.

The scientific climate change research is divided into climate change prediction & modeling technology and adaption technology, such as climate change impact assessment and adaptive technology. For climate change prediction & modeling technology, the government of Korea has expanded the scale of its long-term continuous investment as they are national public services which requires continuous attention and investment. Climate change impact assessment and adaptive technology is divided into seven areas: health, food security, water management, marine, natural disaster, forestry, and generic technology. For areas such as water management, marine and disaster technology that require timely market entrance and speedy demonstration and distribution, short-term yet concentrated investment is encouraged. On the other hand, for health, food security, forestry, and generic technology that require long-term nurturing for them to improve international competitiveness, long-term continuous investments are being made.

Green technology development for GHG reduction is divided into the following categories: energy resource technology, high-efficiency energy technology, green technology of industry and space, and technology for protection of environment and virtuous circle of resources. Energy resource technology focuses on developing cutting-edge energy technology that will use renewable energy or non-carbon energy instead of depleting resources like fossil fuel. High-efficiency energy technology focuses on increasing the efficiency of fossil fuels and electricity usage by developing the technology which would reduce energy consumption and GHG emission. Greenization of industry & space technology focuses on eco-friendly architecture, urban renewal, and enhancement of transport efficiency through an Intelligent Transportation System (ITS) and green car development. It also focuses on technology development for industrial manufacturing process and efficiency improvement. The technologies of environment protection and resource recycling are focused on prediction of environmental change, impact assessment, emissions and diffusions of pollutants, as well





Source : PCGG, Green Technology Development research and analysis data (2011)

[Figure 7-2] Investment on scientific climate change research in recent 3 years

[Figure 7-3] Investment on green technology development in recent 3 years

as developing mechanism for early prevention, post management, and restoration of damaged ecosystems.

Investments made by the government of Korea in 2009 are in the following order of largest to smallest investment allotment: ITS, power IT and improving efficiency of electronic equipment, green processes, and high-efficiency & low-emission, and environment-friendly vehicles. Out of all investments made for national green technology R&D programs, investment in the public sector is increasing compared to that of industrial sector. The investment allotments in the public sector are listed as follows from largest to smallest: energy production/distribution/utilization, environment conservation, and knowledge advancement. The investment allotments in the industry sector are listed as follows from largest to smallest: manufacturing an industry for vehicles and transport equipment, miscellaneous industries, and manufacturing industry for electricity and mechanical equipment. Out of all investments made for national R&D programs in green technology, investments on energy production/distribution/utilization, environment conservation, and manufacturing industry for vehicles and transport equipment came out to have more allotments compared to investment allotments for national defense, other public purposes, and knowledge advancement.

B. Research project

1) Climate change prediction and modeling technology

Climate change prediction and modeling technology (Table 7-1) provide an accurate and long-term earth system prediction using earth system prediction model based on monitoring environmental factors causing climate change The goal of this technology is to identify any paleoclimate/environmental changes that occur and provide simulations of these changes for climate change assessment. For these goals, the government of Korea has provided consumer-oriented scenarios by strengthening ties between the adaptation and impact assessment groups, in order to enhance application of national climate change scenarios.

<Table 7-1> Products and services for climate change predictions and modeling, and its key technologies

Products and services	Detailed products and services	Key technology
National climate change scenario	Climate Change Scenarios based on IPCC RCPs	Climate change Scenario projection
		Uncertainty Assessment of climate change
	High resolution climate change scenario using ESM specified on Korea	Earth System Model specified on Korea
		High-resolution regional climate model
		Uncertainty Assessment of climate change
		Assessment of dangerous levels of climate change
Earth System Model	5-Step Earth System Model	Climate process component model development per unit
		Combination technology
		Regional Climate Modeling
	Prediction system based on a 6-Step or more Earth System Model	Advanced module development
		Regional climate modeling
		High-definition modeling
		Combined data assimilation system
Carbon quantification	Carbon tracking system	Carbon flux and transport modeling
		Monitoring network expansion and carbon data assimilation
	Real-time carbon tracking quantification system	Real-time climate change monitoring technology
		Regional resin assessment technology
Climate change impact monitoring	Monitoring sectoral climate change impacts	Sectoral impact monitoring technology
	Monitoring and assessing regional climate change impacts	Regional impact monitoring and assessment technology
	Integrated monitoring system on climate change	Monitoring DB construction and management technology

* Source: PCGG, Roadmap for green technology deployment (Key green technology commercialization roadmap 2009)

The government of Korea also has tactics to improve its analytical capabilities by conducting cooperative studies with international organizations. Through these international and academic collaborations, the nation seeks to build a foundation for the advancement of technology and quantify the atmospheric carbon level using domestic observation and Asia's network for carbon monitoring. The nation is also dedicated to acquiring advanced technology by participating in collaborative international research projects.

The development purpose and target of main climate-related component technology are as follows.

First is the development of climate change prediction model (Earth System Model). Five-steps integrated earth system modeling framework will be developed and will be expanded into six steps model by 2020, through which the foundation of independent prediction data generation will be laid out. The development of the national climate change scenarios using Representative Concentration Pathways with established climate model is being progressed. After completing the Earth System model development, the national climate scenarios using the newly developed Earth System model will be development and contributed to the IPCC assessment report in the

long term plan. Also, the long term plan will include development of climate change scenarios with ultra-high resolution below 5 km. For the construction of a carbon tracking system and technology development for the quantification of the atmospheric carbon level, the government of Korea aims to optimize the carbon monitoring network, construct a real-time monitoring system by 2030, and gather internationally recognized prediction data on carbon emission and absorption level quantification.

Finally, the government of Korea has classified its research projects into monitoring climate change, clarifying climate change causes, predicting climate change, utilizing climate change science information and other service projects to develop adaptation technology for climate change prediction and modeling. Since 2010, Korea had planned to promote a commercialized roadmap that is deployed into three steps: Phase 1 (2010~2012), Phase 2 (2013~2020), Phase 3 (2021~2030). Through these detailed activities and plans, Korea strives to advance its research development.

2) Technology for climate change impact assessment and adaptation

To assess and prepare for the climate change impact on social infrastructure, land, and humankind, Korea is investing in building a system made up of the following seven areas of technology: health, food security, water management, marine, natural disaster, forestry, and generic technology (Table 7-2). The goal of this R&D is to come up with an authentic national GHG emission reduction model, construct an integrated national system for climate change adaptation, and attain advanced climate change prevention technology that reaches 90 percent of developed countries' relative technology deployment. This R&D also covers impact and vulnerability assessment based on those scenarios, as well as adaptation and mitigation technology in response to these results.

The government of Korea also places focus on R&D which conducts vulnerability assessments such as the impact of air quality degradation by climate change on natural and human system. Korea is also concentrating on the development of an atmosphere-climate satellite data analysis system, technology for simultaneous reduction of GHG and air pollutants, and information technology which assesses sectoral vulnerability from climate change.

Because climate change impact assessment and adaptation technology have been recognized as key components of climate change prediction data in recent years, Korea has been focusing on building a network for joint-research and communication with climate change prediction and modeling groups. Also, viewing the impact assessment and adaptation technology as a pedestal technology for society, Korea considers impact assessment and adaptation technology as urgent fields of study and development. To protect citizens' security and the nation's goal of sustainable development from ever-increasing natural disasters caused by climate change, the development of social infrastructures (such as an early warning system) has been the center of Korea's attention and support. The government

<Table 7-2> Products and services for climate change impact assessment and adaptation, and its key technologies

Products and services	Detailed products and services	Key technology
Climate change impact and vulnerability assessment	Impact assessment prediction models by sectors	Sectoral impact assessment prediction model
	Comprehensive local impact assessment model	Comprehensive local impact assessment modeling
	Vulnerability map	Vulnerability assessment technology
	Integrated impact assessment prediction model	Integrated impact assessment prediction modeling
		Integrated management of scenarios and web-based service technology
Climate change adaptation	Adaptation strategies by sectors	Sectoral adaptation strategies
	Climate resource map	Climate resource assessment
	Comprehensive regional/sectoral adaptation strategies	Comprehensive regional adaptation strategy
	Adaptation implementation portfolio	Adaptation implementation portfolio technology
Natural disaster prevention and countermeasure	Risk assessment on extreme climate	Risk assessment technology on extreme climate
	Early warning system of natural disaster	Prediction and early warning system of natural disaster
	Natural disaster prevention and adaptation system	Natural disaster adaptation system

* Source: PCGG, Roadmap for Green technology deployment (Key green technology commercialization roadmap 2009)

of Korea prioritize the damage reduction when it comes to climate-related disaster.

The goal is to reduce climatic damages by developing programs for climate adaptation that would drastically decrease the loss of lives and property caused by meteorological disasters. For such improvement in an adaptive capacity, research into development projects have been conducted in areas such as natural disasters (fires, floods, water management, etc.), insurance, consulting, meteorological industry, medical industry (vaccine development, Yellow Dust prevention supplies, etc.), natural restoration, development of new varieties, and so forth. Forecasts of changes in the ecosystem and assessment of subsequent development of alternative varieties of plants and fisheries also has been made, in efforts to foster the forestry and fishery industry to become more eco-friendly.

