Democratic People's Republic of Korea

Environment and Climate Change Outlook

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Acronyms and Abbreviations

A1FI	A high emissions scenario
A1B	A mid-range emissions scenario
AITRC	Agricultural Information Technology Research Center
ALGAS	Asia Least-Cost Greenhouse Gas Abatement Strategy
B1	A low range emissions scenario
AAS	Academy of Agricultural Sciences
AOS	Academy of Sciences
BB, AoS	Biology Branch, Academy of Sciences
CDM	Clean Development Mechanism
CEMSA	Central Environmental Monitoring and Supervisory Agency
CSB	Central Statistics Bureau
STDPIR	State and Trends, Driver and Pressure, Response
DSS	Dust and Sand Storm
DPR of Korea	Democratic People's Republic of Korea
ECCO	Environment and Climate Change Outlook
EDC	Environment and Development Centre
EIA	Environmental Impact Assessment
EMP	Environmental Management Plans
GEO	Global Environment Outlook
GCM	General Circulation Model
GDP	Gross Domestic Product
GIS	Geographical Information System
GHGs	Greenhouse Gases
MDG	Millennium Development Goals
MLEP	Ministry of Land and Environment Protection
NCGFS	National Crop Growth Forecasting System
NCCE	National Coordination Committee for Environment
NCPC	National Cleaner Production Centre
NOE	National Ozone Unit
ODS	Ozone Depleting Substances
POPs	Persistent Organic Pollutants
ROAP	Regional Office for Asia and the Pacific
RRC AP	Regional Resource Centre for Asia Pacific
SEA	Strategic Environmental Assessment
SHMA	State Hydro-Meteorological Administration
SoE	State of the Environment
SRES	Special Report on Emission Scenarios (IPCC)
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

Foreword

Democratic People's Republic of Korea

Global environment issues including climate change affect our quality of life, our opportunities for sustainable development and the ecosystem services we rely on. Protecting the natural environment and human populations from the negative impacts of economic growth such as air and water pollution, destruction of biodiversity, forest depletion and land degradation is a common task for all countries. Mainstreaming environmental considerations into development activities is an essential component of advanced planning for sustainable development and a necessary condition to make the earth as the foundation of life and happiness for the existence and development of humankind forever.

The great leader comrade Kim Jong Il said:

"To provide more favorable natural environment for the existence and activities of human beings by conducting sound environment protection work is the intrinsic demand of the man-centered socialism of our own style."

Mindful that environment protection is of great importance for the construction of a powerful and prosperous nation and the independent and creative life of its people, the government of DPR of Korea has placed primary importance on the prevention of environment pollution and the integration of environmental considerations into socioeconomic development activities.

Accurately monitoring and assessing the state of environment and how it is changing is an essential precondition to establishing appropriate strategies for the sustainable and the rational use of natural resources. The United Nations Conference on Environment and Development emphasized the importance of regular environment assessment and reporting at national, sub-regional and global levels in Agenda 21, a road map for the sustainable strategies in the 21st century. The government of DPR of Korea prepared its first State of the Environment Report in 2003 with the cooperation of UNDP and UNEP and used it to establish resource management and conservation activities.

The Environment and Climate Change Outlook Report (ECCO) provides a detailed update to the 2003 State of the Environment report, highlighting important issues and trends that have emerged in recent years and clarifying key national responses to protect and improve the environment. The ECCO Report synthesizes the results of extensive scientific research. It outlines both current environment conditions and actions for improvement. The ECCO Report also includes observations of climate change, impacts on natural and human systems, scenarios of future change based on regional modeling, and adaptation responses.

We are convinced that the ECCO Report will make a meaningful contribution to informed and strategic decision making to advance the sustainable socioeconomic development of the country and protect the splendor of its natural environment.

We express our gratitude to UNEP for their financial and technical assistance in the preparation of the ECCO Report and thank the relevant agencies that provided information and wholehearted assistance for the preparation of the report.

Ri Hung Sik
Secretary General
National Coordinating Committee for Environment
DPR of Korea

Foreword

United Nations Environment Programme

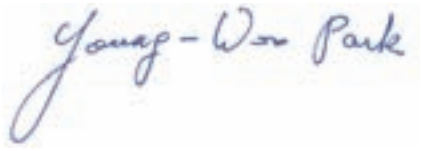
The United Nations Environment Programme (UNEP) is mandated to keep the state of the global environment under review. This mandate is implemented through the Global Environment Outlook (GEO) process, which involves supporting global, regional, sub-regional, national and city-level assessments. The GEO process is participatory, consultative, and focuses on capacity-building to produce scientifically authoritative information for environmental management and policy development for a wide target audience.

The Democratic People's Republic (DPR) of Korea Environment and Climate Change Outlook Report (ECCO) is an important product of this process, which UNEP has supported through technical assistance. This report includes a synthesis of national studies and monitoring programmes that have taken place since the first State of Environment Report was released in 2003. It analyses key environmental issues in the country and is expected to guide environmental policy, strategy development and planning in coming decades.

Observations of long term temperature and precipitation trends in DPR of Korea suggest that the climate has changed over the last century with more rapid change occurring in recent decades. Extreme cold events have become less common while extreme hot events have increased in frequency. Climate change is a significant concern since many human and environmental systems are already vulnerable to climate variability. Agricultural production is likely to be significantly affected by changes in the timing, frequency, location and intensity of precipitation. Floods and droughts over the past two decades have caused considerable damage and greatly reduced agricultural productivity. This has had disastrous effects on people's livelihoods and wellbeing and resulted in declines in the gross domestic product.

Economic development, population growth and the impacts of climate change have made environmental protection an important issue in the DPR of Korea. Environmental management priorities include increasing the efficiency of natural resource use, restoring degraded ecosystems and protecting biodiversity, and introducing new technologies and practices that minimize air, land and water pollution. Most importantly, mainstreaming environmental considerations into economic development will set the foundation for achieving sustainable development.

We hope that the technical assistance provided by UNEP has contributed to building the capacity of the Ministry of Land and Environment Protection in the area of assessment and reporting on the state of environment, as well as identifying emerging issues and policy options for action to improve environmental management in the DPR of Korea.



Young-Woo Park
Regional Director and Representative
United Nations Environment Programme
Regional Office for Asia and the Pacific

About the ECCO Report

Regularly assessing the state of the environment and identifying changes over time are essential for devising a sustainable development strategy and informing decisions for the protection, management and rational use of environmental resources. Decision makers and technical experts within the DPR of Korea have built their capacity for integrated environmental assessment and reporting through the preparation of major reports and participation in training programs. In 1999, the DPR of Korea prepared the "Asia Least-cost Greenhouse Gas Abatement Strategy" (ALGAS) and Greenhouse Gas Emissions (GHGs) inventory. In 2000, it prepared its "First National Communication under the Framework Convention on Climate Change"; and in 2003, its first "State of the Environment" report. These reports informed planning and environmental management and brought attention to the importance of environmental trends, particularly climate change, in decision-making.

The Environment and Climate Change Outlook (ECCO) report provides an important update to the 2003 State of the Environment by identifying environmental and climate change trends that have occurred in recent years. The ECCO Report contains an analysis of key environmental issues that is expected to guide environmental policy, strategy development and planning in the coming deca des.

The ECCO Report describes the state and trends in the environment and the drivers and pressures that influence them. It is also identifies impacts on people and describes policy measures that have been introduced to address the situation and reduce threats to socioeconomic development and human wellbeing.

Chapter 1 provides an overview of the country, including geographic, climatic and demographic information. It also describes the governance and institutional arrangements for environmental management in DPR of Korea. Chapter 2 provides an assessment of the atmospheric environment including pollutants, greenhouse gas emissions, and dust and sand storms. Chapter 3 discusses the state of fresh water resources. Chapter 4 provides an assessment of forest and soil resources including solid waste management. Chapter 5 examines the state and trends in biodiversity. Chapter 6 provides an assessment of climate change observations, impacts and adaptation strategies. It also explores climate change projections for the region and analyses extreme temperature and precipitation events. Chapter 7 provides conclusions and recommendations for action.

The assessment uses a State and Trends, Drivers and Pressure, and Response (S-T-D-P-I-R) analytical framework that makes use of available monitoring data and scientific research. The report is a nation-wide analysis of biophysical and socioeconomic conditions and trends in the country, and the national responses designed to balance human and ecosystem wellbeing. The ECCO report seeks to be a source of information and guidelines for policy makers and practitioners to support decision making for sustainable development, and contribute to planning that will mainstream environmental protection into economic development. In addition, the assessments should increase public awareness and understanding of the state of environment and foster community engagement.

The ECCO report was prepared by the Ministry of Land and Environment Protection (MLEP) in collaboration with the Central Bureau of Statistics (CBS), the Ministry of Agriculture (MA), the Ministry of Chemical Industry (MCI), the State Academy of Science (SAoS), the Environment and Development Centre (EDC) and related experts. Financial and technical support was provided by the United Nations Environment Programme (UNEP).

Executive Summary

Introduction

The Democratic People's Republic of Korea encompasses approximately 123,138 km^2 of land in the east of the Asian continent that is endowed with a wealth of natural resources. Much of the country is mountainous and densely covered in forests. There is a diversity of ecosystem types including forests, wetlands, river systems and marine areas that provide habitat for an abundance of different species, many of which are unique to the country. The country has a population of just over 24 million and has a rich cultural heritage with many sites and structures of international importance.

The government of the DPR of Korea has always placed great importance on the socioeconomic development of the country. In recent decades resource-intensive economic development, population growth and the impacts of climate change have resulted in an increased emphasis on environmental protection. Environmental management priorities include increasing the efficiency of natural resource use, restoring degraded ecosystems and protecting threatened biodiversity, and introducing new technologies and practices that minimize air, land and water pollution. Mainstreaming environmental considerations into economic development will set the foundation for achieving sustainable development.

Environmental protection and sustainable development are long-term imperatives that require integrated and proactive planning and action. Understanding the current state of environment and the natural and anthropogenic pressures that cause unwanted environmental change are important for decision making since socioeconomic well-being is closely related to the condition of natural resources and the provision of ecosystem services.

The Environment and Climate Change Outlook (ECCO) is an important milestone in the ongoing process of environmental assessment and reporting in the DPR of Korea. The information and conclusions contained in the report include a synthesis of numerous studies and monitoring programs that have occurred since the preparation of the previous State of Environment Report in 2003. The ECCO Report contains an analysis of key environmental issues and is expected to guide environmental policy, strategy development and planning in the coming decades. The ECCO Report contains seven chapters that describe the state and trends in the environment and the drivers and pressures that influence them. It is also identifies impacts on people and describes policy measures that have been introduced to address the situation and reduce threats to socioeconomic development and human wellbeing. The following provides a brief summary of the report.

Air and Atmosphere

Air quality

The DPR of Korea makes use of coal for producing much of its electricity and as a fuel for industrial processes. Some infrastructure associated with thermal electricity production, smelting, and other energy intensive industrial processes is no longer operating at peak efficiency. This is affecting air quality, particularly in areas in close proximity to thermal electrical and energy intensive industries as measured by levels of sulfur dioxide, precipitated dust and other pollutants. Air quality at emission intensive sites tends to be worse in the winter months when electricity demands are greater and meteorological conditions are less favorable to pollutant dispersal. In cold periods coal is also burned in greater quantities in urban residences for heating and cooking. Air quality in rural areas is more affected by the combustion of wood for cooking and heating since it is the predominant fuel. As a result, indoor air quality may be a concern although no studies have been undertaken to date.

Air quality at certain sites (close to power plants and industrial areas) periodically exceeds environmental standards. At present the monitoring program is limited in the number of locations covered and the pollutants monitored.

Ozone depleting substances

The DPR of Korea is a party to international agreements to reduce the use of substances that deplete the ozone layer. These agreements include the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer including the London, Copenhagen, Montreal and Beijing Amendments. As part of its obligations under these agreements, the DPR of Korea has made inventories of its sources of ozone depleting and has taken active steps to phase them out over time.

Over the period 2006-2010 the country implemented the National Phase-out Project through which is successfully eliminated the use of CFCs in the service sector. In keeping with its obligations under the Montreal Protocol the country is now focusing on freezing the production of HCFCs by 2013 and then reducing their consumption by 2015.

Greenhouse Gas Emissions

The DPR of Korea is a signatory to the United Nations Framework Convention on Climate Change and the Kyoto Protocol. In 2007, the country emitted a combination of greenhouse gases equivalent to just about 94 million tonnes of carbon dioxide. That represented around 0.32 percent of the global emissions for that year.

The primary source of greenhouse gas emissions in the DPR of Korea is combustion of fuel for energy. This accounted for about 90 percent of the country's greenhouse gas emissions in 2007. Industrial processes, agriculture and waste related emissions made up the remainder. Emissions dropped significantly between 1990 and 2007 due to an economic contraction. Carbon sequestration from forests and land use fell over the same period due to forest conversion and deforestation.

Emissions are projected to increase in the future as a result of increased economic output and population growth. The DPR of Korea hopes to minimize growth in its emissions by introducing new technologies and renewable energy, in part through participation in the Kyoto Protocol's Clean Development Mechanism or its successor.

Dust and sand storms

Air quality in the DPR of Korea is periodically affected by severe dust and sand storms that originate in desert regions of China and Mongolia where deforestation and excessive water extraction have occurred. Dust is carried over long distances by strong northwest winds gusting in the lower atmosphere.

Dust storms hinder air and road transportation, and aggravate human respiratory conditions such as asthma and bronchitis. The dust can damage crops, interfere with industrial processes, contaminate waterways, increase sediment loads and may require the diversion of limited resources to clean up urban areas.

Water

Water supply

The DPR of Korea has considerable freshwater resources including large lakes and rivers as well as many smaller tributaries. The abundant rainfall and mountainous nature of the country have allowed for the construction of many hydroelectricity dams and irrigation networks. There are more than 1700 artificial reservoirs in the country.

Population growth and economic development have increased the demand for water for industrial, agricultural and domestic uses, most of which comes from surface sources. The primary challenge of water supply management is capturing water from heavy summer rains to avoid flooding and using the water during dry months when there are shortages. Dams and reservoirs have played an important role in meeting demand for industrial, agricultural and potable water and minimizing flooding. Nonetheless, considerable flood and drought damage still occur as a result of adverse weather events.

Water quality

Water quality is a concern in several rivers, especially during the December to March period when there is less water in the river systems. Major rivers including the Taedong, Amnok, Tuman and Chongchon supply drinking, industrial and agricultural water. However, the quality of these rivers has been degraded, mainly in the mid and lower sections. The majority of water pollutants come from the discharge of industrial wastewater and untreated sewage, particularly in rural areas where facilities are inadequate or absent altogether. Runoff from agricultural land is another source of contaminants, while soil erosion in deforested areas adds large sediment loads to waterways. The existing water quality monitoring program is limited and is unable to provide accurate information on the quality of water in different systems across the country.

Land, forest and soils

Deforestation and forest degradation

Forests are the dominant ecosystem in the DPR of Korea and as such represent both an important habitat as well as a key natural resource for economic development. The relative scarcity of arable land has resulted in the conversion of some previously forested areas to agricultural production in order to ensure adequate food for a growing population. Canopy cover and forest density have also been affected by harvesting for fuel and building material. The quality and extent of forest cover has declined, especially since the mid-1990s when economic difficulties led to shortages of energy and food.

Given the dominance of forest ecosystems in the DPR of Korea and their economic, social and environmental importance, preventing further forest degradation and undertaking large scale forest restoration is of critical importance. Considerable efforts have been made in recent years to protect and rehabilitate the nation's forests.

Soil quality

Unsustainable agricultural practices have resulted in soil erosion, compaction and acidification and have reduced soil depth and limited agricultural productivity in some areas. In coastal areas, some tideland rice fields are characterized by low nutrient soils and have declining silicon content from continuous freshwater irrigation. This has negatively affected soil quality and productivity.