The government of Korea has also been considering impact assessment and adaptation technology as the key parts of public good that are in line with the national agenda of sustainable development. For these reasons, different areas of the government of Korea have been taking the leading role in managing related projects and also encouraging participation from the private sectors. The nation also has been actively involved with international organizations like World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP); domestic organizations like Korea Meteorological Research Institute, Rural Development Administration, Korea Forest Research Institute, National Institute of Environmental Research, Korea Institute of Construction Technology, and National Emergency Management Agency have been actively researching their respective fields of

study regarding impact assessment and adaptation technology for climate change.

C. Technology development project

1) Environmental protection and resources recycle technology

R&D of environmental protection and resources recycle technology is supported by the government of Korea through public funding. Also the government is encouraging the participation of private industry sector by supporting the demonstration and deployment project. University and public research institutes focus on training experts. Consequently, the government of Korea has been investing in technologies such as carbon capture, storage, and processing, non-CO_2 processing technology, water quality assessment and management technology, alternative water resources securing technology, waste technology (waste reduction, recycling, and waste-to-energy), toxic substance monitoring technology, and environmental remediation technology. Through these technological developments, Korea expects a dramatic reduction of CO_2 by lowering dependence on fossil fuels and raising energy efficiency levels instead. The introduction of eco-friendly low-carbon projects and reduction of GHG emissions using green technology will play a critical role.

As mentioned above, the government of Korea is focusing on developing water quality assessment and management technology, alternative water resource securing technology, waste technology (waste reduction, recycling, and waste-to-energy), resource recycling technology, toxic substance monitoring technology, and environmental remediation technology. While the Eco-innovation Project (2011~2020) supports the more traditional development projects (such as projects on water quality, air, waste, etc.), the Climate Change Technology Development Program (2011~2020) focuses more on developing breakthrough technologies in eco-friendly materials, climate forecasting, and cost reduction of carbon capture and storage. In addition, the Plant Technology Advancement Program (2005~present) fosters the commercialization of desalination systems and the Global Expertise Technology Development Program (1987~present) concentrates on developing technologies for clean manufacturing-based resource recycling. The government of Korea sponsors these projects to develop environmental technology for the public sector, sponsor environmental projects, make climate change projections and expand adaptive capabilities for climate change.

2) High efficient energy technology

To improve energy and resource efficiency, the government of Korea focuses on the core fundamental technologies and the demonstration/ dissemination of key technologies. For example, the spotlight is on the following four technologies: Integrated Gasification Combined Cycle (IGCC) technology, LED illumination/green IT technology, power IT and electrical equipment efficiency enhancement technology and high-efficiency secondary rechargeable battery technology. The government of Korea also promotes technology development by operating a smart grid test-bed.

For IGCC, the government is constructing a post-hoc study on response system development for industry by building infrastructure like power plants, designing policies that encourage participation of electricity companies, attaining fundamental technology and materials for the key components and making policy improvements to invigorate the related industry.

The investment allotment is as follows: out of the four technologies mentioned above, most R&D investments have been allotted to the power IT and electrical equipment efficiency technology, in which more government investment is allotted than that of the other three technologies combined. Although the investments allotted to the LED illumination/green IT technology and the secondary rechargeable high efficiency battery technology are smaller, the investments allotted to these two technologies have drastically increased to double the last year's allotment. The key investment programs are as such: the Global Frontier Technology Development Program (2010~present) that focuses on developing core technologies like the bio-energy technology; Green Industry-leading Battery Technology Development Program (2011~2018) that focuses on developing key battery components like the separation membrane and medium-large batteries for energy storage and transport system; and Fusion Technology Industrial Technology Development Program (2009~present) focuses on IT convergence and electronic information devices. Energy Resources Technology Development Program (1992~present) represents the energy high-efficiency technology development.

3) Energy source technology

The focus of Korea's investment on energy source technology has been on using alternative energy sources such as renewable energy or non-carbon energy instead of fossil fuels that cause GHG emission. Some examples of these energy source technologies are photovoltaics, non-silicon solar cells, bioenergy, advanced light-water reactors, fast reactors, nuclear fusion, hydrogen energy, fuel cells, wind power, and so forth. Following are some examples of Korea's efforts to acquire a considerable share of the new & renewable energy market and develop competitive technologies for nuclear energy utilization. First, the government of Korea plans to build a commercial supply chain to lessen foreign dependence on energy resources, and protect against supply chain infrastructure vulnerability. Second, legal, institutional, and national support and investment such as the expansion of renewable portfolio standards will be provided. Finally, the nation will support the establishment of breeding and cultivation technology for creating bioenergy crop varieties.

The current state of investment on the development of new and renewable technology is as follows. The investment allotment for the development of new & renewable energy technologies has been continuously increasing the last five years in the areas of photovoltaics, wind power, fuel cells, and bioenergy. It is expected that this trend of investment expansion will continue. The focus of Power Generation & Electricity Delivery Technology Development Program (2001~present), New and Renewable

27 green core technologies

In order to ascend as a green developed country, the government of Korea recognized the importance of discovering the most advanced green technology and its potential to become a new power supply. Thus, the nation established *Green Technology R&D Integrated Measures* and *27 Green Core Technologies* as roadmap.

Core green technology development & commercialization strategy promotion

- Strategic expansion of green technology development & efficiency of the technology development system
- Expansion of infrastructure for green technology development
- Generation of regional growth engines by establishing Green Regional Innovation System(GRIS)
- Revitalization of international cooperation to secure the cutting edge green technology

27 core green technologies

27 Core Technologies

1. Climate change forecast & modeling development technology
2. Climate change impact analysis and adaptation technology
3. Silicon solar battery's High efficient, low cost silicon solar cell technology
4. Non-silicon solar cell manufacturing & core technology
5. Bioenergy production component & system technology
6. Improved light-water reactor design & construction technology
7. CCS
8. Fusion reactor design & construction technology
9. High-efficiency hydrogenation & storage technology
10. New generation high-efficiency fuel cell system technology
11. Eco-friendly plant growth accelerating technology
12. Coal gasification integrated development technology
13. high-efficiency & low-pollution vehicle technology
14. Intelligent transportation and logistics technology
15. Ecological space establishment & urban restoration technology
16. Eco-friendly low-energy architectural technology
17. Green Process technology that considers environmental load and energy use forecast
18. LED Green IT technology
19. Smart electricity systems & electronics efficiency improvement technology
20. High-efficiency secondary cell technology
21. Eco-friendly nuclear cycle system development technology
22. Non-CO_2 GHG reduction technology
23. Hydrosphere water quality analysis & management technology
24. Alternate water resource security technology
25. Waste reduction, recycling, and nergy recovery technology
26. Pollutant particle monitoring & purification technology
27. Virtual reality technology

Source: PCGG (2009)

Investment direction of green technology

- Short-term investment direction (investment that approaches the market in a timely fashion through an effective, short period demonstration and supply) : Silicon solar cell, improved light-water reactor, LED technology, etc.
- Mid-term investment direction (technology that requires prior market occupation through improving competitiveness) : high- efficiency & low-pollution vehicles, Green Process, secondary cell, Non-CO_2 processing, water quality analysis in water system, alternate water resource security, waste reduction, virtual reality technology, etc.
- Long-term investment direction (world-leading technology) : climate change forecast, climate change impact analysis and adaptation, fast reactor, fusion reactor, hydrogen energy, fuel battery, eco-friendly plant growth, IGCC, urban restoration, eco-friendly construction, Smart electricity network and CCS, pollutant particle technology, etc.
- Long-term gradual investment (field that requires basic root technology with constant investment) : non-silicon solar cell, bio-energy, Intelligent traffic distribution, etc.

Energy Technology Development Program (2006~present), are on the development of thermal power generation, hydroelectric power generation, photovoltaics, wind power generation system, and development of pilot plant for Integrated Gasification Combined Cycle. generation systems. Another focus has been on the development of nuclear power plant performance and regulations abiding environmental equipment technology through programs like Nuclear Power Technology Development Program (2008~present) and Nuclear Power Fusion Technology Development Program (2001~present). In addition, the Life Industrial Technology Development Program (1994~present) supports the development of biomass energy.

4) Green technology of industry and space

In order to adapt to international environmental regulations and continuously changing global markets, the government of Korea has been making long-term national policies to gain competence in the global green race. The government of Korea also has been investing on ongoing green technology research development such as high-efficiency low-emission vehicle technology, intelligent transport and logistics technology, ecological space and urban regeneration technology, eco-friendly low-energy building technology and green process technology considering environmental loading, and energy consumption projections. Research on high-efficiency low-emission vehicles (electric vehicles) has completed the development of mass production-ready EV, which will be supplied to the public and private sector, along with the continual increase in national support for core technology development.

Korea has a large population living in urban areas and most of CO_2 is emitted within urban spaces. While the discussion of the climate change response is focused on the development of clean natural energy and renewable energy sources, there has not been sufficient structural approach to the urban problem which is the major cause of the GHG emission. For this reason, there has been increasing emphasis on CO_2 reduction strategy in urban planning. Part of this emphasis has been on the introduction of various policy measures and the provision of various systematic countermeasures, which resulted in the following technology development goals. First, the gradual expansion of eco-friendly land areas and attainment of national ecosystem management techniques in metropolitan areas will be introduced. In addition, there will be an increased focus on the application of urban renewal practices, and construction of resource recycling and eco-friendly industrial complexes. The government of Korea will further encourage construction of green industrialization by creating a green building certification system. Finally, the nation will augment the development of eco-friendly transportation, and establishment of low-cost and high-efficiency intelligent transport system by integration of advanced transport technologies and IT.

For the development of eco-friendly construction materials, urban regeneration, transportation, and logistics technologies, Korea promoted programs as follows: 1) Construction

Technology Innovation Program (1994~present), 2) Transportation System Innovation Program (2003~present), 3) High-tech Urban Development Program (1994~present), 4) Urban Railroad Technology Development Program (1995~present), and 5) Plant Technology Advancement Program. Also, the green car industry is being supported through programs such as the development of the original technology for transportation systems (2009 ~present, MKE) and the Eco-Innovation Project.

2. Systematic observation

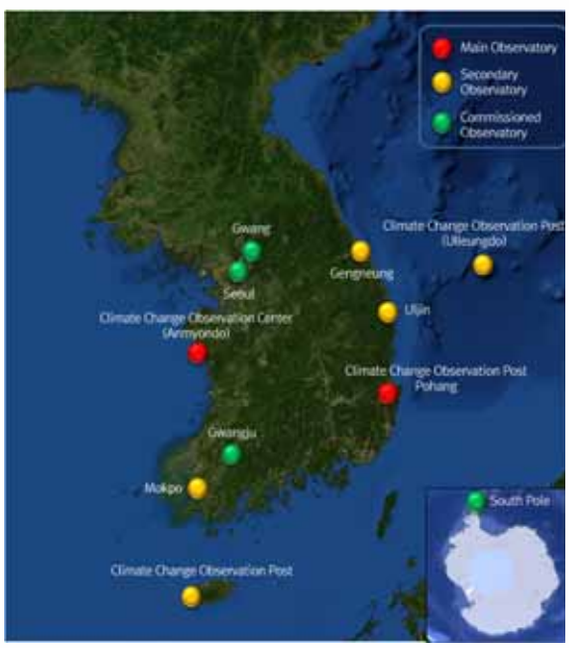
To monitor the long-term changes in atmospheric substances that cause climate change (GHG, reactive gases, aerosols, atmospheric radiation, etc.), the government of Korea has been operating Korea Global Atmosphere Watch Center (GAW) in Anmyeondo on the west side, Global climate observing system Surface Networks (GSN) at Gosan, Jeju, on the south side and at Ulleungdo in the east side of the country. As a member state of the WMO, the government of Korea is also operating 11 GSNs and 5 GUANs (Global climate observing system Upper Air Networks) for temperature, atmospheric pressure, and precipitation calculation. There are 34 centers in the Coast of Korea that observe changes in surface water temperature and 48 centers that observe changes in sea levels. In order to continuously observe the flux levels of water, CO_2, and energy, Korea has constructed three material flux system towers in the agriculture and forest regions, respectively. These towers observe not only changes in vegetation, but also periodically the health of soil, biodiversity, and forest ecosystems. On June 27, 2010, the government of Korea successfully launched its first geostationary satellite (The *Cheonlian Satellite*). Beginning on April 1, 2011, regular observations are being performed by the satellite.

A. Atmospheric observing system for climate

The observation on land, ocean, upper air, satellite, radar, and aviation is conducted by 110 observatories, automatic meteorological observation equipment in 468 centers, 8 marine meteorological buoy observatories, and 1 meteorological observation ship. 80 out of 110 observatories are utilized for synoptic observation, 5 observatories for upper air observation, 13 observatories for aviation meteorological observation, and 12 observatories for radar-using observation. The government of Korea is actively participating in the GCOS to meet the UNFCCC requirement and also to gather systematic information on the climate. The 11 GSNs (in Seoul, Chuncheon, Gangneung, Ulleungdo, Cheongju, Daejeon, Pohang, Busan, Yeosu, Mokpo, and Jeju) and five GUANs (in Sokcho, Baengnyeongdo, Pohang, Gosan in Jeju, and Heuksan) are WMO registered centers, operated to calculate temperature, atmospheric pressure, and precipitation. The GUANs are measuring upper-air temperature, humidity, wind, altitude, and atmospheric pressure twice a day.

To follow the WMO/GAW (Global Atmosphere Watch) agenda for monitoring

substances that cause climate change, a regional GAW Station (WMO/GAW Station 47132) was set up at Anmyeondo, located in the west of the Korean Peninsula in 1996. The Station monitors GHG (CO_2, CH_4, N_2O, CFCs, and SF_6), aerosols, air pollutants (CO, SO_2, NO_x, and ground-O_3), atmospheric chemistry, and atmospheric radiation. There also has been systematic observation on ozone stock, vertical ozone distribution, and surface UV radiation by the Pohang Weather Station (WMO/GAW Station 47138/GO_3OS Station 332), the UV Observation Network (located in Anmyeondo, Jeju Gosan in, Mokpo, and Gangneung), and the Acid Rain Observation Network (located in Anmyeondo, Gosan in Jeju, Uljin, and Ulleungdo) (Figure 7-4). In 2008, a GAW Station was installed at Gosan, Jeju, south of the mainland, to monitor GHG such as CO_2, CH_4, water concentration of aerosols, and atmospheric radiation. There is also a new GAW Station under construction in Ulleungdo and Dokdo, east of Korea. The government of Korea started measuring CO_2, UV, Ozone level at the Sejong Antarctic Research Program in the Antarctic, and registered it as a WMO/GAW Station in October 2010, expanding Korea's surveillance zone.



Source: Korea Meteorological Administration

[Figure 7-4] Korea network for climate forcing agents caption

Currently, a three hundred meter observation tower in Boseongun, south of Korea is under construction. The goal is to finish the installation by 2012 and to be used for collecting vertical climate change and weather observation data to analyze climate disaster and climate change mechanisms. This tower will monitor synoptic meteorology, like temperature and wind, and also monitor the substances that cause climate change like GHGs, air pollutants, aerosols, atmospheric radiation, etc.

B. Ocean observing system for climate

Ocean information such as the sea level and sea surface temperature is used to estimate trends in climate change, and Korea's average of sea information is greater than the global average. To analyze the cause of this phenomenon, there has to be a continuous and long-term gathering of temporal and spatial changes information. Therefore, the government of Korea has been constructing an integrated national ocean observing system, the National Ocean Observation Network (which includes a comprehensive ocean research station, tide station, buoy observatory, and costal observatory), which established a comprehensive ocean observation network (established 124

centers in 2010) in the jurisdictional sea area. Meanwhile, at the Gageodo Ocean Research Station climate change ocean super site, the government of Korea has installed and operates comprehensive observation equipment that can precisely monitor parameters causing climate change in the ocean and also observe their ocean-atmospheric interactions. Moreover, in 1991, in order to construct an integrated network that would enable the sharing of the global ocean data, the nation participated in the construction of Global Ocean Observing System (GOOS) under the leadership of the IOC (Intergovernmental Oceanographic Commission). Since 2005, Korea also has been participating in GEO, an inter-governmental international institution, to make accessible the comprehensive, continuous, and coordinated monitoring, analysis, and prediction of data on land and ocean conditions. For the development of a practical system for the real-time ocean information exchange and marine services enhancement in Northeast Asia, the North East Asia Region-Global Ocean Observing System (NEAR-GOOS) was established with the participation of Korea, Japan, China, and Russia. The government of Korea is also planning to build other various observation systems to observe the status of ocean and fisheries and thereby assess the impacts of climate change.