Although most land is in the DPR of Korea is not affected by pollution, domestic waste and fly ash from cities are sometimes applied to arable land around cities for the purpose of preventing soil acidification and to enhance soil structure. Sludge from wastewater treatment plants is used as an organic fertilizer. This soil amendment may not meet environmental standards and is a potential source of contamination at sites where it is applied.

Biodiversity

The DPR of Korea has abundant biodiversity relative to its size, although much of it is reliant on forest habitat which has been negatively impacted by deforestation and climate change. Overuse of natural resources is closely related to population growth and the areas with greatest biodiversity loss tend to be closer to human settlements. Fresh water systems are an example of this with water quality decreasing in proximity to settlements and industrial areas and in the lower reaches of rivers. This has negatively impacted freshwater biodiversity. Marine ecosystems, coastal tidal flats and wetlands provide important habitat for migratory birds of Northeast Asia and are also under pressure from development and agriculture.

There are 2 extinct, 8 critically endangered, 46 endangered and 105 vulnerable species of animals in the DPR of Korea and 153 varieties of threatened or endangered plants. Although legislation and regulations exist to protect biodiversity and manage natural resources, the response needs to be enhanced in order to meet conservation goals. The system of protected areas that have been established do not represent the full spectrum of threatened species and habitats and are diminished by fragmentation and threatened by encroachment. Climate change is expected to exacerbate the situation.

Climate change

Observations of climate change

Observations of long term temperature and precipitation trends in DPR of Korea suggest that the climate has changed over the last century with more rapid change occurring in recent decades. Over the period from 1918 to 2000 the average temperature increased by 1.9°C. This represented one of the fastest rates of warming among Asian countries. During the same period, severe cold events became less common while the frequency of heat waves increased.

Climate change is a significant concern since many human and environmental systems are already vulnerable to climate variability including droughts and floods. Heavy rainfall events have exacerbated soil erosion in areas where forest cover has been removed and increased sediment loads in waterways and reservoirs.

Forest quality is likely to be impacted by climate change as a result more frequent extreme temperature and precipitation events, forest fires and an increase in pests

and diseases. This will have follow-on effects on local livelihoods and biodiversity. Given that much of the DPR of Korea is mountainous and forested, changes in the quality of forest ecosystems and warming at higher altitudes will alter species composition, to the disadvantage of some flora and fauna. Many species that are already endangered will be at greater risk from changing climate conditions.

Projections of future change

An analysis of 21 global circulation model projections suggests that on balance precipitation will increase across the country although changes are not expected to be uniform. Higher average precipitation could lead to increased flooding, landslides and mud flows if it occurs in the already wet summer months, or if it comes in the form of heavier rainfall events as has been observed in recent years. Extreme rainfall events are projected to increase in frequency, as are average, minimum and maximum temperatures. This will place considerable stress on crops and livestock, human health, infrastructure and ecosystems such as forests and waterways.

Adaptation to climate change

Ensuring that socio-environmental systems are resilient to climate change will require careful planning and adaptation. This will include developing crops and agricultural production methods that are capable of coping with greater extremes of temperature and precipitation, preparing health systems for new disease vectors and other impacts on human health, upgrading infrastructure, reviewing the adequacy of protected areas and species in light of future climatic conditions, and preparing a planned retreat from coastal areas that will be affected by sea level rise and coastal erosion.

Conclusions and recommendations

Effectively responding to environmental conditions in the DPR of Korea will require a comprehensive and integrated approach with adequate resources and technical capacity building. Advancing the objectives of sustainable development will necessitate an iterative management process. Such an approach will be strengthened by the adoption of international best practice in environmental monitoring and management, and knowledge sharing across government agencies. Research, investment and policy responses should be assessed against sustainability principles and criteria and prioritized on the basis of their contribution to improvements in human wellbeing and ecosystem health.

In general, the response should be consistent with the following principles:

- Improvements in the state of the environment are necessary for social, cultural and economic wellbeing.
- Information and recommendations from the ECCO Report should be integrated into planning processes across government agencies.
- Follow-on responses should be evaluated against the level of contribution they make to arresting negative environmental trends, restoring degraded ecosystems and improving human health and well-being.
- Emphasis should be placed on actions with co-benefits that improve food security, strengthen local livelihoods and provide alternative energy sources so as to reduce the key drivers of ecosystem degradation.
- Effort should be made to encourage gains in resource use efficiency and provide incentives to switch to alternative lower impact inputs in industrial, manufacturing, residential and energy production processes.
- Legislation and policy should be accompanied by targets against which performance can be evaluated using clearly defined criteria, indicators and monitoring processes.
- A systems-based approach that encourages inter-agency cooperation, institutional learning and adoption of best practice will make faster progress in reversing negative trends, restoring degraded systems and advancing sustainable development objectives.
- An integrated environmental management approach should be adopted that includes Strategic Environmental Assessment (SEA) for the analysis of policies and development plans, Environmental Impact Assessments (EIA) for determining potential impacts and mitigation measures, and Environmental Management Plans (EMP) for the managing and monitoring of specific developments.

CHAPTER 1

Country Overview

1. Country overview

1.1 Geography and climate

The Democratic People's Republic of Korea is located in the temperate region of North-East Asia. It has a mild climate with four distinct seasons: spring, summer, autumn and winter. The continental landmass of Asia and the surrounding oceans influence the climate, which is typically humid in the summer and cold and dry in the winter. The average temperature is between 9°C and 10°C, with an average summer temperature of 24°C (Jun-Aug) and an average winter temperature of -5.5°C (Nov-Feb). The annual average precipitation is between 1,000 - 1,200 mm and varies by region.

The total land area of the DPR of Korea is approximately 123,138 km^2. Most of this area is mountainous. In 2005, forests covered approximately 89,273 km^2 or 73 percent of the country. Table 1.1 shows the land use status in 2005. Figure 1.1 illustrates the relative proportion of the different land uses.

Table 1.1
Land use (km^2) in 2005

Land Use	2005
Forest land	89,273
Agricultural land	20,421
Industrial land	2,063
Water bodies	7,374
Residential land	1,659

Source: Central Statistics Bureau 2010

1.2 Administrative arrangements

The DPR of Korea is divided into 5 zones (western north, eastern north, middle, eastern south, western south) based on geography and customary administrative areas. There are nine provinces: Ryanggang, North Hamgyong, South Hamgyong, Gangwon, Jagang, North Pyongan, South Pyongan, North Hwanghae and South Hwanghae. Provinces are further divided into 210 cities (districts) and counties. Counties consist of ri-s (gu- and dong-), the smaller geographical units, and up, the county seat. Cities (districts) consist of dong-s. In large cities, dong are grouped into districts. The nation's capital is Pyongyang, a city of approximately 3.26 million people.

1.3 Socioeconomic conditions

Population

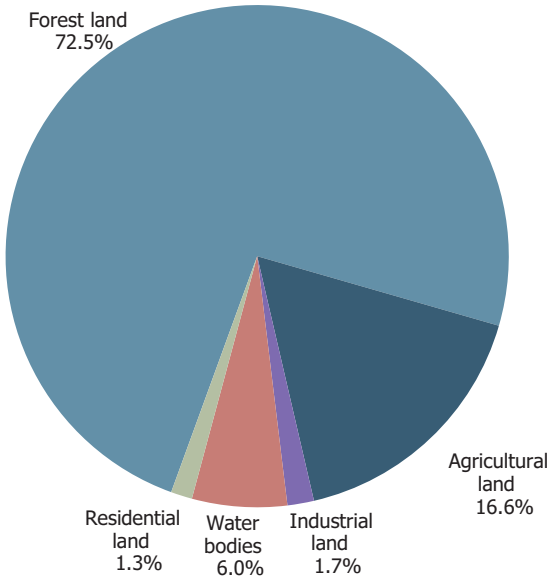
In 2008, the population of the DPR of Korea was approximately 24.05 million: 48.7 percent male and 51.3 percent female.

The DPR of Korea has a young population with 62.8 percent under the age of 40. Figure 1.2 on the opposite page shows the growth in the population since 1990. The population grew at an annual rate of about 0.86 percent from 1991 to 2008.

Figure 1.3 shows the breakdown of the population by age group. Females constitute 58 percent of the population over 50 years of age, and 72 percent of the population over 70 years of age. The average life expectancy of both groups combined is 69.3 years.

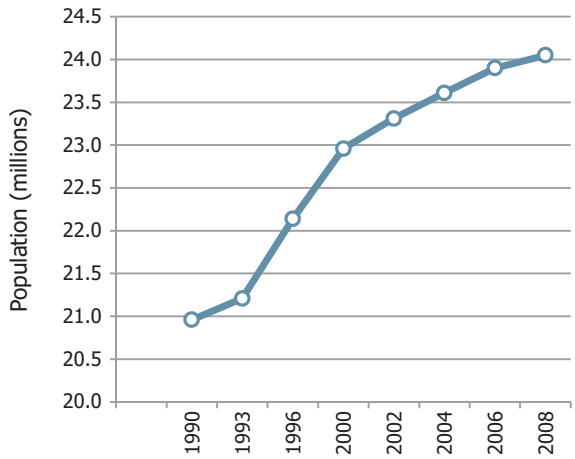
About 60.6 percent of people lived in urban areas and 39.4 percent in rural areas. Figure 1.4 on the next page shows the distribution of the population by province. There are approximately 5.9 million households. Figure 1.5 on the next page illustrates the number of households by size.

Figure 1.1
Land use in 2005



Source: Central Statistics Bureau 2010

Figure 1.2
Population growth



Source: Central Statistics Bureau 2010

The live birth rate was 14.4 per 1000 people in 2008. Mortality (number of deaths) was about 9.03 per 1000 people in the same year.

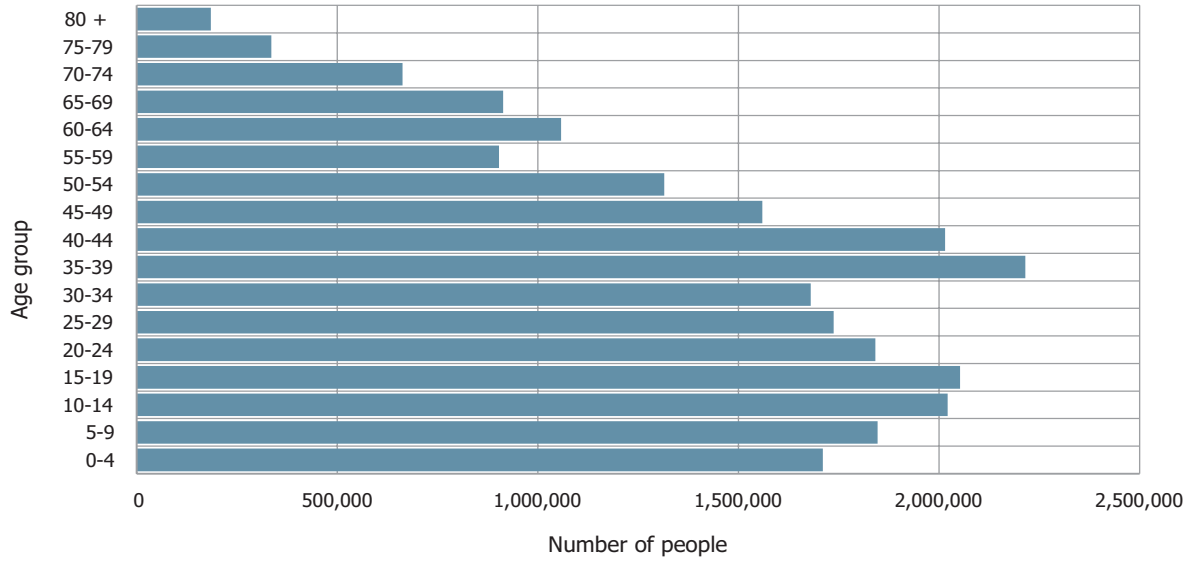
Public health

The DPR of Korea has a free universal medical care system provided by the state and mandated in the "Law on Public Health". Medical care is delivered from the central level to the province (city), county (district) and ri (dong) levels.

The medical system emphasizes a policy of preventive medicine. Sector-doctors are provided at the village or apartment block level and assist health workers to fulfill their roles in residential areas and in factories, enterprises, co-op farms, schools, cultural and welfare facilities and public institutions. Through regular medical examinations and consultations the system contributes to the preservation and improvement of people's health. Medical practitioners in DPR of Korea use a combination of Western medicine and traditional Koryo medicine in the treatment of diseases and the promotion of well-being.

Hospitals specializing in respiratory, circulatory, dental and obstetric medicine exist in provinces (cities) and counties (districts) and in major population centers as indicated in Table 1.2 on the next page. Specialized sanatoriums have been established throughout the country to promote public health and community well-being. Medical research on various diseases is conducted through scientific institutions located in major population centers.

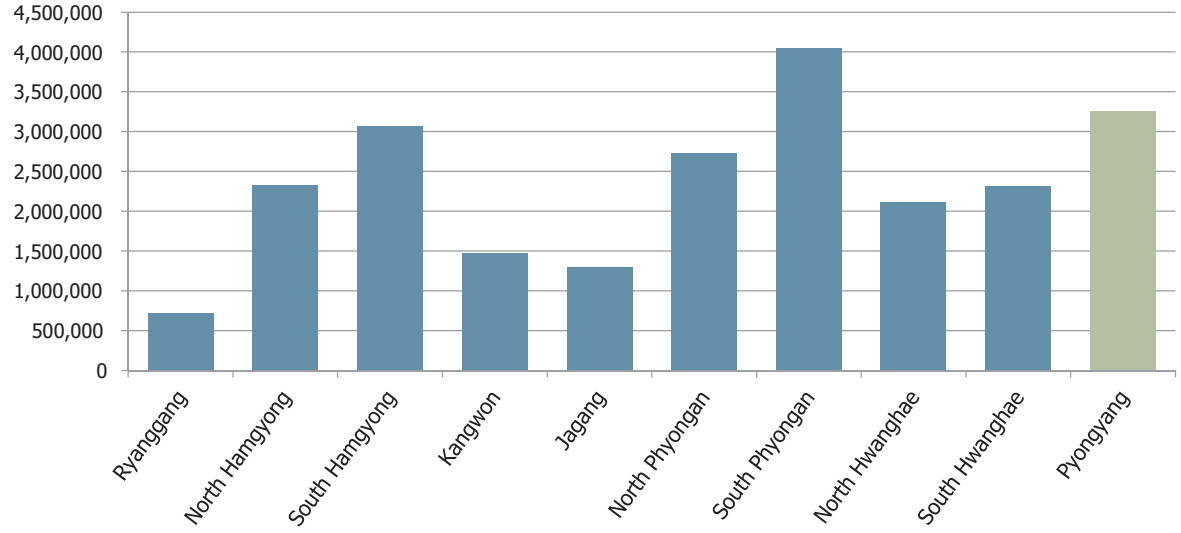
Figure 1.3
Population by age group



Source: Central Statistics Bureau 2008

Figure 1.4

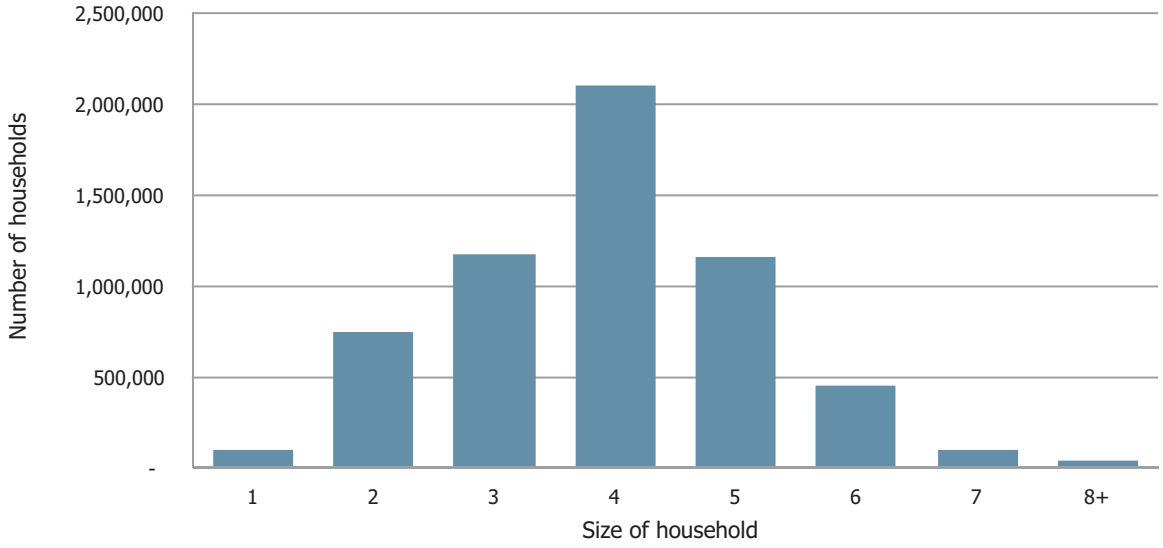
Population by province (2008)



Source: Central Statistics Bureau 2009

Figure 1.5

Household size (2008)



Source: Central Statistics Bureau 2009

Table 1.2

Number of medical and preventive institutions by administrative units (2007)

Classification	Hospital			Clinic	Preventive centre	Sanatorium
	Central, provincial	County	Ri			
Units (no.)	133	601	974	6,263	55	682

Source: Central Statistics Bureau 2010

Education

In the DPR of Korea education is provided for free by the state as mandated through legislative and institutional mechanisms identified in the "Law on Socialist Education", the "Thesis on Socialist Education" and the "Law on Science and Technology". The commitment to universal free education has been implemented progressively since 1956 (Table 1.3).