Since 1961, the government of Korea has been conducting an oceanographic survey of the areas surrounding the nation with the same frequency and on the same designated spots as

Source: National Fisheries Research & Development Institute(NFRD)

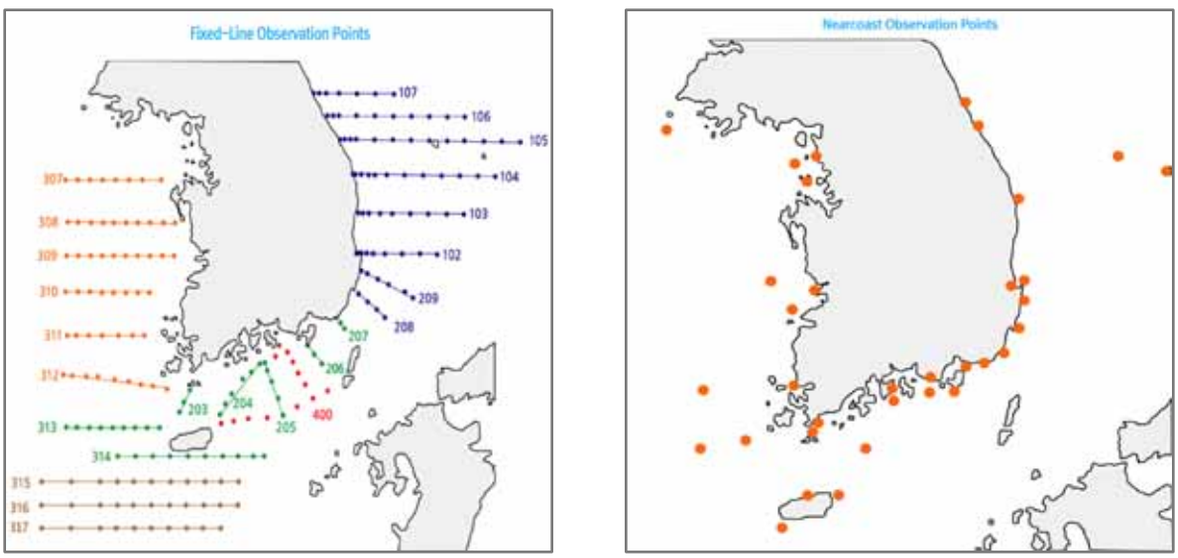
[Figure 7-5] Status of the national ocean observation network establishment

at present. Since 1996, observations have been expanded on the East China Sea, south of Jeju, to collect climate change data in the 25 survey lines, 207 designated spots, and 14 standard water layers. This data will be used for fishery management, and marine/fishery policy formation. Currently, observations on East Sea, West Sea, and South Sea have been conducted six times a year, on consecutive even-numbered months. The observations on the East China Sea have been conducted four times a year (in each season). During each observation, survey ships were used to measure water temperature, salinity, dissolved oxygen, zooplankton, nutrient salts, suspended solids, and transparency (Figure 7-6, left). In addition, in the 34 branch offices in the national coastal area, water temperature, temperature, and specific gravity have been measured once per day since 1934, accumulating a long-term set of data on the national coast areas (Figure 7-6, right). Data for fixed line ocean survey, specific gravity, and meteorological factors on the coastal areas are offered by the Korea Oceanographic Data Center (KODC) and are distributed to the related institutions or universities in the form of follow-up reports, informational journals, annual reports, etc.

Also, on concentrated fishing areas, the government of Korea is collecting information on fisheries conditions. With this, the nation will prevent fishery damage and is identifying the changes in oceanic conditions. Also, in order to obtain basic data for short-term marine forecasting, the government of Korea has been operating real-time fishery environment information systems since 2003 in 27 national coastal centers. These centers monitor water temperature and salinity level every 30 minutes (Figure 7-7, left).

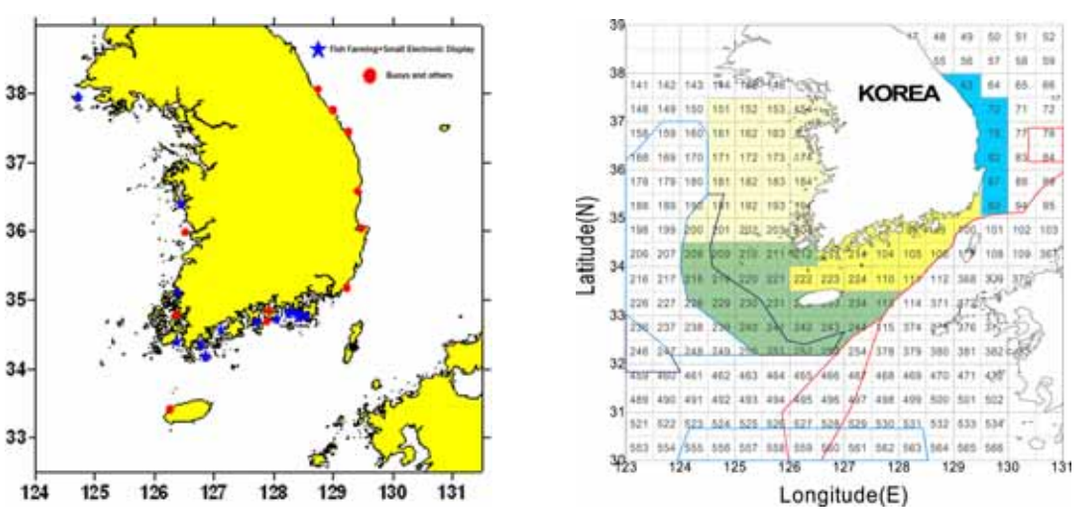
To apprehend the changes that occur in the fishery resources in the neighboring areas of the Korean peninsula and to propose measures for fishery resource management for ecosystem establishment, the government of Korea has been using specialized marine resource survey ships to observe fish eggs and larvae, run test surveys on fish catch, survey density of resources, and survey fishery environments. These surveys have been conducted twice a year in the 75 ocean trenches. Such surveys on the near-coast fisheries resources were conducted to use the collected data for scientific evaluation and assessment on fishery resources (Figure 7-7, right).

At the present time, Korea is implementing and operating 48 tide stations and 11 stations that will closely observe diastrophism and the mean sea level to thoroughly observe any changes in sea level such as tides, waves, and currents. Observations on physical oceanography (i.e. ocean currents, temperature, and salinity) are being conducted using vessels, the national ocean observation network, satellite buoys, and artificial satellites. From the late 2000s, Korea has established and operated comprehensive climate change observation systems including an integrated ocean research station, integrated ocean/land carbon monitoring equipment on large buoys, sea level observation equipment, differential GPS observation equipment, sea level temperature/electrical conductivity observation equipment, and other strategies to monitor the atmospheric concentration of the climate change and observe time series



Source: National Fisheries Research and Development Institute (NFRDI)

[Figure 7-6] Pathway of the ferry boats for a regular monitoring of the ocean



Source: NFRDI

[Figure 7-7] Real-time fisheries environment information system (left) and survey on the near-coast fisheries resources

variations. As mentioned earlier, observations in the 25 survey lines and 207 designated spots set up in Korea's sea jurisdiction have been conducted four to six times a year using survey ships, measuring water temperature, salinity, dissolved oxygen, zooplankton, nutrient salts, suspended solids, and transparency.

To acquire meteorological data by observing the atmospheric and oceanic interaction, the government of Korea is operating marine meteorological observation buoys and Automated Weather Station (AWS). Marine meteorological observation buoys that accumulate marine meteorological and temperature data were introduced and installed in nine locations (Deokjeokdo, Chilbaldo,

Geomundo, Geojedo, Donghae, Pohang, Marado, Ulleungdo and Oeyundo) in 1996. There have been nine AWS installed in marine structure since 2001, operating in Seosudo, Gadaeam, Sipyidongpado, Galmaeyeo, Haesuseo, Ganyeoam, Jigwido, Guangan, and Yideokseo.

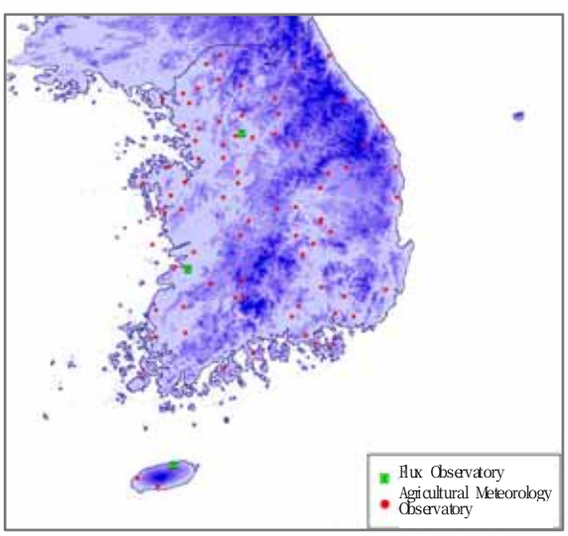
C. Terrestrial climate observation system

1) Agricultural outlook service system

The government of Korea has installed and managed automatic climate observation systems in the main 77 farmlands (rice cultivation areas, fruit trees areas, vegetable areas, etc.) to systematically observe weather elements that have direct relation to agricultural production (Figure 7-8). Nine elements are observed every minute: temperature, humidity, precipitation, insolation, soil moisture, soil temperature, dew-period duration, wind direction, and wind speed. Due to the complicated process of supplying AC power to agricultural land in Korea, the use of solar panels to power the automatic climate observation system has been instrumental. The observation data is collected in data loggers and is transmitted through CDMA every ten minutes to the data collection server. The accumulated data in the data collection server is reproduced in the units of every hour, every day, every ten days, and every month and is nationally provided on the web through the agricultural weather information system.

Meanwhile, tower-shaped flux observatories have been installed (Figure 7-8, 7-9) in three main agricultural belt observatories (rice, fruit trees). These flux observatories use the Eddy -covariance method to measure the flux rate of water, CO_2, and energy in agricultural ecosystems. The flux observation elements for farmlands are the following six elements: CO_2, sensible heat, latent heat, short wave radiation, long wave radiation, and net radiation. The observation interval is 10Hz and the preservation interval averages 30 minutes. The collected data of Net Ecosystem carbon dioxide Exchange (NEE) has become an important criterion to evaluate if an agricultural ecosystem is functioning as a carbon sink or a carbon source. The data is also used to estimate crop production and growth and to establish the correlation of environmental factors by subdividing the components that make up the process of carbon and water flux cycles in the agricultural ecosystem.

The systematic observation of agriculture and the climate information system have enlarged capacity for reducing the impact of



Source: Rural Development Administration

[Figure 7-8] Agricultural meteorology and flux observatories

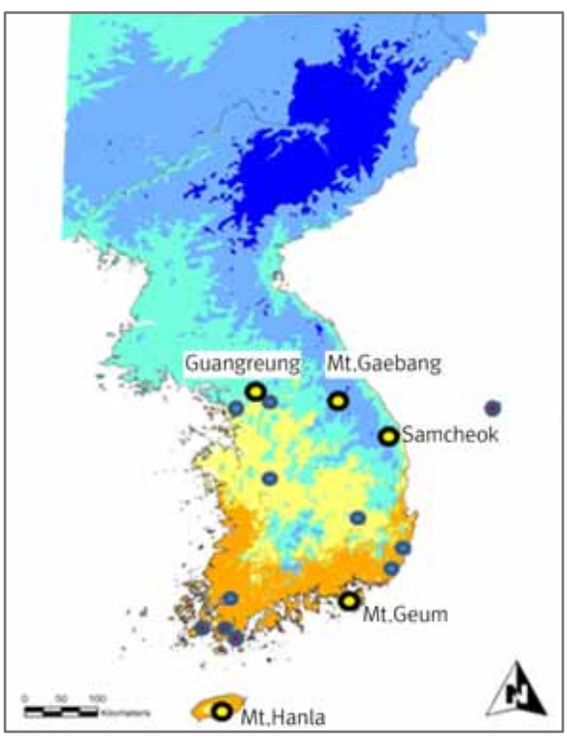
Source: Rural Development Administration

[Figure 7-9] Agricultural flux observation equipment installation (left: rice cultivation; right: tangerine cultivation)

agricultural extreme weather events. Moreover, the nationwide agricultural climate observation data is applied as a basis for the research of agricultural experiments and as guidelines for the farming technology industry.

2) Forest ecosystem monitoring system

Long-term observation is necessary for forest ecosystems consisting of complex climate change topography and diverse vegetation species. Therefore, to understand and predict the forest ecosystem, there has to be an organized national system for forest ecosystem monitoring. To systematically observe the structure of and changes in forest ecosystems, such as forest structure, biodiversity (plants, mammals, birds, arthropods, etc.), forest water, and forest productivity, the government of Korea has been monitoring forest ecosystems in Gwangneung, Gyeonggi Province; Mt. Gyebangsan, Gangwon Province; Mt. Geumsan, Gyeongnam Province; Mt. Hanlasan, Jeju; and Samcheoksan, Gangwon Province. In 2009, the monitoring scope was expanded to include Mt. Namsan, Mt. Jumbongsan, and Mt. Jirisan (Figure 7-10).



Source: Korea Forest Research Institute

[Figure 7-10] Locations of forest monitoring stations

Since 1995, the station in Gwangneung (Soheuleup, Pocheon, Gyeonggi Province) has been monitoring the status of forestry stand, soil texture, micrometeorology, air pollution, Net Primary Production (NPP), coarse woody debris, and decomposing trees. The station has been managing data, models for forest dynamics and observing changes in biodiversity including plants, insects, birds, mammals, pests, and fungi all through the use of GIS. Specifically, a forest ecosystem flux observation is conducted in broadleaf and coniferous forests. Korea's KoFlux Network, a regional network under the international flux network, was set up to monitor influx and output of carbon, energy, and water moisture since January 2002. In 2012, a plan to install the third monitoring flux tower atop Mt. Gariwangsan and other mountains will be implemented (Figure 7-11).

Source: Korea Forest Research Institute

[Figure 7-11] Gwangneung flux tower

Mt. Gyebangsan in Gangwon Province is a temperate forest with an altitude of 900~1577 meters. After a monitoring station was set up in 1994, vegetation and forest productivity of the mountain has been observed every five years. Mt. Geumsan in Namhae, Gyeongnam Province is also a temperate forest in the south with an altitude of 100~700 meters. In 2000, the foundation of a 1ha research station was established in the mountains and research has been conducted every five years ever since. Mt. Gumbongsan in Samcheok, Gangwon Province, is an area that has an altitude of less than 844 meters. Because the region was the site of a forest fire in 2000, there has been observation on damage recovery, vegetation change, soil, hydrological process, and wild life.

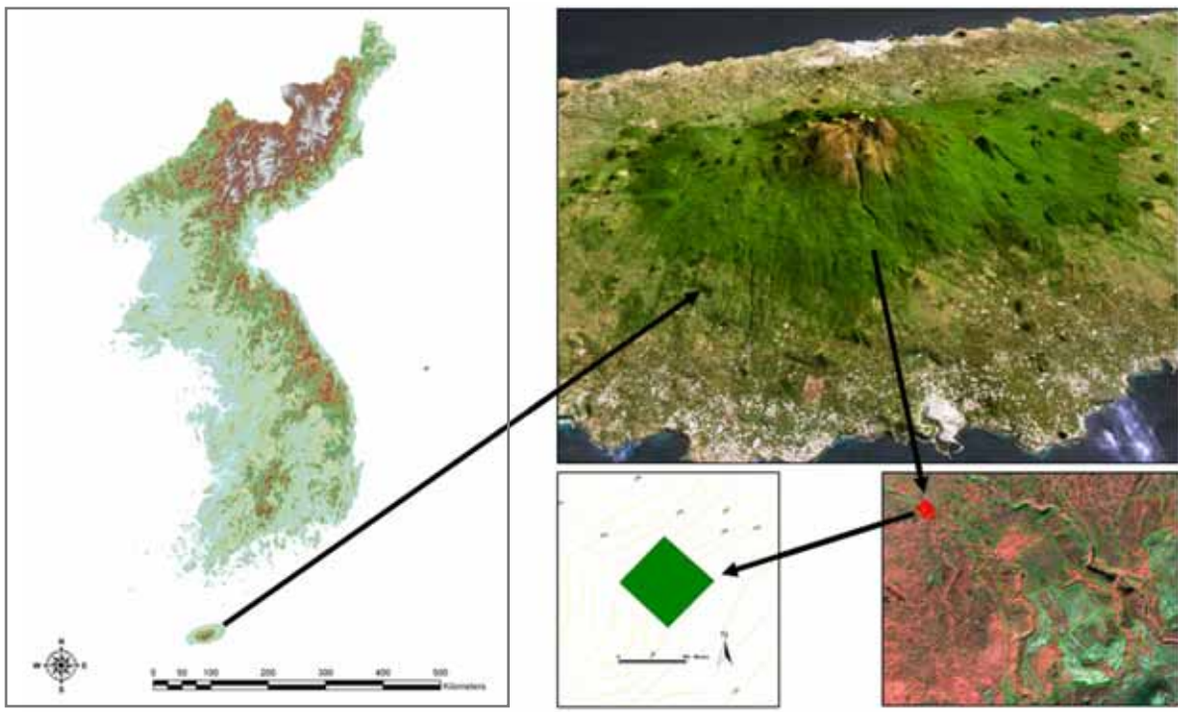
In Jeju - in the area with an altitude of 464-909 meters that has a warm temperate deciduous-evergreen mixed forest (WTDEF) - a research station was established in 2004 and surveys have been conducted every five years. There has also been observation on meteorological and vegetation changes on Mt. Hanlasan to investigate the cause of the decline in Korean fir (Figure 7-12).

64.5 percent of Korean geography consists of forests which is why the forest resource investigation is very important for forest management. From 2006, the government of Korea has selected 4000 plots to conduct forest surveys. Every year the survey has been done on 800 spots for a whole cycle of five years.

Since 2008, forest health was monitored every five years for tree crown vitality, stem damage, tree species, tree height, soil physical property, physicochemical properties of soil, soil pH level, and biological diversity.