The education system is composed of a combination of compulsory and optional programs to address the needs of students of different skill levels, occupational pathways and locations. The system includes primary/secondary general education (which includes the universal 11-year compulsory education), post-secondary and tertiary education, correspondence, work-study programs, remote education and advanced training for students demonstrating exceptional ability.

The universal compulsory education consists of one year of kindergarten, four years of primary school and six years of secondary school. All students have the opportunity to pursue higher education on completion of the compulsory program. Students who choose this pathway receive four to six years of professional education at a university or two to three years of training at a college and obtain a bachelor degree or technical qualifications respectively. A work-study program ensures that people employed in industry sectors receive professional training in factory, farm and fisheries management to supplement their practical knowledge.

Figure 1.6 on the next page shows the field of study among the population who have completed at least three years of post-secondary education. The majority of people pursue training in health, primary industries (agriculture, fisheries, and forestry), engineering, business and administration, and teaching.

The government is training experts and technicians in fields related to environmental protection as a way to build capacity and raise public awareness of environmental issues. Universities including Kim Il Sung University, University of Construction and Building Materials and Pihyon University of Land Management have established faculties and departments in environmental management relevant to different industry sectors. Other universities have developed courses and curricula relevant to environmental protection and contemporary environmental issues (e.g. climate change). Currently, the number of students enrolled in these programs is low compared to the need. However, many students are entering careers in environmental management from an academic background in science, engineering or public administration.

Figure 1.7 on the next page shows the breakdown of the population 16 years and older by occupation. The majority of the working age population are engaged in primary industries (agriculture, fisheries, and forestry), followed by industrial and manufacturing jobs.

Table 1.3

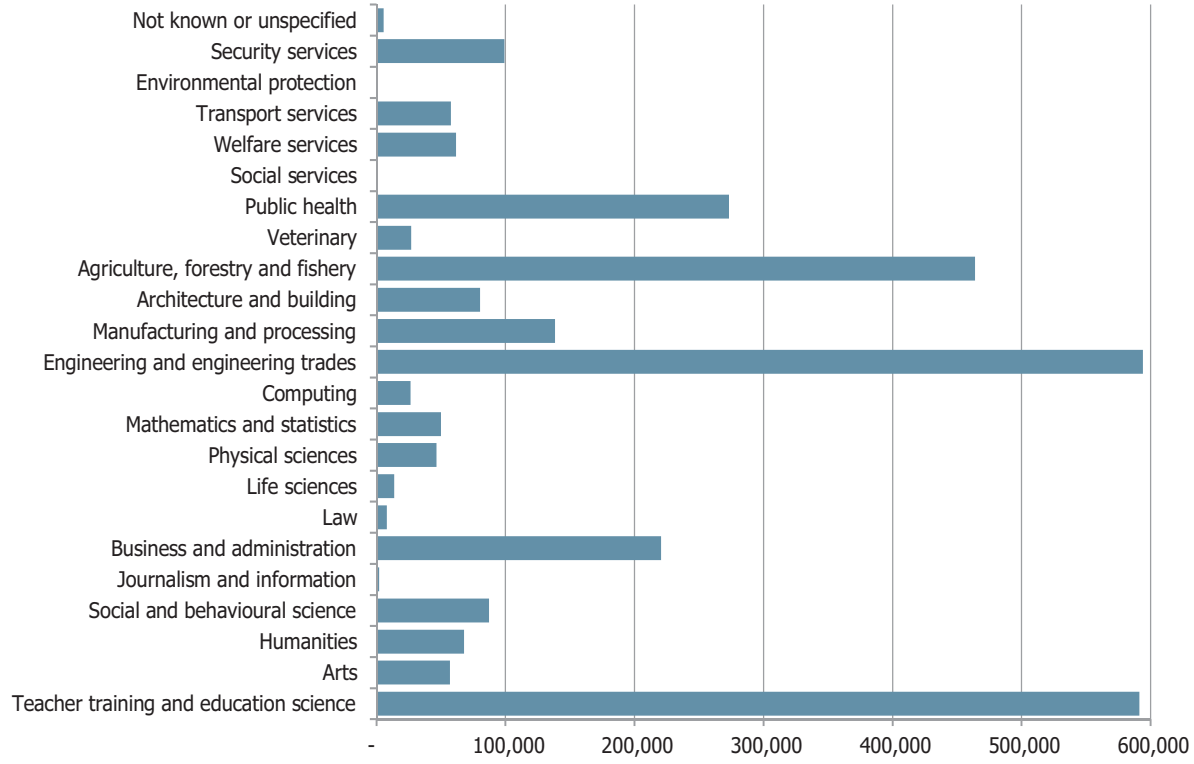
Major political measures to enforce universal free education

Policy	Year
Compulsory primary and abolition of tuition fees	1956
Compulsory secondary and abolition of tuition fees	1958
Free education	1959
Compulsory 9-year education	1967
Compulsory 11-year education	1972
Law on Nursing and Upbringing of Children (codification of existing policy)	1976
Theses on Socialist Education (codification of existing policy)	1977
Education Law, adopted in 1999 (ensuring free compulsory education for 11 years, including for children with disabilities)	1999

Source: Central Statistics Bureau 2010

Figure 1.6

Population 16 years old and over with at least 3 years of post-secondary education by field of study



Source: Central Statistics Bureau 2009

Figure 1.7

Working population 16 years old and over by major occupational group

Source: Central Statistics Bureau 2009

Economy

The DPR of Korea is a socialist industrial state with an independent national economy, mainly relying on its own technologies and resources. Its economic basis is a combination of state and public/community ownership. The supreme principle of state activities is the continual improvement of people's living standard under a socialist system whereby people are the masters of national sovereignty and the means of production.

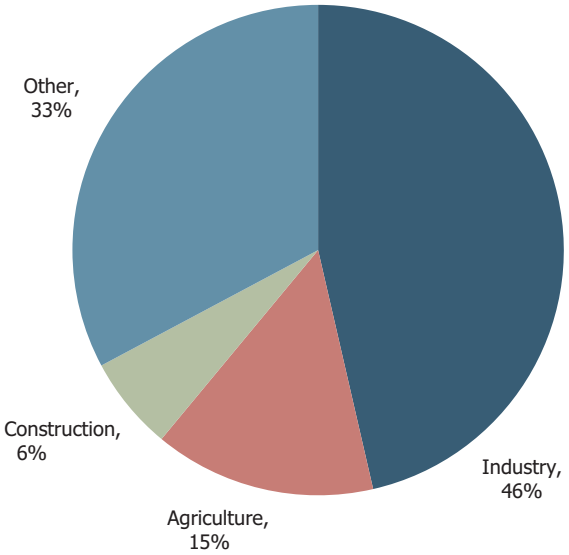
The national economy was affected by natural disasters and declining terms of trade with socialist countries in the 1990s. GDP decreased to a low of US$10.6 billion in 1996 but has increased since then. Over the last decade the economy has stabilized and resumed a moderate rate of growth in the major sectors. In 2008 GDP was approximately US$16.36 billion, more than one hundred and fifty percent of the level of economic output in 1996 (see Figure 1.8). Further flooding in 2007 marked another setback for agricultural production from which the economy has recently rebounded.

In 2008 the industrial, agricultural and construction sectors contributed 46 percent, 15 percent, 6 percent respectively to national economic output while other sectors including trade, services, transportation, fishery, and forestry added a further 33 percent (see Figure 1.9 on previous page). Industrial production processes have been modernized, particularly for iron, vinalon and fertilizer.

The major industrial components of the economy in DPR of Korea are power production, coal and other mining, metal production and manufacturing, railway transportation, and the building-materials, chemical and light industries. These industries rely mainly on domestic natural resources. Production in the steel, cement and fertilizer sectors declined from its peak output in 1990 but has increased since 2000 (see Figure 1.10).

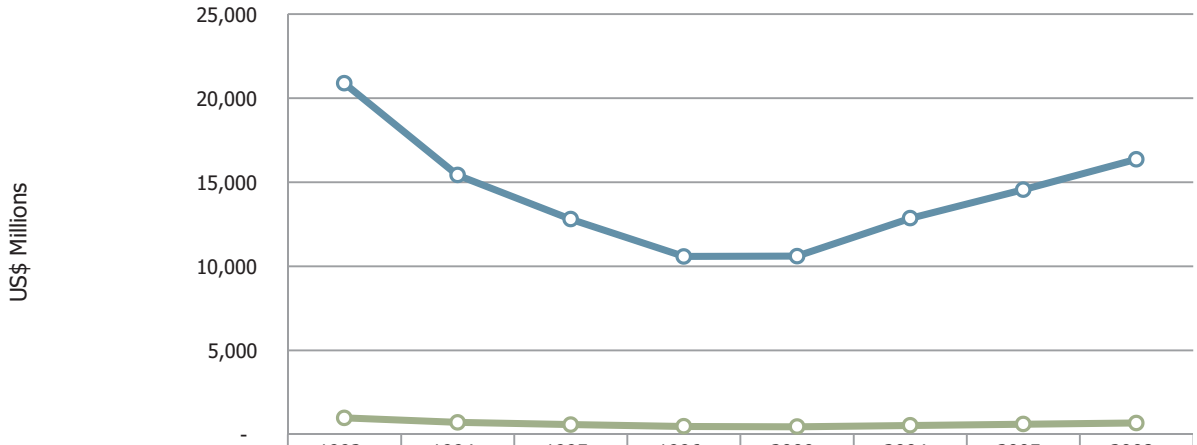
Figure 1.11 shows electric power production levels from 1990 to 2007. The main sources of power in the

Figure 1.9
Contribution to GDP by sector



Source: Central Statistics Bureau 2010

Figure 1.8
Gross Domestic Product (1992 - 2008)



	1992	1994	1995	1996	2000	2004	2005	2008
GDP (million US$)	20,875	15,421	12,802	10,588	10,608	12,859	14,561	16,360
GDP per capita (US$)	990	722	591	482	464	546	615	683

Source: Central Statistics Bureau 2010

DPR of Korea are coal-fired thermal and hydro-electric power plants. Power production also decreased from a high in 1990 but has been recovering since a low period in 1995.

Agriculture

Agriculture is a key economic sector, playing an important role in national output and improving people's livelihoods. The major crops are rice and maize, followed by wheat, barley, sorghum, beans, and potatoes.

Rice and maize production increased steadily from 2000 to 2006 but fell significantly in 2007 due to severe flood damage. Crop production has since recovered (see Figure 1.12).

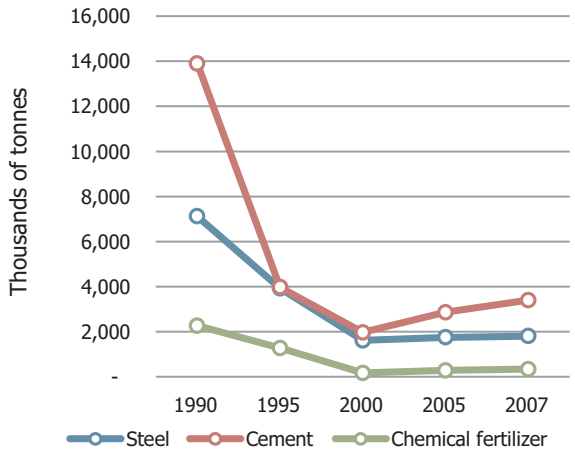
The area of land cultivated for rice production has remained largely stable since 1996, while maize cultivation has declined and wheat and barley has increased (see Table 1.4).

The agricultural sector relies on the production and use of chemical fertilizers to increase output. Nitrogen and potassium fertilizer manufacturing has increased considerably since 1997, while phosphorus fertilizer manufacturing decreased (see Table 1.5). The variability in the production of rice and maize reflect the changing availability of fertilizers.

The DPR of Korea has encouraged the introduction of organic farming using organic fertilizers and manures with the intention of reducing the use of chemical inputs without reducing output. Micro-organic fertilizers and bio-pesticides are being developed to support organic farming.

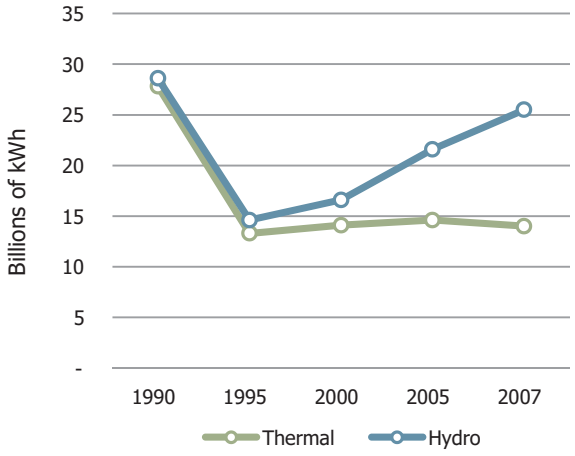
The government is taking active measures to improve food security by supporting large-scale land

Figure 1.10
Trends of major industrial production



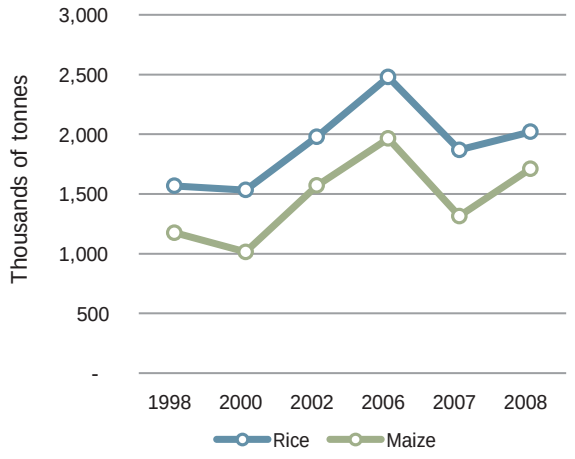
Source: Central Statistics Bureau 2010

Figure 1.11
Electric Power Production



Source: Central Statistics Bureau 2010

Figure 1.12
Production of rice and maize



Source: Central Statistics Bureau 2010

Table 1.4
Major cultivated land use (1996-2008)

		1996	1998	2000	2002	2004	2008
Sown area	Rice	575	574	531	578	-	565
('000 ha)	Maize	584	588	492	493	-	499
	Wheat, barley	64	79	122	126	-	108
Cultivated area	Fruit	159	159	157	158	143	-
('000 ha)	Mulberry	-	92	92	89	84	-

Source: Central Statistics Bureau 2010

Table 1.5
Production, import and manuring of fertilizer ('000 tonnes)

Classification	Type of fertilizer	1997 – 1998	1999 – 2000	2004 – 2005	2007 – 2008
Output	Nitrogen	115	109	160	257
('000 tonnes)	Phosphorus	22	5	8	7
	Potassium	4	7	8	10
Import	Nitrogen	304	417	736	181
('000 tonnes)	Phosphorus	98	126	259	-
	Potassium	-	45	78	-
Manuring	Nitrogen	442	528	896	438
('000 tonnes)	Phosphorus	121	133	267	7
	Potassium	12	54	86	10

Source: Central Statistics Bureau 2010

realignment, constructing artificial reservoirs and waterways, introducing new agricultural technologies and adopting a two-crop per year farming cycle where possible. One recent achievement has been the reclamation of tidal areas. On the west coast the Taegyedo Tideland reclamation project significantly increased agricultural land in the area.