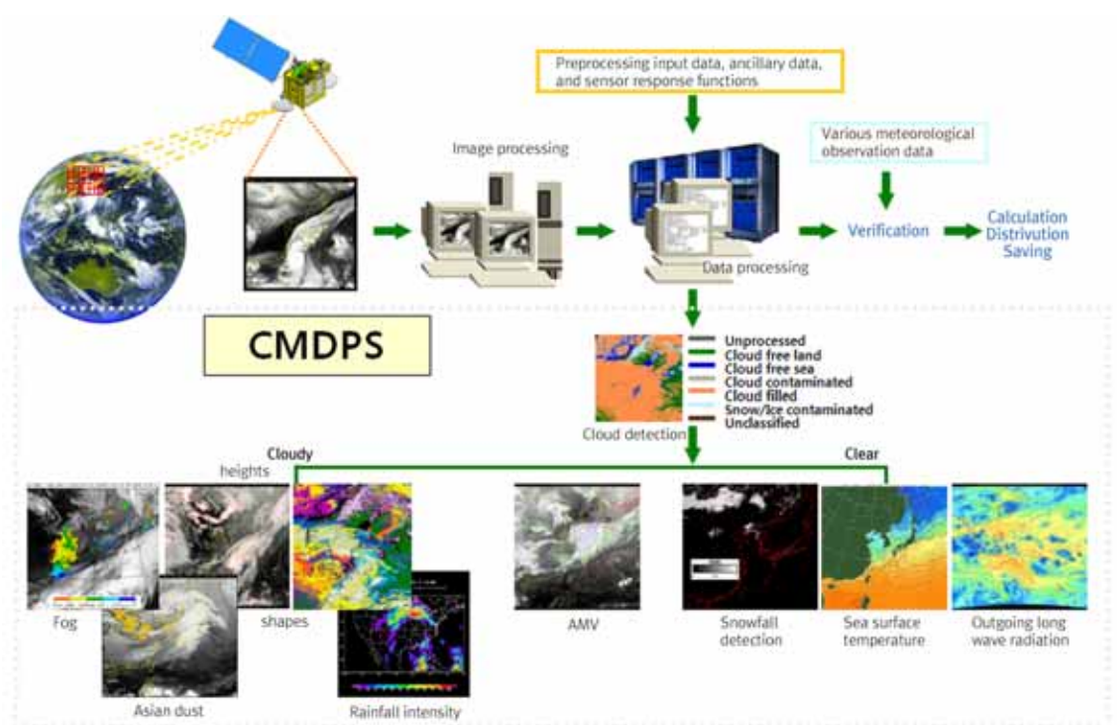
D. Satellite observation systems

In June 27, 2010, the government of Korea became the seventh nation to successfully



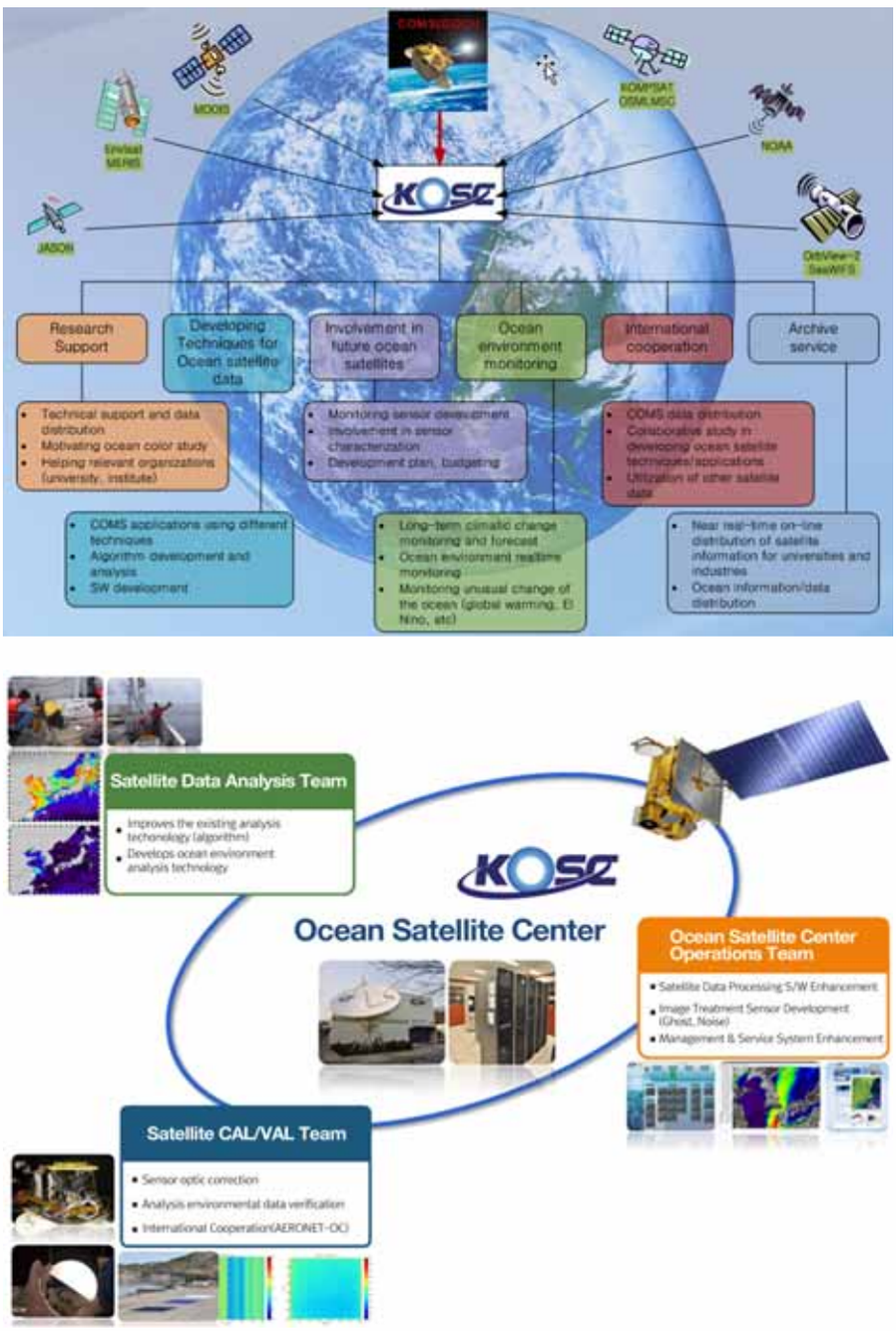
Source: Korea Forest Research Institute

[Figure 7-12] Meteorological observatory in Mt. Hanlasan, Jeju



Source: Meteorological Administration

[Figure 7-13] Concepts of COMS meteorological data processing system



Source: Korea Ocean Research & Development Institute

[Figure 7-14] Concepts of COMS oceanic data processing system

launch a geostationary multi-purpose satellite (COMS). Ever since its first regular monitoring on April 1, 2011, COMS has been providing real-time data on meteorology and ocean conditions. COMS provides general images of the whole globe, including Asia and Korea; gathers data on 16 meteorological elements such as cloud detection, fog, aerosol, sea surface temperature, rainfall intensity, upper tropospheric humidity, and sea ice/snow; and also provides real-time data on ocean current distribution, sea surface temperature distribution,

phytoplankton distribution, red tide monitoring, floater distribution, oceanic pollution monitoring, ocean meteorology monitoring, and cold pool monitoring (Figure 7-13 and Figure 7-14).

E. International cooperation

The government of Korea is actively cooperating with some of the major global atmosphere observation activities and programs led by the WMO such as the International Geo-sphere & Bio-sphere Program (IGBP) and Global Climate Observation System (GCOS). Meanwhile, the Korea Meteorological Administration, Ministry for Agriculture, Forestry and Fisheries, National Fisheries Research Institute, and Korea Ocean Research & Development Institute are involved in GSN and GUAN, the subordinate programs of GCOS. The involved ministries also participate in the Globe Oceanographic Observation System and Globe Terrestrial Observation System (GTOS) that operate in cooperation with GCOS. Regarding global atmosphere observation activities, the government of Korea has been regularly hosting the Asia Climate Change Monitoring International Workshop since 2009. Since 2010, the nation has been joint-publishing the Asia GAW Greenhouse Newsletter with the WMO.

Moreover, the government of Korea installed the Korean Secretariat of the Group on Earth Observation (GEO), which is a national cooperative organization for the integration of the Global Earth Observation System of Systems (GEOSS). The installation was set up to enhance cooperation and coordination efforts between domestic related agencies. The purpose of GEO is to execute all-inclusive global systems observations for enhancing global state monitoring, global process understanding, and global system forecasting. Currently, the government of Korea is actively sharing the global observation data, constructing plans to establish national GEOSS, and enhancing GEO's collaborative activities. The nation also has been designated to be one of the Global Producing Centres for Long Range Forecasts that shares GEO's WMO-standard long-term forecasting information with other WMO members. The government of Korea has been exchanging this type of international data and technology since July 2007.