1.4 Institutional mechanisms and laws for environmental protection and management

Institutional mechanisms

The consolidation of political, legal and institutional components within a unified environmental management framework is the basis of efforts to improve environmental management. The focus is on improving the efficiency of resource use while protecting biodiversity and preventing air, water and soil pollution. These efforts are codified under the Law

on Environment Protection, DPR of Korea, 1986. Environmental protection activities are conducted under the guidance of the judicial and executive arms of government through an institutional mechanism with well-defined responsibilities and functions as shown in Figure 1.13. The Supreme People's Assembly - the highest legislative authority in the country - is mandated to approve laws related to environmental protection. The Cabinet is responsible for implementing these laws by establishing relevant administrative measures. The Cabinet guides the overall execution of environmental protection policy.

The Ministry of Land and Environment Protection (MLEP), an arm of the Cabinet, provides scientific and policy advice and implements the State's strategies and policies. Environmental protection departments exist in every province, city and county and report to the MLEP. The Provincial Land and Environment Protection Bureau operates at the provincial level, and the County Land and Environment Protection Department operates at the city or county level.

Agencies concerned with environment protection and management include the State Planning Commission, Ministry of City Management, Ministry of Chemical Industry, Ministry of Construction and Building Materials, Ministry of Metal Industry, Ministry of Machine Industry, Ministry of Agriculture, the Central Statistics Bureau and others. Environmental coordination between ministries in international cooperation affairs is the responsibility of the National Coordinating Committee on Environment (NCCE).

The Environment and Development Centre (EDC), an agency of the MLEP, conducts research relevant to the protection and management of the environment and acts as a specialized consultative body on strategy and policy formulation for environment protection based on regular monitoring of environmental indicators. The EDC provides environmental data and advice to various agencies including the line ministries involved with national planning, education and public awareness.

The Central Environment Monitoring and Supervision Agency (CEMSA), an agency under the MLEP, is responsible for environment monitoring, data analysis and distribution to MLEP and other relevant ministries. It is also in charge of supervision of environment pollution controls in factories and agencies.

Laws and regulations related to environment protection

In the DPR of Korea, the government's sustainable development policy seeks to mainstream environment protection as an integral component of long term and sustainable development. Table 1.6 summarizes the various law and regulations related to these efforts.

Policy measures and their effectiveness

Environmental protection is important to the continued independent and creative life of the people of the DPR of Korea. As such, the government has introduced a system of strict regulations on production practices and other business activities. Factories, enterprises and residential areas are distributed in a planned and rational way, based on geographic and environmental characteristics and the availability of raw materials. Environmental impact assessments (EIA) are now required by law to prevent pollution and environmental degradation. A pollutant discharge permit system is in place to regulate existing operations at levels prescribed in national discharge standards. The government has encouraged the introduction of clean production technologies that reduce energy consumption, minimize waste and allow for recycling. Other activities are aimed at the development and use of purification equipment that makes use of nanotechnology and biotechnology.

Table 1.6
Laws and regulations for environmental protection

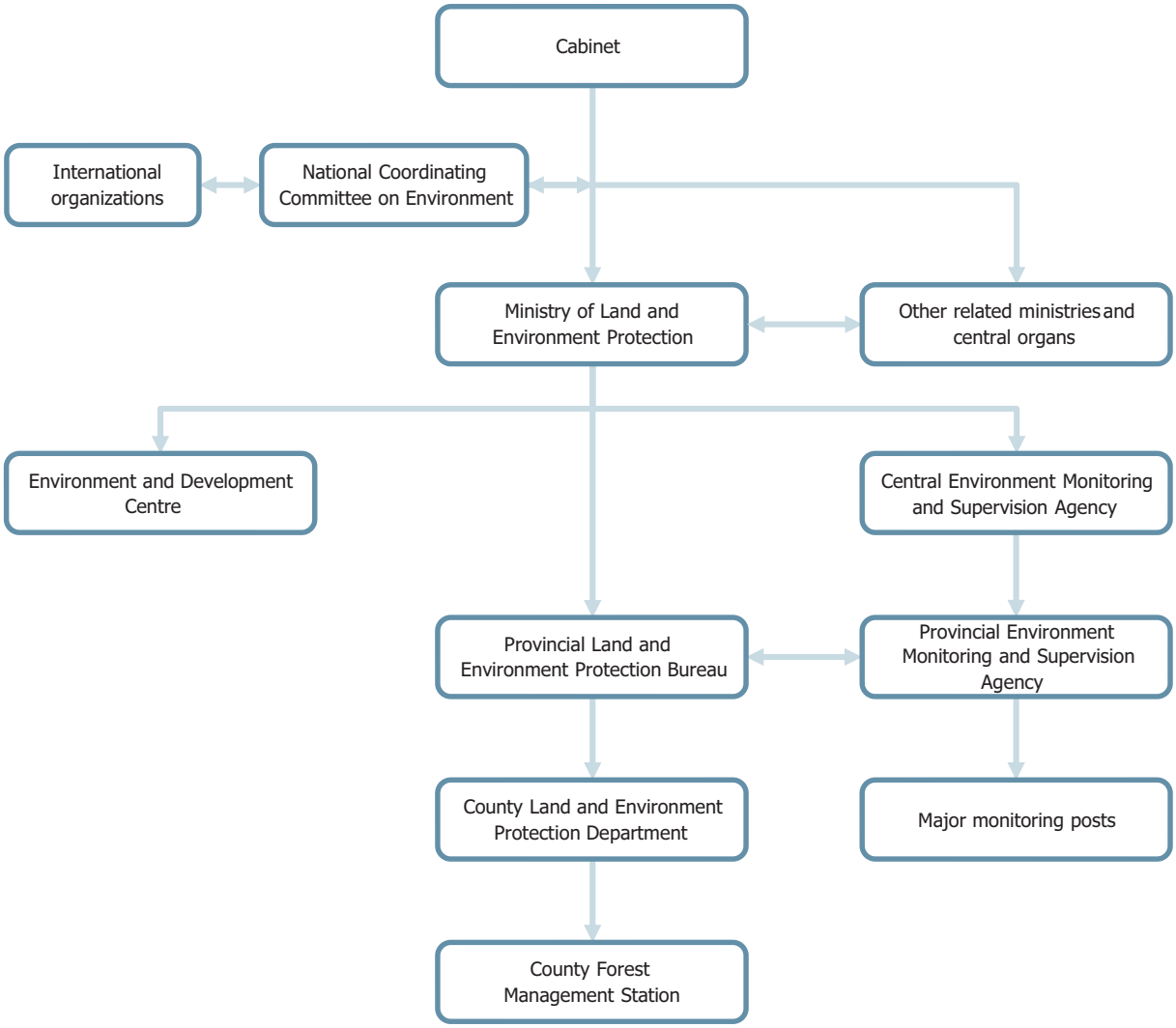
Law / regulation	Year	Content	Impact
Law on Land	1977	Stipulates the provisions on land ownership, planning, development, protection, construction, management and supervision.	Establishment of controls on construction; land realignment, irrigation systems; and the preparation and implementation of rehabilitation strategies for degraded areas.
Law on Environment Protection	1986	Stipulates the primary principle of environmental preservation, pollution control and guidance and supervision on environmental protection	Establishment of legal framework for overall environment protection; strengthening of institutional mechanisms; supervision and control of environment.
Law on Forest	1992	Stipulates the provisions on management of the country's forest resources including categories of forest use, reforestation, and protection.	Preparation and fulfillment of long-term plan for reforestation; establishment of strict discipline and order in reforestation, and forest protection.
Law on City Management	1992	Stipulates the provisions on building maintenance, water supply and drainage, heating facility operation, municipal roads, river improvement, afforestation, and city beautification.	Consolidation of city management such as water supply and drainage, building care, river improvement; strengthening of supervision and control on overall city management.
Law on Water Resource	1997	Defines guidance and control of surveys, development, use and protection of water resources; stipulates legal obligations in the case of violations.	Nation-wide survey of water resources; preparation and implementation of a strategy and action plan for protecting and efficiently using water resources.
Control Law on Land and Environment Protection	1998	Establishes legal responsibilities for supervision and control of land environment and defines seriousness of violations.	Strengthening of legal control of environment pollution; consolidates supervision and monitoring.
Law on Public Sanitation	1998	Establishes provisions for a hygienic environment and controls sanitary conditions.	Establishment of a strict system of public sanitation work and the intensification of public hygiene programs and controls.
Law on National Land Development Plan	2002	Stipulates the procedure and method of national land development; control of agricultural land reserves, prioritization of reforestation and river improvement in land protection, prevention of urban sprawl, incorporation of climatic and soil conditions, and prevention of environmental damage.	Establishment of strict system and order in the planning, design and implementation of land construction.
Law on River	2002	Stipulates measures for the construction, protection and improvements of state and local rivers	Establishment of a strict system of improvement, protection and use of rivers including improvements for areas vulnerable to floods and for city and farm land.
Law on Environment Impact Assessment	2005	Stipulation of environment impact assessment procedures including (a) definition of environment impact assessment, (2) principles of environment impact assessment, (3) preparation, application and deliberation of environment impact assessment, (4) execution of decisions on environment impact assessment	Establishment of a strict system to draw up and submit and deliberate environment impact assessment reports prior to construction.
Law on Protection of Pollution in Taedong River	2005	Stipulation of provisions to promote water quality, protection of environment and afforestation along the basin of Taedong River so as to prevent sand, mud and sewage from entering the river. Also to intensify scientific research on water quality, and reduce contamination and sedimentation.	Establishment of strict system and order to protect and manage Taedong River; dispose of waste water and domestic sewage appropriately; intensify reforestation efforts, and improve environmental management in the Taedong River basin.
Regulation on Handling Toxic Chemicals	2006	Definition of prohibited and controlled chemical substances and their handling methods.	Establishment of strict controls of the handling, storage, transport and disposal of toxic chemicals.
Law on Wastes Handling	2007	Regulations on the control and management of general and toxic wastes.	Enforcement of permit system for discharge of waste, safe disposal regulations and management procedures.

Public Participation

The government has conducted extensive public awareness raising activities on environmental issues. The results of pilot projects on potential solutions to environmental issues are disseminated to policy-makers and the public through publications such as *Environment Scientific and Technical Report*, *Environment Pollution Report*, *Ozone Newsletter*, *National Land Management*, *Nature Protection* and others.

Environmental improvement activities are implemented on a national scale. Campaigns include the "General Mobilization for Land Management" and "Improvement in Medium- and Small-scale Rivers and Streams" which take place each spring and autumn. There is also tree-planting on the occasion of Reforestation Day every year. Through these activities public awareness on environment protection has been greatly enhanced. People voluntarily take part in improving the local environment of their villages and production sites. The government also sponsors celebrations, lectures and workshops on the occasion of global commemoration days such as "World Environment Day", "World Water Day", "World Desertification Prevention Day" and "International Ozone Day".

Figure 1.13
Institutional arrangements for environment management



International Cooperation

DPR of Korea recognizes the importance of national and global environment protection and is an active partner in international cooperative activities through collaboration with international organizations. DPR of Korea is a signatory to many Multilateral Environmental Agreements (MEAs) as indicated in Table 1.7 below.

The government of DPR of Korea has planned and implemented numerous national actions to fulfill its obligations as a party to international treaties for global environment protection. Table 1.8 provides a list of some of these activities.

Table 1.7

Multilateral Environmental Agreements (MEAs) of which DPR of Korea is a signatory

International Conventions	Date
UN Convention on Biodiversity	26 Oct 1994
UN Framework Convention on Climate Change	05 Dec 1994
Vienna Convention on the Protection of Ozone Layer	05 May 1995
Montreal Protocol on Substances that Deplete the Ozone Layer	06 May 1995
Stockholm Convention on Persistent Organic Pollutants	19 Aug 2002
Cartagena Protocol on Biosafety	29 Jul 2003
UN Convention on Combating Desertification	28 Mar 2004
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	06 Feb 2004
Kyoto Protocol under UNFCCC	27 Apr 2005
Basel Convention on Transboundary Movements of Hazardous Wastes and their Disposal	10 Jul 2008

Table 1.8

Activities to fulfill international treaties

Activities	Period	Cooperating organization
Ozone layer protection projects in DPR of Korea	1995	UNIDO, UNEP
Preparation of biodiversity strategy in DPR of Korea	1998	UNDP, WWF
Asia Least-Cost GHGs Abatement Strategy in DPR of Korea	1999	GEF, ESCAP, UNDP
Preparation of first communication under UNFCCC in DPR of Korea	2000	UNEP, Secretariat of UNFCCC
Project for biodiversity protection in Mt. Myohyang	2002	UNDP, WWF
Capacity-building for State of Environment preparation	2003	UNDP, UNEP
National action plan for land degradation/desertification and drought protection (2006-2010)	2006	UNEP
Strengthening Environmental Monitoring and information technologies in DPR of Korea towards sustainable decision-making	2006	UNDP, UNEP
National implementation plan for persistent organic pollutants (POPs) management in DPR of Korea	2008	UNITAR
PCB management plan in DPR of Korea	2010	UNITAR

CHAPTER 2

Air and Atmosphere

2. Air and Atmosphere

Good air quality is fundamental to the health and well-being of people. As such, it's an important environmental policy goal for all countries. Reducing air pollution can have health and environmental benefits at both the local and global levels. Air pollution prevention is an important environmental issue for urban centers and rural residences in the DPR of Korea and a priority area for government action.

Airborne pollutants result from energy production, industrial processes, motorized transportation and daily activities such as household heating and cooking. They are released into the atmosphere in volumes that fluctuate on a daily and seasonal basis.

Generally, air pollution is classified according to pollutant type. Primary pollutants include particulate matter, sulphur dioxide (SO_2), nitrogen oxides (NOx) and other substances that are released in the process of fossil fuel production and combustion and other industrial activities. Secondary pollutants, such as smog, are created by chemical change of primary pollutants. These pollutants tend to be non-uniformly mixing and are eventually assimilated in the atmosphere and local environment. As such, their impact on air quality is localized and occurs over shorter periods of time. Other pollutants, such as greenhouse gases and ozone depleting substances, are more uniformly mixing, accumulative and persistent in the atmosphere resulting in longer term global impacts. In addition to these anthropogenic pollutants, air quality in the DPR of Korea is also strongly affected by dust and sand storms (DSS) that originate in the deserts of China and are transported over the Korean Peninsula on prevailing winds.

2.1 State and trends

Air quality

Air quality is closely associated with the volume of pollutants emitted and the geographic, topographic and meteorological conditions of the region. Generally, air quality is more adversely affected in cities and industrial areas than in rural areas because there are more point sources of pollution and larger volumes of emissions.

A combination of limited capital investment in infrastructure, limited access to efficient and low emission technologies, population growth, industrial development and reliance on energy produced from coal in low efficiency thermal power plants has impacted air quality in urban and industrial areas.

State of air quality monitoring

An environmental monitoring network has been established under the Ministry of Land and Environmental Protection (MLEP) and covers major cities and some provinces. The network is coordinated by the Central Environmental Monitoring and Supervisory Agency (CEMSA). Local monitoring stations are distributed in priority areas and monitor air quality on regular basis, measuring key indicators such as precipitated dust and SOx. Monitoring results are submitted to the MLEP and utilized for air quality assessment and decision-making.

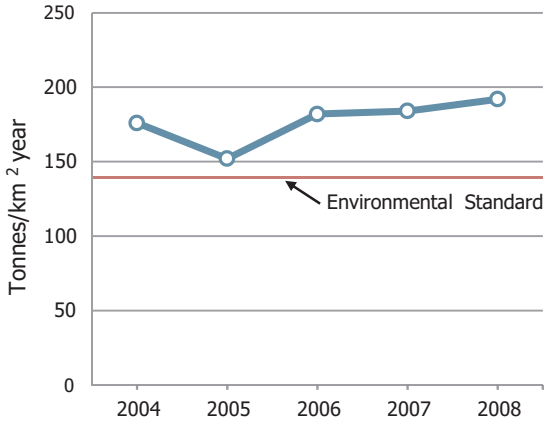
The monitoring has not yet achieved full coverage of the country due to limited technical and financial resources. Equipment and reagents are in limited supply which has impeded regular data collection and successful assessment of air quality in many areas. The modernization of the monitoring network is considered a high priority including establishing a remote telemetry monitoring system and expanding data collection to include TSP, PM10, PM2.5, and NOx, and O_3 since the present monitoring is limited to tracking only a few pollutants (such as dust and sulfur dioxide) in a few key locations such as Pyongyang City and surrounding industrial areas. Air quality monitoring programs in other major cities and industrial centers are limited to only a few key indicators. There is no program to evaluate the effects of coal and wood combustion on indoor air quality. An expanded system of integrated air quality monitoring

that included more pollutants and provided greater geographic coverage would contribute to a better understanding of the type, extent and severity of air pollution and assist in prioritizing action and assessing the effectiveness of policy responses.

Precipitated particulate dust

Air quality impacts from precipitated particulates has been observed in some urban and industrial areas and may be the cause of environmental health issues where industry and coal combustion facilities are located. The annual volume of combustion related precipitated dust in proximity to the industrial area in Pyongyang has slowly increased since 2004 (Figure 2.1) despite a drop in 2005. Prevention of dust pollution is important issue because the particulates can contain heavy metals and other toxic and radioactive substances that persist in the local environment, accumulate in food chains and affect the health of humans and animals. The major pollution sources in Pyongyang city and other industrial areas are associated with fossil fuel (particularly coal and heavy oil) in thermal power plants, industrial boilers, kilns, motor vehicles, residences and manufacturing (Li Kang Ho, 2008).

Figure 2.1
Precipitated dust volume in the industrial area of Pyongyang (annual)



Source: Environment and Development Center 2009

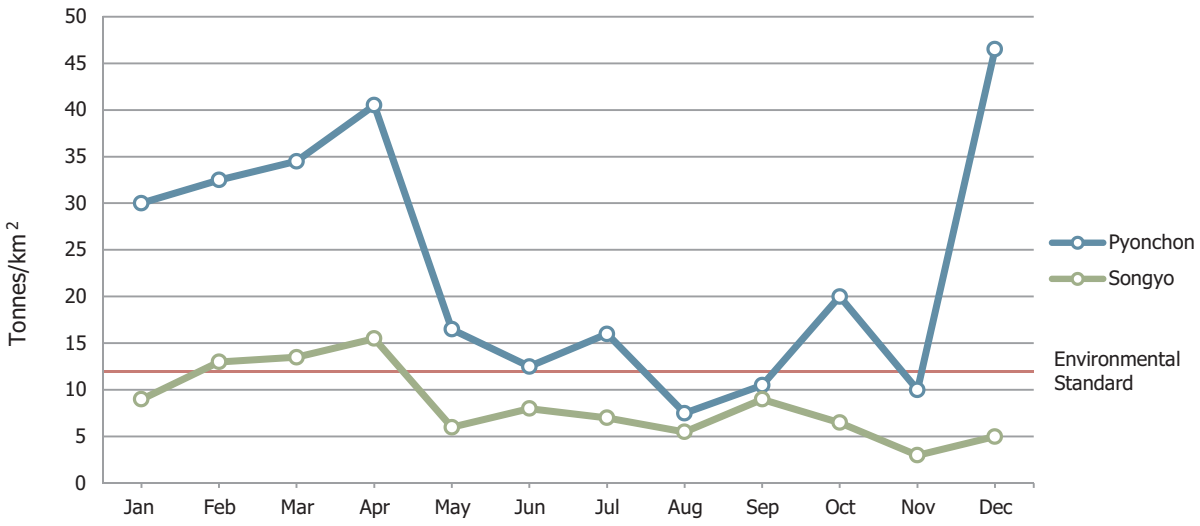
Table 2.1 below provides the monthly and annual air quality standards for precipitated dust. Precipitated dust levels are relatively high in Pyongyang's Songyo and Pyongchon districts, industrial sites which are closer in proximity to the thermal power plant (Figure 2.2).

Table 2.1
Monthly and annual quality standard for precipitated dusts

Substances	Amount of precipitated dusts	
	Tonnes/km² per month	Tonnes/km² per year
Precipitated dusts (clean area)	Below 11.6	Below 139.2

Source: Ministry of Land and Environment Protection 2000

Figure 2.2
Precipitated dust volume in the industrial area of Pyongyang (monthly) for 2008



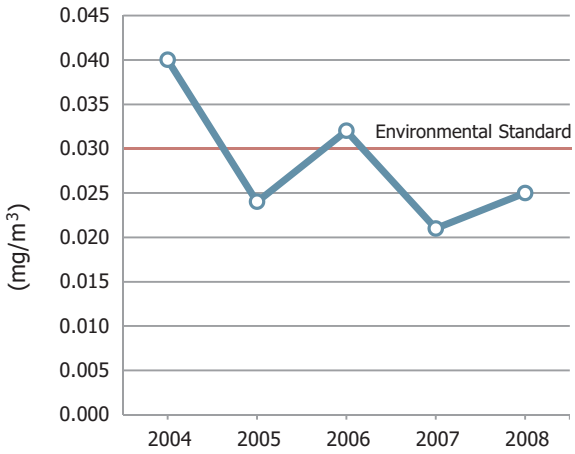
Source: Environment and Development Center 2009

Seasonal variation of precipitated dust is considerable. High levels of precipitated dust in Pyongchon and Songyo districts occur during the winter season from December to April, when there is increased coal combustion for thermal power and heat generation (in addition to industrial sources). Levels are lower from May to November, when the weather is warmer and there is more rain.

Sulfur dioxide

Sulfur dioxide levels in major industrial sites are also an environmental concern. Sulfur dioxide is produced from fossil fuel combustion and smelting of mineral ores that contain sulfur. In an airborne state, sulfur dioxide can affect the respiratory system causing coughing, mucus secretion, and aggravating conditions such as asthma and bronchitis. It is also an eye irritant. Sulfur dioxide forms sulfuric acid when it reacts with water in the air which results in acid rain. Acid rain can degrade forests, acidify waterways, affect organisms and corrode infrastructure.

Figure 2.3
Daily average SO_2 concentrations in Pyongyang



Source: Environment and Development Center 2008

Figure 2.3 illustrates that sulfur dioxide concentrations in Pyongyang have shown a downward trend since 2004 with inter-annual variability. Tables 2.2 below lists daily air quality assessment standards by category of use.

Ozone depleting substances (ODS)

The DPR of Korea has acceded to the Vienna Convention for the Protection of the Ozone Layer and ratified the Montreal Protocol on Substances that Deplete the Ozone Layer including the London, Copenhagen, Montreal and Beijing Amendments. According to the Montreal Protocol, the DPR of Korea is an Article 5 country which indicates that it is a developing country whose annual consumption of controlled ozone depleting substances is less than 0.3

Table 2.2
Daily air quality assessment standards by category of use (unit: mg/m^3)

Substances	Special class		First grade		Second grade		Third grade	
	Daily maximum	Daily average	Daily maximum	Daily average	Daily maximum	Daily average	Daily maximum	Daily average
Suspended dust	0.05	0.03	0.10	0.05	0.30	0.10	0.50	0.20
SO_2	0.05	0.03	0.10	0.05	0.30	0.10	0.50	0.15
NO_2	0.04	0.01	0.06	0.03	0.10	0.04	0.15	0.05
CO	3.0	1.0	4.0	2.0	6.0	3.0	15.0	10.0
Oxidant	0.05	0.02	0.10	0.03	0.12	0.04	0.14	0.06
Description	Natural reserves and areas of special protection		Resort, health, tourist and recreation sites		Residential areas		Industrial areas	

Source: Ministry of Land and Environment Protection 2000

Table 2.3
Main types and uses of ozone depleting substances

Type	Uses
CFC-11	Foam and refrigerant
CFC-12	Refrigerant
CFC-113	Cleaning agents in electronics and precision materials
Methychloroform	Synthesis of organic solvent and cleaning agents for electronic devices and metal
CTC	Metal cleaning agent, fumigant, process agent
Halon	Fire extinguisher
Methylbromide	Agricultural fumigant
HCFC-22	Refrigerant
HCFC-141b	Foam and refrigerant

Source: National Ozone Unit, DPR of Korea 2010

kilograms per capita. Article 5 countries are allowed to delay implementation of control provisions and are eligible to receive international funding to assist them reduce the production of these substances. The primary types of ozone depleting substances and their uses are listed in Table 2.3.

The DPR of Korea strictly controls the production, consumption and phase-out of ozone depleting substances in the national economy as a Party to these agreements. The DPR of Korea ceased production of methyl bromide in 1995; CFC-11, CFC-12 and CFC-113 in 2003; and carbon tetrachloride in 2005. The country still produces and uses some ozone depleting substances. The Montreal Protocol sets 2013 as the year countries will freeze the consumption and production of HCFCs and 2015 as the time countries will begin reducing consumption.

The DPR of Korea has implemented the National Phase-out Project (NPP) to eliminate CFC use in the service sector from 2006-2010. The successful implementation of the project has made a great contribution to reducing CFC emissions nation-wide. The government is also planning to phase-out production and consumption of HCFCs. Following the requirements of the Montreal Protocol, the DPR of Korea is planning to freeze production of HCFCs in 2013 and begin reducing consumption of HCFCs by 2015 (Jang Chol Gun, 2011b). The production and consumption of ODS in the DPR of Korea is shown in Box 2.1 on the following page.

The DPR of Korea uses HFCF-22 as a propellant and for refrigeration purposes. The country began to produce its own HCFC-22 in the early 1990s. The total quantity consumed in 2008 and 2009 was well below that consumed in 2007. There has been a steady increase in the consumption of HCFC-141B, all of which is imported. HCFC-141B is used as a foam blowing agent and a cleaning solvent (Jang Chol Gun, 2011b).

Greenhouse Gas Emissions

Greenhouse gases have the ability absorb and reradiate infrared radiation in the atmosphere which captures heat energy and warms the earth. They are produced through both natural processes and human activities and include water vapor, carbon dioxide, methane, nitrous oxide, and ozone as well as CFCs, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). They vary in their ability to absorb and reradiate thermal energy, a characteristic known as radiative forcing. They also differ in the rate at which they are broken down from decades to thousands of years. These two properties dictate the gas's global warming potential as illustrated in Table 2.4 below.

Greenhouse gases are uniformly mixing and accumulate in the atmosphere which means that the location of their release is independent of their global warming effect. Globally, concentrations of greenhouse gases have been rapidly increasing in the atmosphere with the utilisation of fossil fuels and the conversion of forest land to agricultural production that has accompanied industrialization over the last two hundred years. Concentrations are now sufficiently high in the atmosphere that an enhanced greenhouse effect is observable and is altering climate patterns around the world. Concern about continued changes in temperature and precipitation patterns, the frequency and intensity of extreme weather events, ocean acidification and sea level rise resulted in the negotiation of a global policy framework to reduce greenhouse gas emissions. The centerpieces of this

Box 2.1 Ozone Success Story

To fulfill its commitments under the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer, the DPR of Korea prepared a Country Program Report in 1997 and set up a National Ozone Unit (NOU) in 1998.

The DPR of Korea has a centrally planned economy which has assisted it to control the production and consumption of ozone depleting substances (ODS). The country established a quota system for the production and consumption of ODS and a licensing system for their import and export. Relevant agencies carried out their activities in a planned and unified way. Only licensed companies could apply for an import quota of ODS. With the intensification of the legal framework, specific laws and regulations were promulgated and enforced on ODS-related activities. Accordingly, ODS-based equipment imports were banned.

In the DPR of Korea the ozone depleting substances were produced in 2.8 Vinalon Complex. The country stopped the production of ODS and phased out the production facilities in 2.8 Vinalon Complex (CFC-11,-12 in November, 2003, CTC in December 2005, methyl bromide in February 1996, methyl chloroform in January 2002) and encouraged the ODS producers to convert to ozone-friendly technologies. Ozone-friendly facilities were tax exempt.

After the closure of the production facilities in the country, most of the ODS were imported under strict controls. The role of the customs agency was enhanced through training programs and the introduction of detection tools such as ODS-identifiers. The country has now been implementing CFC phase-out activities since 2006 in the refrigeration service sector, which was completed by 2010. Through the dissemination of ozone-friendly technologies public awareness of ozone layer protection was improved.

The production and consumption of ODS in DPR of Korea is shown below.

Production of Ozone Depleting Substances (Metric Tonnes)

Name of ODS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CFC-11	185	60	50	45	40	23	54	64	109.1	0	0	0	0	0	0
CFC-12	500	150	125	40	50	42	208	235	478.3	0	0	0	0	0	0
CFC-113	100	40	35	35	20	15	36	0	0	0	0	0	0	0	0
CTC	1060	1822	1893	2022	1985	1594	1889	1843	1441	1999	174	0	0	0	0
Methyl chloroform	100	100	100	90	90	51	70	0	0	0	0	0	0	0	0
Methyl bromide	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCFC-22	308	350	420	430	450	480	480	485	495	490	497	502	0	394	504

Consumption of Ozone Depleting Substances (Metric Tonnes)

Name of ODS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CFC-11	194	70	70	45	40	23	56	64	109	0	46.4	0	38	13	9.5
CFC-12	447	165	135	40	50	42.2	237	235	478	0	45.4	24.5	22.7	20.5	17.7
CFC-113	100	40	35	35	20	15	36	0	0	0	0	0	0	0	0
CFC-115	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
halon-1301	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CTC	1060	1822	1893	2022	1985	1594	1889	1843	1441	1999	174	0	0	0	0
Methyl chloroform	100	100	100	90	90	51	70	0	0	0	0	0	0	0	0
Methyl bromide	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCFC-22	308	350	650	730	870	1150	1210	1248	1116	1487	1559	1484	1550	13	865
HCFC-141b	-	-	-	-	-	-	-	55.6	61.7	54.8	90.4	89.6	111.6	117.6	129.0

Source: National Ozone Unit 2010

Table 2.4
Global warming potential values for different greenhouse gases

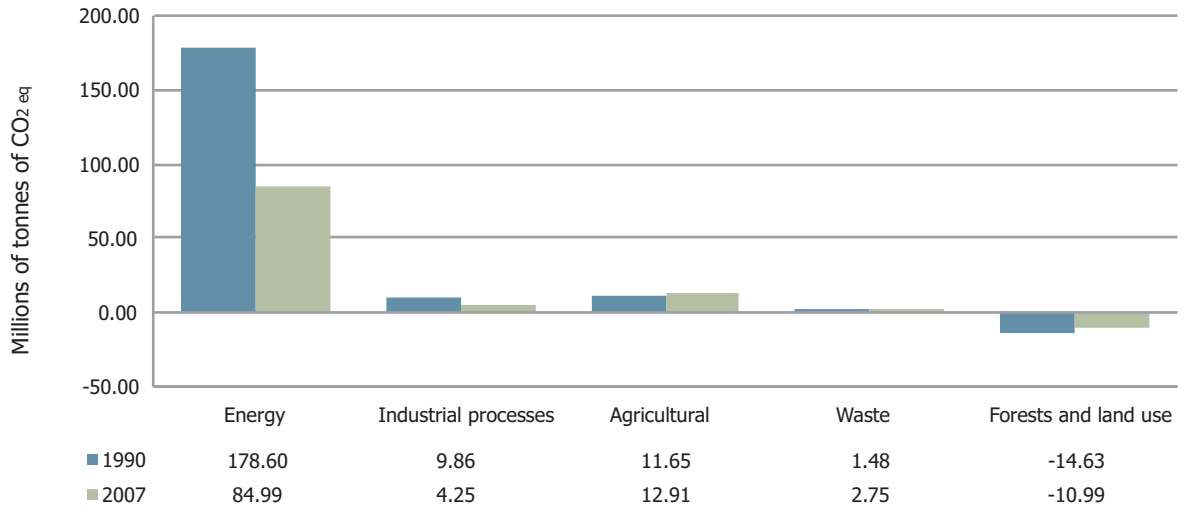
	Chemical formula	100 year global warming potential
Carbon Dioxide	CO2	1
Methane	CH4	21
Nitrous oxide	N_2O	310
Sulphur hexafluoride	SF6	23,900
Perfluoromethane	CF4	6,500
Perfluoroethane	C2F6	9,200
Perfluorobutane	C4F10	7,000
HFC-23	CHF3	11,700
HFC-32	CH2F2	650
HFC-43-10	C5H2F10	1,300
HFC-125	C2HF5	2,800
HFC-134a	CH2FCF3	1,300
HFC-143a	C2H3F3	3,800
HFC-152a	C2H4F2	140
HFC-227ea	C3HF7	2,900
HFC-236fa	C3H2F6	6,300
HFC-245ca	C3H3F5	560

Source: Intergovernmental Panel on Climate Change 2007

policy framework are the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The DPR of Korea has ratified both agreements.