As a WMO/IOC's international joint-program, the government of Korea has operated Array for Real-time Geostrophic Oceanography (ARGO) that carries out systematic observation and real time monitoring of the special-temporal oceanic temperature, salinity, and currents, in conjunction with GCOS/GOOS, CLIVAR project, and GODAE project. ARGO Floats are designed to dive down to a certain sea level and then drift around at the designated sea level until it rises up to the sea surface using the float's internal power. As the float rises up to the surface, it continuously observes water temperature/salinity and then transmits all recorded data by satellite.

Chapter 8

Education, Training, and Public Awareness

Chapter 8 Education, Training, and Public Awareness

The government of Korea is trying to enhance public awareness and participation in the *Low Carbon, Green Growth* vision. To enhance social consensus for the climate change response, Korea is fostering public education on global warming, encouraging civic activities, and strengthening public-private partnership. As part of this effort, education and training programs are implemented in the primary, secondary, and undergraduate curriculum, as well as the postgraduate professional level, along with the programs provided for the general public and expert group. Publicity on climate change is widely promoted by central and local government level, and public-private partnership and civil group activities are rapidly growing both in quantity and quality.

1. Education and training

A. Primary and secondary education

1) Primary and secondary education curriculum enhancement

Education on climate change and energy is well integrated and practiced in primary and secondary level education curriculum. Previously, environmental education for primary and secondary students was limited to certain subjects such as ethics, sociology, and science. However, Korea is now developing a curriculum that will lead students to understand and study climate issues in various courses.

Korea's independent research for energy education first started in 1991. At the time, energy education consisted mainly of energy-saving and utilization, whereas information about new & renewable energy was limited to basic concepts. In the revised textbooks, topics on energy education, new & renewable energy, and international convention on climate change were included. In particular, education on energy and climate change is emphasized to disseminate the vision of low carbon and the practice of low caron lifestyle.

In the language used in the curricula, more emphasis was placed on words like alternative energy rather than fossil fuels and terms such as clean energy and new & renewable energy are extensively used. In 2010, the *Korea Society of Energy and Climate Change Education* was established to set the direction for long-term energy and climate change education and to include related information in the curricula. Establishment of the society also enables continuous efforts such as hosting conferences and publication of scientific journals. Also, development of a standard instruction manual is emphasized for effective energy and climate change education.

In addition, after-school environmental chemistry programs were offered as easy and fun climate change education. For this program, 100 intern teachers who completed an appropriate training program were delegated to each demonstration school for environmental education.

Korea is also actively promoting the development of appropriate materials and textbooks for effective climate change school

education. To provide the latest information on climate change and forestry to educators and students, teaching materials were made and distributed nationally to public libraries and schools. In particular, in accordance to the *2009 Curriculum Revision Act*, a professionally approved fifth grade textbook for forestry climate change was developed in 2010. Education materials (of six sets) are being developed to encourage elementary students to learn climate change and energy issues in a forestry-centered way.

2) Extra-curricular programs for primary and secondary education

Korea has been implementing the *Save Energy, Save Earth (SESE) NARA* program since 2010, which targets children and youth to develop interest in climate change and further develop an energy-conserving lifestyle from an early age. Through this program, students volunteer to participate in various activities that will help them realize energy-saving at home, school, and in the community. Some examples of these activities include composing an energy conservation song, presentation of energy-saving practices, productions and demonstrations of energy-saving UCC, and participation in an energy camp. Through these activities, students are taking an active role in spreading the energy-saving awareness to the public. To improve the capacity of educators, 650 teachers participate in the annual forest experience program for climate change response, which is operated by the government of Korea.

3) Development and dissemination of exemplary cases through policy research school operation

The government of Korea established energy-saving policy research schools to foster climate change literacy and encourage climate-friendly practice in daily life. Starting in 1993, primary and secondary schools have been selected biannually as energy-saving policy research schools. Energy saving policy research schools develop education materials that are used in regular schools, operate energy experience exhibitions, and participate in energy-saving activities in the local community. Second-year policy research schools report their performances and best practices in the debriefing sessions, maneuvering policies that would raise energy saving awareness in communities. The government of Korea provides instructors, grants, books, pamphlets, and other audio-visual materials to the currently operating 37 policy research schools.

B. Higher and professional education

1) Designation of climate change specialized graduate schools and thesis award competition

Climate change specialized graduate schools are designated and operated to establish a research foundation for climate change response and to cultivate professional human resources (Table 8-1). Designated graduate schools receive research grants from the government, conduct related research, and develop climate change curricula and education materials.

The research area includes GHG emission statistics, climate change impact assessment and adaptation measures, climate industry

management strategies, GHG mitigation measures, GHG inventory, climate change policies, and GHG mitigation analysis. These specialized graduate schools contribute significantly in building capacity for active responses to climate change by performing research, writing SCI level theses, and raising master and doctorate-level professionals. Since 2004, thesis award competitions for graduate students have been held to explore innovative policy options and foster climate change interest in the young and talented. The winners of the competition are given the Minister's Award and an internship opportunity at UNFCCC Conference of the Parties.

2) Customized education on climate change

In the era of lifelong learning, education for the general public and continuous professional training for government officials and experts are crucial. The targets for professional training are municipal officials in charge of energy and environment, management personnel in industries, and school teachers.

Through these training programs geared towards climate change professionals, the government of Korea provides information on climate change response and professional training to lay a foundation for fostering professionals that would contribute to sustainable growth. Such climate change responses include energy-saving and efficient usage, new & renewable energy development and dissemination, and GHG reduction technology. Korea has set fostering professionals in national GHG reduction and establishing low-energy consumption society as its educational mission. Accordingly, Korea strives to build nation-wide literacy on energy-saving and climate change through energy specific consumer education.

Professional education programs are largely classified into three training programs: energy management expertise, energy expertise, and climate change expertise. Training for energy management expertise aims to foster energy personnel in industries and raise energy-related technical professionals. Training for energy expertise includes education for local energy public officials, internships at energy-saving policy research schools, and education for public space staff. Training for climate change expertise includes education for GHG reduction performance verification specialists, climate change executive professional courses, GHG reduction implementation strategies, and energy management systems expertise training programs.

<Table 8-1> Application record of climate change specialized graduate school

(Unit: KRW Million)

	Type	2009		2010		2011	
		Budget	Number of project	Budget	Number of project	Budget	Number of project
Climate change specialized graduate school	New	1,460	8	-	-	450	3
	Continuous	750	5	2,210	13	1,760	10
	Total	2,210	13	2,210	13	2,210	13

Source: Korea Environment Corporation, Ministry of Knowledge & Economy

As such, through the operation of diverse but specialized education curricula that reflects national policy, current international and domestic issues, and the professional skills required, Korea is making an effort to foster green growth professionals that will build the national capacity for climate change response.

2. Publicity and public awareness

A. Publicity building through media

1) Television and advertising

The media's interest in energy and climate change is ever increasing as high oil prices and extreme weather events receive global attention. For this reason, the government and related companies have been raising public awareness via media such as TV, radio, newspaper and internet to foster climate change awareness amongst the general public.

Advancement in IT technology is rapidly changing people's lifestyles, diversifying the mediums that can be used for climate change publicity. As such, the government and public institutions are proactively utilizing day to day interactive mobile media such as free application programs for smart phones. Moreover, the government selected credible media to conduct special broadcasts, campaign advertisement, and promotional events that will raise public awareness regarding climate change response and GHG reduction programs.

2) Operation of publicity center and distribution of publicity materials

The *green energy experience center* was founded in 2000 for youth and children to encourage green living practices through direct experience with energy-saving, efficient use of energy and eco-friendly new & renewable energy. From 2005 to 2008, the *energy-saving mobile exhibition* was set up in local events and festivals to distribute publicity materials on energy-saving. Since 2010, the government of Korea green growth publicity events in cities, rural areas, and island districts, spreading the vision of green growth to every corner of the country. The government sectors are also operating mobile green growth experience

Source: Korea Energy Management Corporation

[Figure 8-1] Publicity poster and 3D video clip regarding saving energy to counteract climate change

Source: Korea Forest Research Institute

[Figure 8-2] Carbon tree calculator website & application

centers that will publicize the background, necessity, and vision of green growth to the general public.

Meanwhile, the government of Korea produces and distributes various types of energy-saving publicity materials to encourage energy-saving practice in daily life.

Particularly, there are posters that inform tips on energy-saving such as setting the appropriate room temperature during summer and winter time when there is an elevation in energy consumption. As well as leaflets that detail green practices that can be utilized in everyday life (Figure 8-1).

B. Awareness through civic education

1) Cyber education program

For the new generation that is accustomed to online activities, the government of Korea is intensifying online environmental education through related government ministry websites. The government of Korea has opened a homepage for elementary and middle school students, providing them with grade appropriate environmental education programs.