In 2007, the DPR of Korea emitted a combination of greenhouse gases equivalent to about 94 million tonnes of carbon dioxide (Kwak Man Su, 2005). That represented around 0.32 percent of the global emissions for that year. Emissions and absorption of GHGs from energy, industrial process, agricultural, wastes, forest and land use sectors in 2007 were estimated based on methods defined in the "Guidelines for GHG Inventory Preparation" adopted by the Intergovernmental Panel on Climate Change (IPCC 2006). Figure 2.4 provides summary, and Table 2.5 detailed,

Figure 2.4
Greenhouse gas emissions by sector



Source: Institute of Thermal Engineering, State Academy of Sciences 2010

Table 2.5

DPR of Korea detailed greenhouse gas emissions by sector

Sources and sinks	CO_2 Emissions (Gg)		CO_2 Removals (Gg)		Net CO_2 Emissions (Gg)		CH_4 (Gg)	
	1990	2007	1990	2007	1990	2007	1990	2007
Total emissions and removals	169,444.60	75,208.07	-14,631.00	-11,000.99	154,813.54	64,207.08	975.20	934.80
1. Energy	159,941.90	72,085.37	-	-	159,941.90	72,085.37	649.40	584.42
A. Fuel combustion	159,941.90	72,085.37	-	-	159,941.90	72,085.37	43.60	133.79
Energy industry	90,775.30	28,008.59	-	-	90,775.30	28,008.59	1.10	0.31
Manufacturing industry and construction	34,272.80	15,002.06	-	-	34,272.80	15,002.06	3.40	1.46
Transportation	3,472.70	2,072.93	-	-	3,472.70	2,072.93	0.40	0.37
Others	15,685.70	24,952.55	-	-	15,685.70	24,952.55	38.80	127.07
Other	15,735.40	2,049.24	-	-	15,735.40	2,049.24	-	4.57
B. Fugitive Fuel Emission	-	-	-	-	-	-	605.80	450.63
Solid fuel	-	-	-	-	-	-	605.80	450.60
Oil and natural gas	-	-	-	-	-	-	-	0.03
2. Industrial process	9,502.70	3,122.71	-	-	9,502.70	3,122.71	0.10	0.20
A. Mining	8,074.65	1,959.50	-	-	8,074.65	1,959.50	-	-
B. Chemical industry	595.10	949.00	-	-	595.08	949.00	0.10	0.20
C. Metal production	833.00	214.20	-	-	833.00	214.20	-	-
3. Solvent and Other Products use	-	-	-	-	-	-	-	-
4. Agriculture	-	-	-	-	-	-	254.71	218.99
A. Enteric fermentation	-	-	-	-	-	-	52.19	68.15
B. Manure management	-	-	-	-	-	-	38.70	9.89
C. Rice cultivation	-	-	-	-	-	-	163.82	140.95
D. Agricultural soils	-	-	-	-	-	-	-	-
5. Land use and Change and Forestry	-	-	-14,631.00	-11,000.99	-14,631.00	-11,000.99	0.41	0.41
A. Changes in forest and other woody biomass stocks	-	-	-15,021.00	-11,390.65	-15,021.00	-11,390.65	-	-
B. Forest and grassland conversion	-	297.99	298.00	-	298.00	297.99	0.41	0.41
C. Emission and removals of CO_2 from soil	-	91.67	92.00	-	92.00	91.67	-	-
6. Waste	-	-	-	-	-	-	70.54	130.78
A. Solid waste disposal on land	-	-	-	-	-	-	66.51	126.18
B. Wastewater treatment	-	-	-	-	-	-	4.04	4.60
7. Others	-	-	-	-	-	-	-	-

Source: Institute of Thermal Engineering, State Academy of Sciences 2010

emissions figures across sectors for 1990, the first year emissions were calculated, and 2007.

Most notable is that emissions in 2007 had decreased by about 50 percent to 93,913 Gg (thousands of metric tonnes), compared with 186,515 Gg in 1990. This is directly attributable to the economic contraction experienced by the DPR of Korea as described in Chapter 1 of this report. Industrial and energy production fell substantially during the 1990s and began to regain momentum after about 2002. Per capita emissions fell by more than half from 8.9 tonnes of CO_{2e} in 1990 to 3.9 tonnes in 2007.

As Figure 2.4 illustrates, the primary source of greenhouse gas emissions in the DPR of Korea is

N_2O Emissions (Gg)		NO_x Emissions (Gg)		CO Emissions (Gg)		NMVOC Emissions (Tonnes)		CO_2 Equivalent (Gg)	
1990	2007	1990	2007	1990	2007	1990	2007	1990	2007
38.70	31.75	432.00	3.98	478.10	146.6	60.50	-	186,515.00	93,912.97
17.30	2.04	425.10	0.01	474.50	0.01	60.50	-	178,596.00	84,990.85
17.30	2.04	425.10	0.01	474.50	0.01	60.50	-	165,875.00	75,527.59
12.50	0.42	279.50	0.01	18.70	0.01	4.80	-	94,635.00	28,146.21
4.70	0.22	104.50	-	50.30	-	6.80	-	35,707.00	15,101.40
0.10	0.12	24.10	-	93.60	-	17.70	-	3,510.00	2,117.82
-	1.25	17.00	-	312.00	-	31.30	-	16,501.00	28,008.51
-	0.03	-	-	-	-	-	-	15,735.40	2,153.66
-	-	-	-	-	-	-	-	12,721.80	9,463.26
-	-	-	-	-	-	-	-	12,721.80	9,462.53
-	-	-	-	-	-	-	-	-	0.73
1.13	2.90	6.78	3.87	-	143.02	-	-	9,855.13	4,253.21
-	-	-	-	-	-	-	-	8,074.65	1,960.52
1.13	2.90	6.78	3.87	-	143.02	-	-	947.48	2,078.49
-	-	-	-	-	-	-	-	833.00	214.20
-	-	-	-	-	-	-	-	-	-
20.32	26.81	-	-	-	-	-	-	11,654.31	12,908.60
-	-	-	-	-	-	-	-	1,096.03	1,431.13
0.02	0.01	-	-	-	-	-	-	818.90	210.86
-	-	-	-	-	-	-	-	3,440.22	2,960.04
20.30	26.80	-	-	-	-	-	-	6,299.20	8,306.58
0.00	0.00	0.10	0.10	3.57	3.57	-	-	-14,631.00	-10,985.98
-	-	-	-	-	-	-	-	-15,021.00	-11,390.65
-	-	0.10	0.10	3.57	3.57	-	-	298.00	313.00
-	-	-	-	-	-	-	-	92.00	91.67
-	-	-	-	-	-	-	-	1,481.34	2,746.29
-	-	-	-	-	-	-	-	1,396.71	2,649.72
-	-	-	-	-	-	-	-	84.84	96.56
-	-	-	-	-	-	-	-	-	-

combustion of fuel for energy. Emissions from fuel combustion, which contributed 96 percent to the country's emissions in 1990, had fallen to 91 percent in 2007. This includes the production of electricity as well as thermal energy for manufacturing and residential heating and cooking. The DPR of Korea uses coal and oil in its thermal power plants, while hydroelectric power is also an important source of energy.

In the residential sector, coal and wood are the primary sources of thermal energy for cooking and heating. Urban centers rely more heavily on coal while rural areas depend on wood. These energy sources have implications not only for greenhouse gas emissions, but also emissions of other air pollutants with consequent negative health and environmental impacts.

Emissions from industry in 2007 were 4,253 Gg, which represented 43.2 percent of their 1990 level of 9,855 Gg. This was due to the contraction of production in the industrial sector, particularly in steel, cement and chemical manufacturing.

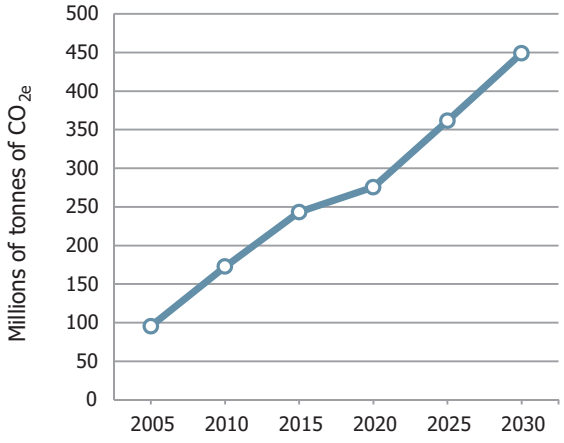
Agricultural emission levels increased slightly from 11,654 Gg in 1990 to 12,909 Gg in 2007. Agriculture represented about 14 percent of total emissions in 2007.

Methane emissions from solid waste disposal and waste water treatment combined were 131 Gg in 2007, a large increase compared to 71 Gg in 1990. This equated to an increase from 1481 Gg to 2746 Gg in carbon dioxide equivalent values. As a percentage of the national total, waste related emissions of methane increased from 0.8 percent to 2.9 percent. The increase of greenhouse gas emissions in the waste sector is attributed to population growth and the associated increase in the volume of waste generated.

The primary source of methane emissions across the economy as a whole in 2007 was from fugitive emissions released during the extraction and processing of coal. This produced roughly 450 Gg of methane. Rice production, manure management and enteric fermentation in livestock produced approximately 219 Gg of methane combined.

The sequestration of carbon through forests fell between 1990 and 2007, from -14,631 Gg to -11,001Gg. This trend reflects deforestation due to conversion of land from forests to agriculture, provision of building materials, and fuel for household cooking and heating. In its First National Communication on Climate Change, the DPR of Korea projected that forest sequestration rates would diminish by approximately 10 percent to -13,119 Gg by 2010 and a further decline to -12,291 Gg by 2020. The fact that forest sequestration has declined more than projected deserves careful review and may require additional measures to reverse.

Figure 2.5
Projected growth in greenhouse gas emissions in the DPR of Korea



Source: State Academy of Science 2009

Across the economy, emissions grew by less than the projections contained in the First National Communication on Climate Change to the UNFCCC, which had forecast an increase to approximately 125,000 Gg by 2010 continuing to 250,000 Gg by 2020 based on the Long Term Development Plan of the DPR of Korea. Improvements in the energy efficiency of power production and manufacturing, possibly in part through Kyoto Clean Development Mechanism type financing, are need to ensure that economic growth is decoupled from emissions growth.

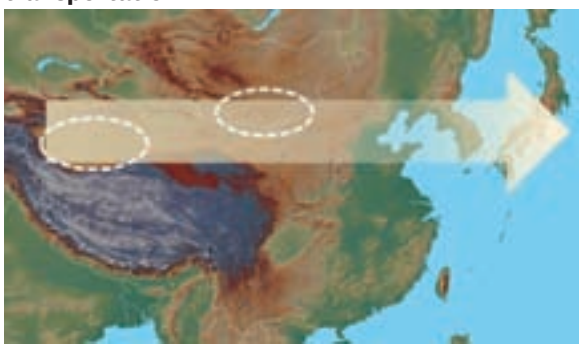
Projected growth of greenhouse gas emissions

Developing a projection of future greenhouse gas emissions at the country level is difficult due to uncertainties about rates of economic growth, economic investment, technology development and transfer, population growth, climate change mitigation responses and other factors. Figure 2.5 presents a scenario for greenhouse gas emissions growth that is predicated on estimates of economic growth consistent with the DPR of Korea's expectations under its Long Term Development Plan. Emissions are currently tracking below the projected levels. Nonetheless, emissions are expected to grow in the coming years in DPR of Korea without considerable investment into more efficient infrastructure and better land use practices. Projections indicate that by 2030 the DPR of Korea's greenhouse gas emissions will be approximately 4.5 times more than 2005 levels, with the energy and industrial sectors accounting for more than 90 percent of the total. However, the carbon dioxide intensity of production (emissions/GDP) during the forecast period is expected to gradually decrease due to improvements on the demand-side in terms of energy efficiency and shifts to cleaner energy. The annual increase of greenhouse gas emissions is predicted to be 7.3 percent between 2005 and 2030.

Dust and sand storm (DSS)

In addition to anthropogenic sources of air pollution, the DPR of Korea also experiences significant air quality disturbances from dust and sand storms originating in desert regions of China and Mongolia as

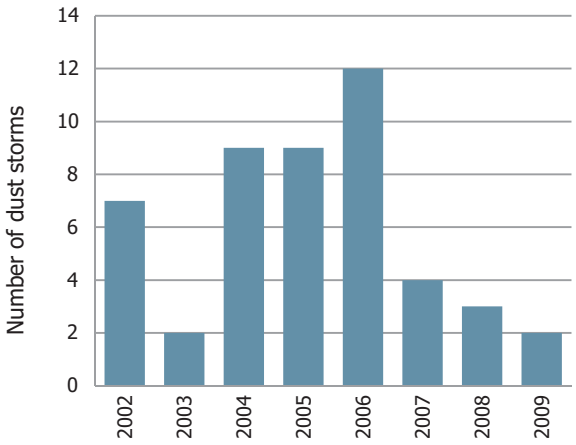
Figure 2.6
Sources and direction of sand and dust transportation



Source: Ministry of Land and Environment Protection 2009

shown Figures 2.6 and 2.7. The occurrence of dust and sand storm events is closely related to deforestation and excessive use of water resources combined with dry and windy conditions around the sources of the dust. Dust is carried over long distances by strong northwest winds (700-850 hpa) gusting in the lower atmosphere (Li Kang Se, Ham Myong Ho, 2003).

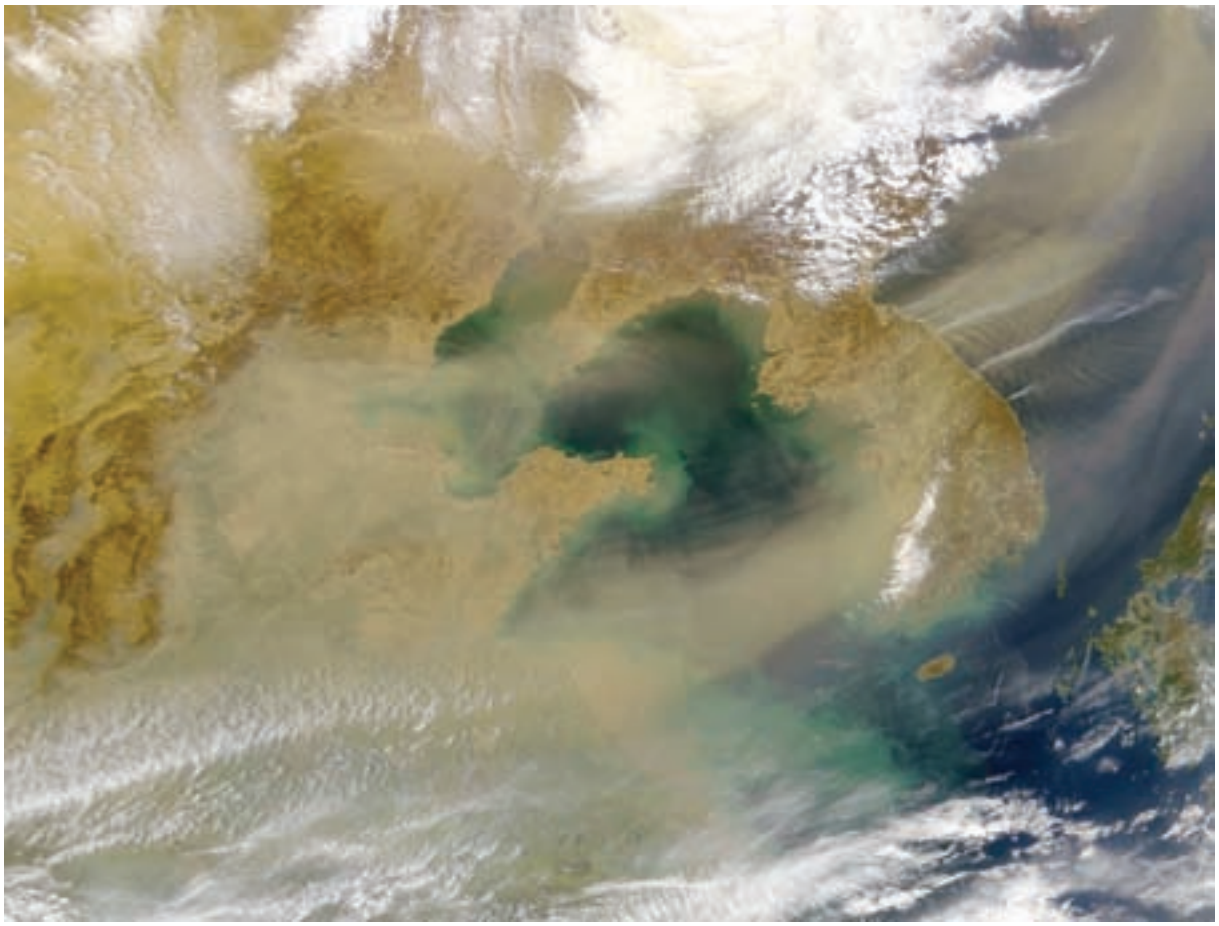
Figure 2.8
Frequency of dust and sand storms



Source: Environment and Development Center 2010

The frequency of dust storms decreased from the mid-1960s to the mid-1980s, however, since that time their frequency and intensity has increased. Figure 2.7 shows a satellite photo of a dust storm in on April 7th, 2000.

Figure 2.7
Large dust storm blowing eastward from China over the Korean Peninsula



Source: SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE Date: 2000-04-07

Figure 2.8 shows the inter-annual variability in dust storm frequency from 2002-2009.

Dust storms result in loss of top soil and organic matter which reduce agricultural productivity at the source. Airborne dust reduces visibility which affects aircraft and road transportation and aggravates human respiratory conditions such as asthma and bronchitis. It has also been shown to transport bacteria. It has an abrasive effect on plants and in large quantities can smother vegetation. The dust can interfere with industrial processes, contaminate waterways, increase sediment loads and may require the diversion of limited resources to clean up urban areas.

The spring of 2002 had several intense dust and sand storm events. Clouds of dust and sand, originating in the Gobi Desert and Inner Mongolia, blew over the Korean Peninsula on the north-west air current. For two days, the concentration of suspended dust and sand was higher than 2 mg/m^3.

Between 2004 and 2007, the annual concentration of suspended dust and sand was 0.3-2 mg/m^3 and the amount of precipitated dust and sand was 0.08 tonne/km^2 per hour. These volumes were far above levels in non-dust storm periods which average around 0.02 t/km^2 (Jong Chang Gun, 2005).

2.2 Drivers and pressures

Increase of energy consumption

As in most countries, energy is a primary factor of production in the DPR of Korea at both industrial and household levels and its use is closely correlated with economic activity and socioeconomic development. Following a decline in economic production from the mid-1990's, the DPR of Korea economy has returned to positive rates of growth. Production of steel, cement and chemical fertilizer in 2007 had increased by 1.1, 1.7 and about 2 times, respectively compared to 2000 output levels. Recent economic progress has corresponded to increased energy consumption, mostly of fossil fuels. Over the same period coal consumption increased 1.2 times. Growth in energy consumption in the industrial sector has increased emissions of carbon dioxide, sulfur dioxide and nitrogen oxides.

Table 2.6
Coal and heavy oil consumption 1995-2007

Type of fuel	1995	2000	2005	2007
Anthracite (10,000t)	2,382	1,921	2,034	2,254
Lignite (10,000t)	617	341	462	480
Total coal consumption (10,000t)	3,020	2,273	2,505	2,743
Heavy oil (10,000t)	175.3	113.9	128.5	130.1

Source: Central Statistics Bureau 2010

Air pollution sources

Stationary sources of pollution

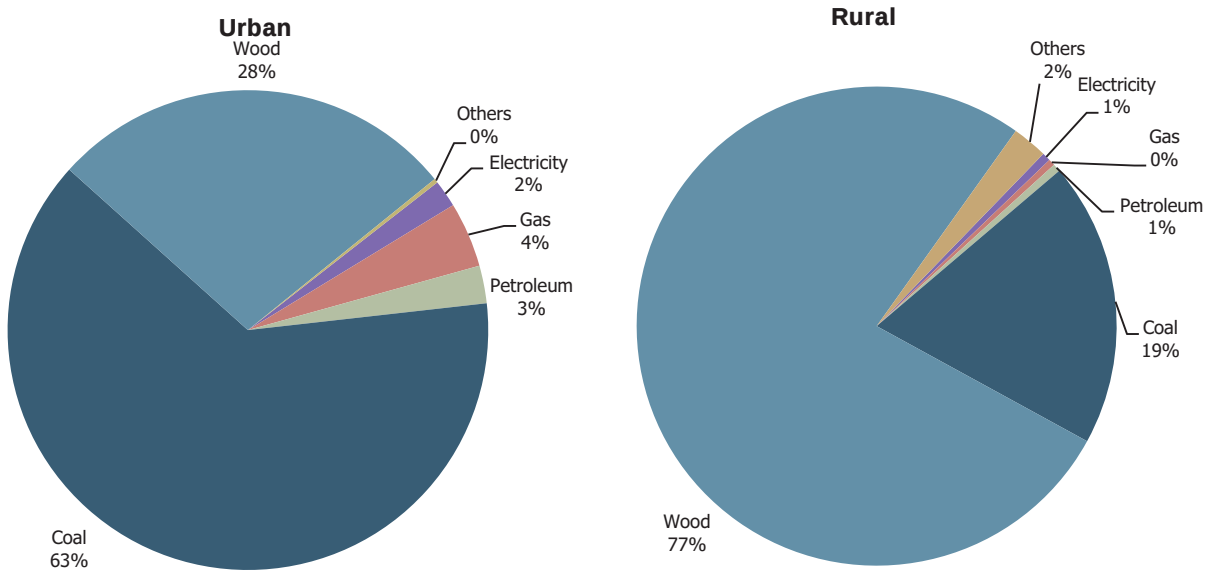
Thermal power plants in Pyongyang City and other cities in the DPR of Korea consume large quantities of coal and heavy oil for power production and central heating. They are a primary source of particulate, sulfur dioxide and nitrogen oxide emissions as are heavy industries. Total consumption of coal and heavy oil is shown for selected years in Table 2.6.

From 1990 to 2008, the population of the DPR of Korea grew by about 3 million people, adding to pressures on energy and resources. In addition to growth of the overall population, the percentage of people living in urban centers has increased from 60.2 percent of the population in 1996 to 60.6 percent in 2008. Due to a heavy dependence on coal as a fuel for heating and cooking in urban areas, larger populations correspond to higher emissions. Population growth has also contributed to the rapid rise in waste related methane emissions.

Residential buildings are a substantial source of air pollution. In higher density neighborhoods air pollution from household heating and cooking is impacting public health and urban ecosystems. Air quality is reduced in urban areas in winter when larger quantities of coal are consumed for heating and unfavorable climatic conditions reduce pollutant dispersal. Emissions of air pollutants is also occurring in residential areas of northern regions where lignite (brown coal) is used for heating and cooking and where efficient technologies are not widely used.

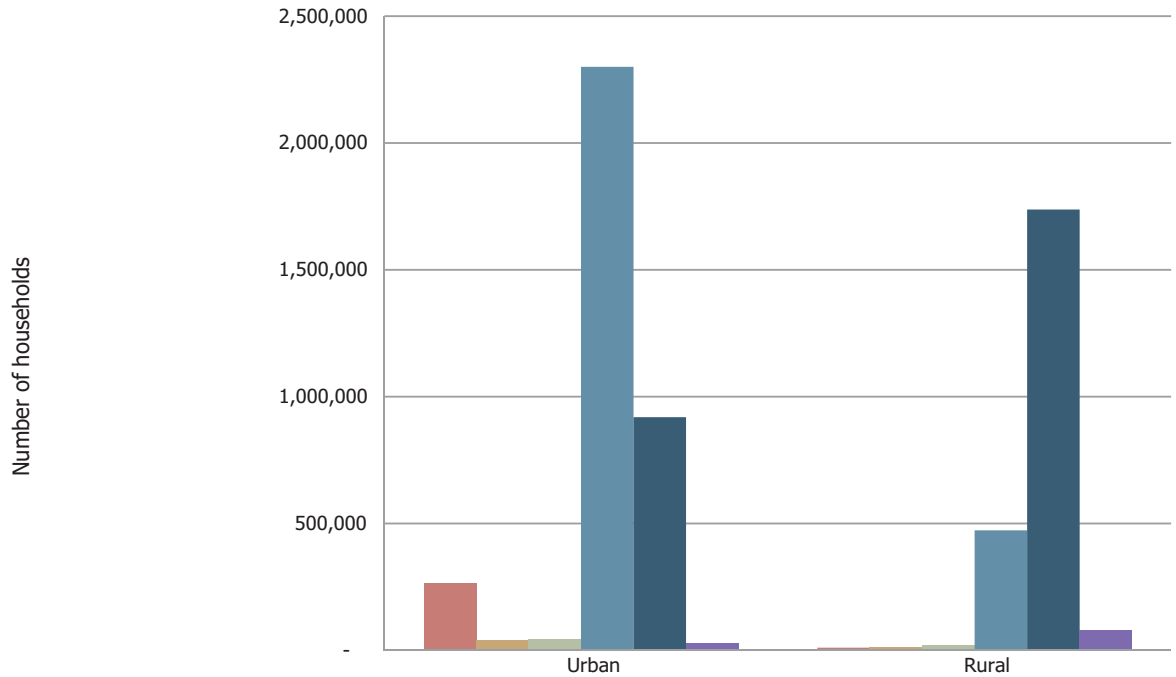
Figures 2.9 and 2.10 show the relative use of different fuel types for cooking and heating at the household level for rural and urban areas. Coal is the main energy source in urban areas representing 63 percent of fuel used in cooking and 64 percent used for heating. Wood

Figure 2.9
Energy sources for household cooking in 2008



Source: Central Statistics Bureau 2009

Figure 2.10
Type of household heating system used



	Urban	Rural
Central or local heating system	263,055	754
Electronic heating system	35,630	4,994
Electronic heating system with others	45,343	10,369
Coal boiler or briquette hole in the dwelling	2,300,395	472,843
Wood hole in the dwelling unit	918,583	1,738,283
Others	16,620	80,602

Source: Central Statistics Bureau 2009

is the second most common source of energy in urban areas. In rural areas, the main sources are reversed, with wood providing 77 percent of energy for cooking and 75 percent for heating followed by coal.

Mobile sources of pollution

The main mobile sources of air pollutants are cars, mini-buses, large buses, lorries and motorcycles. The main pollutants contained in vehicle exhaust are carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter, volatile organic compounds and sulfur dioxide. Hydrocarbons and nitrogen oxides react to form ground-level ozone which can cause respiratory problems and lung damage.

The level of pollution in cities caused by motorized vehicles is related to meteorological conditions, vehicle engine efficiency, road surface quality, number of vehicles, distance travelled and speed. At present, air pollution from mobile sources has not been observed at significant levels. However, traffic pollution is expected to emerge as an issue as traffic loads increase.

2.3 Responses

The government of the DPR of Korea is extremely concerned about prevention and management of air pollution, particularly that created by coal combustion for energy generation. As a result, the government is taking measures to improve combustion and exhaust performance of thermal power plants and encouraging lower coal consumption in households. Actions that have been taken include setting emission standards boilers and industrial furnaces and strengthening regulatory provisions and social supervision to achieve the standards. In addition, the government has introduced new innovations to households, such as thermostat regulated ovens with high combustion and heat utilization efficiency.

The DPR of Korea aims to strictly control activities that harm the natural environment through the use of legal and economic instruments. In many cases outdated production processes have been modernized to reduce pollution. Some enterprises have been equipped with environmentally sound equipment based on advanced technologies which have yielded improvements in local air quality.
National measures have been taken to reduce pollutants including greenhouse gases and ozone depleting substances, which have both local and global impacts. As previously mentioned, the DPR of Korea has ratified multilateral environmental agreements to implement environmental projects that will reduce emissions of air pollutants. These include the United Nations Framework Convention on Climate Change and its Kyoto Protocol, and the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer.

Actions to reduce air pollution

The government has developed an integrated strategy to prevent air pollution and decrease greenhouse gas emissions. To meet the increasing demands for energy with lower emissions, the government is encouraging the development and use of renewable energies, including the construction of hydro-power plants, such as the Huichon power plant.

It has also taken positive steps to address transportation problem in cities and minimize vehicle exhaust gases. Use of private cars in the city has been limited, while public transportation (e.g. trolley-buses, trams and the subway) has been improved. Bicycle use is encouraged. Legal controls on vehicles that emit excessive pollution are enforced and ring roads for trucks and freight cars have been constructed to allow them to avoid passing through city centers.

Box 2.2 City Environment Planning in Progress

In recent years the negative environmental effects of urbanization are becoming more evident. This has highlighted the importance of environmental planning at the city scale and emphasized the importance of measures that will promote long term sustainability and preserve local amenities. Environment planning in the DPR of Korea will now be integrated with other aspects of city development planning. Cities will increasingly be divided into the functional areas (sections), and each area will be assessed against qualitative standards addressing air, water, waste, and ecosystem indicators. Technical engineering measures will be undertaken to advance sustainable development objectives. The planning teams will consists of experts from the Ministry of Land and Environment Protection, the Ministry of City Management, the Environment and Development Center, the Academy of Science and Kim Il Sung University. Pyongyang, the capital of the DPR of Korea has been selected as the pilot city for the new environmental planning arrangements.

The government has also taken institutional measures to prevent air pollution. Actions include establishing a pollutant permit system and a compensation system for environmental damage. Beginning in 2009, an environmental management system (EMS) was introduced in different factories as a pilot demonstration to reduce pollution in production processes. The system is now being implemented across the country.

Cleaner coal combustion technologies, such as newly developed coal briquettes with higher combustion efficiency, are being introduced for heating and cooking in residential areas. Efforts are being made to establish electric heating systems in cities.

Actions to reduce greenhouse gas emissions

The primary mitigation response is to improve the energy efficiency of power production and manufacturing. This action will also help to reduce air pollution. Part of this strategy will include adopting cleaner coal combustion technologies such as briquettes, gasification, and advanced combustion as well as pursuing cogeneration where possible. Energy substitution through renewable sources is also considered important.