In particular, the general public's interest in climate change and its connection to their carbon footprint have increased over the past few years. This has led to the development of an online program entitled *Carbon Tree Calculator* (http://carbon.forest.go.kr/tree_carbon_calculator/) and *Carbon Footprint Calculator in 2006*. *The Carbon Tree Calculator* calculates the relation between carbon emissions from daily energy consumption and the number of trees needed to absorb the emitted carbon. This program was developed to raise public awareness on the importance of carbon sinks such as forests. The program was recently developed into a smart phone application in Korean and English for iPhone and Android users.

2) Expanding public education and fostering green leaders

The government of Korea operates diverse but specialized education curricula, which reflect national policy, current international and domestic issues, and professional skills - to foster green growth professionals. In particular, information on municipal energy projects,

systematic education on climate change response, and education on energy-saving and efficient use of energy are provided to municipal officials in charge of energy so these officials will acquire the management skills necessary to make them local energy experts.

Until recently, energy-saving and environment education has been targeted towards relevant personnel. However, after the government presented the national vision of *Low Carbon, Green Growth* in 2008, the recipients of climate change response and green growth education expanded to the general public.

Moreover, to train civic leaders that will play key roles in green growth, the government of Korea has fostered 20,000 *Green Leaders* and operated a *mobile climate school*. These programs provide grade-appropriate education that is divided into elementary, intermediate, and advanced levels. Intensive courses are provided for the intermediate and advanced level students to foster them as professional climate change instructors.

C. Raising public awareness through events

1) Climate change events

To celebrate the first anniversary of the implementation of the Kyoto Protocol in February 2006, the climate change-related industries held events during *Climate Change Week* to raise nation-wide awareness. The events, such as forums with industry CEOs, corporate response case study workshops, technology development strategy symposiums, and on-site experiences, were held throughout the week. The government of Korea is also collaborating with the media to encourage public participation and raise public awareness.

Since 1995, private environmental organizations have begun observing April 22nd as *Earth Day and have held an annual* commemorative ceremony. The private organizations have conducted various localized events such as *car-free streets* and a *grand march on bicycle*.

Also, Korea has designated June 5 as a legal anniversary of *Environment Day*. On this day, various environmental conservation events are held throughout the country, including a government commemoration. Government officials, environment NGOs, and related corporate bodies take part in commemorating this day. Local governments also hold seminars, campaigns, and cultural events to celebrate the occasion.

In addition, the government of Korea designated August 22nd as *Korean Energy Day* in order to nationally reduce electricity consumption. This date recognizes the largest single day of electricity use, back in 2003. Since 2004, national lights-out and cultural events have taken place for the energy-saving movement. *Korean Energy Day* is an event that uses cultural approaches to engage people in the energy-saving issue and this event has become the first occasion when the whole nation goes lights-out at the same time. After the lights-out event, all people turn on their lights again using electricity generated from solar power and human motion. This event raised awareness regarding new & renewable energy and distributed electricity supply.

The 8th *Korean Energy Day* event took place in 16 regions (including Seoul) in 2011. On the day, all air conditioners and lights were turned off, saving 400,000kW of electricity in one day. At 9 o'clock at night, the whole nation turned on the lights again. About 400,000 individuals, several organizations, and corporations participated in this event. During the event in Seoul Plaza, many participatory programs such as a creative singing contest related to energy, human power experience events, and exhibitions and trial booths concerning new & renewable energy and energy-saving took place and grabbed people's attention and interest.

Since 2008, to publicize the important role of forests as carbon sinks and raise nation-wide public awareness on global warming, the week of Arbor Day was designated as Climate Change and Forest Week and related events have been held throughout the week. In 2010, the government of Korea hosted the 23rd International Union of Forest Research Organizations (IUFRO) where three thousand delegates from 93 different countries participated. Through this event, the government of Korea had the privilege of spreading its *Low Carbon, Green Growth* paradigm internationally by actively participating in such international discussions on forestry. Using this event as a stepping stone for advancement, Korea hopes to be a leading country in forest science.

2) Related contests

Korea is committed to spreading practices that would alleviate climate change through various cultural avenues such as unique exhibitions and contests. Events such as singing contests for elementary students, production of energy-conservation K-pop songs, a green life K-pop contest, public essay contest on energy-saving and transport, and other various types of campaigns were held to stimulate public participation from all different backgrounds and levels.

Since 2007, the best urban forests with excellent ecological health and socio-cultural features have been awarded *the Urban Green City Best Practice Award*, which encourages the expansion of urban forests that are increasing in popularity and public accessibility.

3. NGO activity and private-public cooperation

NGO cooperation and public-private partnership are essential for the government to implement practical and effective climate change response policies. The Korean civil society recognizes climate change and energy issues as a central task for sustainable development in Korea and has extended climate change mitigation activities by creating a voluntary citizen network and also proposing policies and encouraging citizen action through the network. In addition, Local Agenda 21 - a new public-private partnership model for local sustainable development governance - shares local sustainability and climate change issues with various members of the community, fosters policy responsibility in municipal governments, and encourages the daily practice of green living through the Green Start Network.

A. NGO activity

Korean NGOs are playing an important role in raising public awareness on the impact of climate change and on the importance of actively responding to it. In 2000, NGOs launched *Korea NGO's Energy Network (KNEN)* to expand the campaign for voluntary energy-saving and to develop a sustainable energy system.

KNEN consists of 270 NGOs that represent various organizations in fields such as the environment, consumer protection, women's rights, and youth. These organizations come together to form an energy network that produces synergic projects such as the *energy -saving in one million households campaign, green energy movement in apartments, municipal energy ordinance amendment campaign*, *energy/climate change education*, and *energy over-consumption survey*. In particular, the *Energy-saving in One Million Households Campaign* has received a favorable response from the public because the campaign gave them an incentive to conserve energy by rewarding the volunteer participant households for their energy-saving efforts. The central and municipal governments institutionalized these types of campaigns with incentives throughout the country. Some other examples of incentives include *Carbon Point System* and *Eco Mileage*.

KNEN also has been concentrating its efforts into holding practical campaigns such as the *campaign for public transport usage*, *campaign for bicycle and non-motor transport*, and *save energy through unplugging campaign*. KNEN is expanding the energy conservation campaign to become a mass public movement through events such as the *nationwide simultaneous lights-out event, unplugged concert*, and other events that publicize recreational activities that do not require electricity. By holding various nationwide cultural events as mentioned above, KNEN had been providing avenues for the general public to learn about energy issues in informal but interesting ways.

As a private non-profit institute, *Institute for Climate Change Action* is pursuing to explore policies and measures on climate change by sharing the relevant information with the general public. This institute is engaged in various activities such as conducting research on climate change policy regarding mitigation and adaptation, publishing books, releasing periodical newsletters, providing lectures and discussion for the public, and on climate change. The institute continues to organize *2030 Energy Alternatives Forum* for effectively establishing and implementing policies for addressing climate change. The institute is also organizing a monthly forum of climate change, training course for realizable low-energy house, water way expedition camp. And the books regarding climate change are published such as *Cultural History of Climate (2010)* and *From Copenhagen to Cancun (2010)*. The institute is making an effort to taking practical measures by hosting the public seminars and debates on carbon tax, heavy rains, meteorological disasters, etc.

B. Local Agenda 21 and Green Start Network

1) Local Agenda 21

NGO-government partnership is essential to achieve efficient climate change policies. Since 1997, the preparation handbook *for Local Agenda 21* was created for sustainable development of local areas. The handbook was used to spread *Local Agenda 21* for public-private partnership. As a result of this effort, 222 out of 246 local governments have implemented *Local Agenda 21* and 93 local governments have installed private executive offices to incorporate public-private partnership for local sustainable development.

Local Agenda 21 is a local governance that various organizations (such as the local government, parliament, and civil society) come together to take part in. *Local Agenda 21's* main challenge is climate change and energy issues. As such, policies for GHG reduction, climate change response, local energy supply planning, new & renewable energy extension, sustainable consumption and production, public transportation utilization, and bicycle-use extension are implemented by local governments under the support of the central government. Many education and training programs are planned and operated to extend public interest and participation. Related policies are monitored for their implementation progress.

In particular, the Local Sustainability Alliance of Korea - Korea's network for *Local Agenda 21* - created the network for climate change response within itself to map out an agenda for energy, consumption, and transport and also to promote projects. Also an annual nationwide convention is held to award excellent sustainable development projects and to extend community interest and participation.

2) Green Start Network

The Green Start Network was launched in 2008 with the goal of reducing the GHG emission in the non-industry sector through citizen participation and action. The Green Start Network operates a climate change school and fosters local green leaders for the reduction of local GHG emission and establishment of a green lifestyle culture. Moreover, the Green Start Network fosters climate change literacy in general public through the operation of *Climate Change Week* and the operation of public rewards for green life ideas.

Public institutions such as local government and organizations such as *Local Agenda 21* participate in the Green Start Network and 226 local networks are playing active roles.

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