A second component of the mitigation response will be to prevent the conversion of forests and the degradation of other carbon sinks. This will require a combination of afforestation and reforestation and improved forest management techniques to ensure that new forests grow at an acceptable rate and reach their potential. Fire and pest management will be important in reducing losses. Protection of existing forests is paramount. Conservation agricultural practices would be beneficial for emissions reductions, carbon sequestration and soil rehabilitation.
Adoption of advanced techniques to minimise methane emissions from rice cultivation and from livestock production would make an important contribution to an overall mitigation strategy.
Improving the energy efficiency of equipment and avoiding unnecessary energy use have the highest priority in the energy strategy. The government has

Table 2.7
Summary of policies and measures for reducing greenhouse gas emissions by sector

Sector	Policies and measures
Energy supply	• Improvement of energy efficiency and reduction of energy consumption
	• Fossil fuel pricing
	• Development and introduction of clean coal technology
	• Expansion of renewable energy use
Transport	• Increase of railway transport as compared with highway transport
	• Limited use of private cars and increased use of public transportation.
	• Promotion of bicycle use and pedestrian exercise of 10,000 steps each day.
Building	• Improvement of design standards for energy saving
	• Demand-side management programs
	• Appliance efficiency standards
Industry	• Technology standards
	• Provision of benchmark information
Agriculture	• Improvement of land management
	• Maintenance of carbon content in soil
	• Efficient use of fertilizers and irrigation
	• Improvement of enteric fermentation of herbivorous animals.
	• Improvement of fecal treatment of livestock
Forestry/forests	• Management and protection of forest resources
	• Strengthening laws and regulations to reduce depletion of forest resource
	• Public campaigns for tree planting
Waste management	• Legislation for waste management
	• Improvement of waste and wastewater management

initiated a campaign to save energy and lower the environmental impact of energy production. Saving energy is one of the most effective methods of reducing greenhouse gas emissions. The government regularly carries out public awareness activities on energy efficiency and promotes technologies such as no-load cutout switches, uninterrupted batteries, card-based electric meters and compact lamps.

The government has made strides in improving energy efficiency and converting to renewable energy. Initiatives to introduce geothermal energy have been actively undertaken, including the production of geothermal equipment at the Ryongsong machinery complex. In addition, the Solar Thermal Equipment Center was established and production of solar thermal water heaters is occuring. The solar thermal water heater can produce hot water of above 90°C in summer and 50°C in winter. There are also demonstration farms at the city of Sariwon in North Hwanghae province where all families utilize biogas from households and live-stock wastes for cooking. The experiences and practices in this cooperative farm have been widely disseminated through rural areas in the country. Improvements have also been made to energy efficiency by introducing space and fluidized bed combination coal combustion technology, water-liquid oil mixed fuel combustion technology and others to medium and small-size boilers and industrial kilns.
Ensuring an adequate energy supply is critical to national economic, development and environmental goals. The DPR of Korea has developed its energy policy to meet growing demand and ensure a stable supply by maximizing existing generating capacity and constructing new hydroelectric power stations.
The government has also adopted a national long-term energy strategy (2009) which aims to ensure renewable energy provides 20 percent of total primary energy supply (TPES) by 2050. This ambitious goal will support global efforts to adopt sustainable energy resources and reduce greenhouse gas emissions.

Actions to reduce ozone depleting substances

To fulfill its commitments under the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer, the DPR of Korea prepared a Country Program in 1997 and set up National Ozone Unit (NOU) in 1998.

The DPR of Korea's socialist planned economy helped it to overcome many potential obstacles in controlling the production and consumption of ozone depleting substances (ODS) that may have been more difficult to address in market based economies. The government established a quota system for the production and consumption of ozone depleting substances and a licensing system for their import and export. This allowed relevant agencies to carry out their activities in a planned and unified way. Under the system, only licensed companies can apply to import ozone depleting substances. Specific laws and regulations were promulgated and enforced on ODS related activities including a ban and import controls on ODS based equipment. The role of the customs agency was strengthened through training programs and the introduction of control tools such as ODS-identifiers to prevent smuggling of ODS.

The country has stopped the production of ozone depleting substances. Production of CFC-11 ceased in November 2003, CTC in December 2005, methyl bromide in February 1996, and methyl chloroform in January 2002. ODS producers were encouraged to convert to ozone-friendly technologies through tax incentives.

The DPR of Korea has achieved its 2010 commitment to the Montreal Protocol to phase out major ozone depleting substance. Since the closure of domestic production facilities, ODSs have been imported.

Actions to address Dust and Sand Storms

As mentioned, over the last decade dust and sand storm (DSS) events have become a significant concern due to their increased intensity and frequency and their associated human and ecosystem impacts. A national early warning system for DSS was established and television and radio messages are now used to inform the public of DSS events. Public awareness activities have been conducted to prevent or reduce DSS impacts. There has been a concurrent increase in scientific research on DSS with remote sensing and monitoring data in some institutions including the Environment and Development Centre and the meteorology institution under the State Hydro-Meteorological Administration .

At the international level, the DPR of Korea has contributed to regional efforts to address this trans-boundary environmental issue including participating in ministerial meetings in Beijing in 2000 on the control on DSS in Northeast Asia.

CHAPTER

3

Water

3. Water

Water is an indispensable resource and a valuable asset for economic development and the wellbeing of humans and the environment. Provision of clean water and socioeconomic development are inseparably related, necessitating the protection and management of water resources for current and future generations.

The DPR of Korea has relatively abundant water supplies capable of supporting irrigation, industrial, potable water, recreational and hydro-electric demands if supplies are used efficiently and are not adversely affected by climate change or pollution. Population growth and economic development in the DPR of Korea have increased water demand for domestic and industrial purposes and put pressure on the integrity of supplies. It is a national government priority to ensure a clean and predictable supply of fresh water by managing water resources in a rational way and establishing discharge treatment facilities at manufacturing factories, public service facilities and hospitals to prevent water supplies from being contaminated.

The regular supply of water for human use and ecological flows has been affected by floods and droughts in recent years. This has had negative impacts on biodiversity and agricultural production. Management for sustainable use of freshwater resources has become one of the most important environmental issues for the country.

3.1 State and trends

Freshwater sources and volumes

In the DPR of Korea, most freshwater for human use is drawn from rivers, streams and lakes. Ground water is an important but secondary source. The DPR of Korea has about 100 natural lakes, 1,700 artificial reservoirs, 38 major rivers and 10,208 streams. The total length of all streams is approximately 64,855 km, of which the major rivers account for 5,355 km and medium sized streams approximately 59,500 km. The DPR of Korea has a high density of water-courses (0.4 - 0.6 km/km$^{2)}$ compared to most countries.

The total annual precipitation is estimated at about 127.41 billion m^3, of which 83.15 billion m^3 becomes surface water and 44.26 billion m^3 is removed by evaporation. Surface water accounts for about 98.7 percent of the freshwater resources with the remaining 1.3 percent in the form of groundwater. Groundwater supplies total approximately 5.318 billion m^3. Ground and surface water volumes are influenced by weather, soil, geography, forest cover, crop distribution and water utilization.

Some of the major river systems in the country include:

- The Amnok River borders the country to the north with China and flows west to the sea through Ryanggang province, Jagang province and northern Pyongan province starting from Paektu Mountain Range, Ryanggang province.
- The Tuman River flows to the east through Ryanggang province, northern Hamgyong province and Rason city starting from Paektu Mountain Range, Ryanggang province.
- The Taedong River flows to the west through southern Pyongan province, Pyongyang city, the capital, and Nampo city starting from Rangrim Mountain Range.
- The Chongchon River flows to the west and separates north and south Pyongan provinces.

The largest natural lakes are Lake Chon on Mt. Paektu (916 ha), Lake Sobon(1,374 ha), Lake Man(855 ha) and Lake Changyon(816 ha) (Un Chel Nam, Rim Chu Yen, 2002).

Among constructed water bodies, the largest reservoirs for irrigation are Lake Sohung (1,840 ha) and Lake Thaesong (830 ha), and for hydro-power are Lake Suphung (36,500 ha) and Lake Jangjin (4,429 ha).

There are more than 40,000 km of irrigation channels across the main networks: South Phyongan Province Irrigation Network, Kiyang Irrigation network, Amnok River Irrigation Network, Lake Sohung, Lake Unpha Irrigation Network. After the West Sea Barrage was built on the estuary of the Taedong River in 1986, 800 km of waterways were constructed for agriculture in South Phyongan and South Hwanhae Provinces.

Freshwater resources in the DPR of Korea are characterized by:

- variation in regional distribution - the western and eastern lowland areas have fewer water resources

and higher water demand than other regions due to more intense industrial and farming activities;
- variation in the timing of rainy and dry seasons; and
- seasonal availability of water resources due to the location and volume of precipitation.

DPR of Korea has a humid summer and a dry winter-spring, producing seasonal variation in the availability of water from rivers and streams. Precipitation is highest in July and August and more than half of the annual water flow volume occurs in these months. In contrast, from December to March flows are much lower and represent a constraint on agricultural and industrial development. A key component of successful water management in DPR of Korea involves ensuring that there is sufficient water available to meet the spring deficit.

Improved living standards in the DPR of Korea have been accompanied by increased water use. The substantial demand for industrial, agricultural and potable water has been met through the construction of the West Sea Barrage, and dams including Mirim, Taedonggang, Taechon and Nyongwon. Agricultural demand is met through irrigation infrastructure linked to rivers and dams.
Most surface water is used in the first instance to produce hydro-electric power. Agriculture water consumption accounts for about 12.8 percent of total water use, most of which comes from surface sources. Industry consumes about 47.5 billion m^3 and domestic activities about 1 billion m^3.

Water quality

Sources of pollution

Water quality varies by location and also by season. The majority of water pollutants comes from the discharge of industrial wastewater and untreated sewage, particularly in rural areas where facilities are inadequate. Runoff from agricultural land is another source of contaminants. In recent years, water quality has declined in certain areas due to contamination from sewage. This has largely resulted from persistent underinvestment in treatment facilities and their maintenance. Industrial wastewater also affects water quality in some instances but the primary source of

pollution is organic from human and animal waste. Although fertilizers and other chemicals are important factors in agricultural production they can infiltrate ground and surface water following precipitation. The degree of infiltration depends on various factors including the type and volume of the chemical, its method of application, the characteristics of the soil and crop cultivation methods. The main pollutants include nitrogen, phosphorus and potassium although other elements such as sulphate, chlorine, calcium, magnesium, manganese, and boron can pose a hazard. Other more toxic agricultural chemicals include organic chlorine, phosphor and mercury.

Water quality monitoring

Environmental monitoring stations undertake monthly water quality measurements of major rivers. The results are submitted to the Central Environmental Monitoring and Supervision Agency (CEMSA) which analyzes the data and prepares monthly environmental monitoring reports for the Ministry of Land and Environment Protection (MLEP). The MLEP distributes these reports to the Cabinet and relevant ministries for use in determining appropriate responses.

Although the institutional structure for the monitoring system is in place, currently only a limited number of water quality indicators are analyzed. The network needs technical, material and human resources to expand the geographic range of the monitoring effort and increase the number of indicators monitored. In waterways where water quality is poor and monitoring is urgently needed, real time data collection is not possible due to a lack of equipment and reagents.

Improving the quality of the water monitoring network through the installation of remote and real-time monitoring equipment, the expansion of data storage and handling facilities, and investments in a computer network based data distribution system are high priorities.

Water quality standards

Table 3.1 on the following page provides details of the primary indices of water quality and the associated water quality standards for special and normal water areas.

Water quality of the Taedong River

The Taedong River has a high population density and numerous factories and enterprises along its banks. The water quality of the Taedong River exhibits high variability on a seasonal and geographic basis. As would be expected, the water in the upper stream is clear and downstream water is more degraded but improves in the areas of the West Sea Barrage (Ri Mun Hyok, 2008). Table 3.2 provides information on water quality indicators for the Taedong River downstream by season for the years 1999 and 2008. Pollutant concentrations tend to be highest in the spring when water levels are low, and lowest in autumn when rivers are full from heavy rains. The chemical oxygen demand indicator shows that pollution by organic matter has worsened from 1999 to 2008 across all seasons. Ammonium concentrations (NH4-N) were generally lower in 2008 than in 1999 when they exceeded the standard. Chlorine levels (CL) were generally higher in 2008 than 1999. In both years they were below the environmental standard. Coliform counts were lower in 2008 than in 1999, reflecting water treatment investment that occurred in the interim.

Water quality of Amnok River

Water quality in the downstream area of the Amnok River is reduced, with high levels of nitrogen causing red tides on a regular basis (Table 3.3). Red tides harm marine biodiversity and render the water unsuitable for human consumption. COD and BOD levels are below the standard for other areas. The Amnok River is a boundary river, with China, as such it is very important to strengthen international cooperation to ensure high water quality is achieved consistently.

Table 3.1

DPR of Korea water quality standards

No	Indicators of water quality	Unit	Special water area		Water area	
1	Odor		None		None	
2	Color	Shade	Below	2	Below	2
3	PH	mg/litre	Range	7.0-8.5	Range	6.5-8.5
4	Suspended Solids	mg/litre	Below	20	Below	30
5	NH4-N	mg/litre	Below	0.1	Below	0.3
6	NO2-N	mg/litre	Below	0.01	Below	0.01
7	NO3-N	mg/litre	Below	5	Below	10
8	CL-	mg/litre	Below	20	Below	30
9	DO	mg/litre	Above	7.5	Above	5
10	CODMn	mg/litre	Below	1.5	Below	3
11	BOD5	mg/litre	Below	2	Below	4
12	Ni	mg/litre	Below	0.1	Below	0.1
13	CN-	mg/litre	Below	0.001	Below	0.001
14	As	mg/litre	Below	0.05	Below	0.05
15	Hg	mg/litre	Below	0.0005	Below	0.0005
16	Cr	mg/litre	Below	0.03	Below	0.03
17	Zn	mg/litre	Below	1.0	Below	1.0
18	Cu	mg/litre	Below	0.1	Below	0.1
19	Pb	mg/litre	Below	0.1	Below	0.1
20	Cd	mg/litre	Below	0.01	Below	0.01
21	Phenol	mg/litre	Below	0.001	Below	0.001
22	F	mg/litre	Below	0.7	Below	0.7
23	Organic chlorine	mg/litre	Below	0.02	Below	0.02
24	Coliform	no./ litre	Below	500	Below	10,000
25	PCB	mg/litre	Removal		Removal	

Source: Ministry of Land and Environment Protection 2000

Table 3.2

Water quality indicators for the Taedong River by season (1999 and 2008)

Indicator	Spring		Summer		Autumn		Winter		Average		Environmental Standard
	1999	2008	1999	2008	1999	2008	1999	2008	1999	2008	Other
COD	2.14	2.82	1.33	2.11	0.78	1.56	0.73	2.10	1.25	2.15	3.00
NH4-N	0.27	0.30	0.87	0.20	0.08	0.20	0.20	0.19	0.35	0.22	below 0.3
Cl	7.20	8.60	8.40	16.33	8.40	13.53	10.00	7.49	8.70	11.49	below 30
Coliform	311,666	33,743	4,847	63,234	2,300	25,780	68,500	12,000	96,828	33,689	below 10,000

Source: Environment and Development Center 2008

Table 3.3

Annual average water quality indicators for Amrok River (2008)

Indicator	COD (mg/l)	BOD (mg/l)	NO2-N (mg/l)	PO4-P (m/l)	Oil (mg/l)
Value	2.89	3.86	0.18	0.11	16.8

Source: Environment and Development Center 2008

Water quality of Tuman River

The Tuman River is also a boundary river and is influenced by its trans-boundary watershed area. As such it is also necessary to strengthen international cooperation to ensure good water quality.

The midsection of the Tuman River is polluted while the upper reaches remain within required standards. In particular, the upper streams of Musan and Hoiryong maintain high water quality during periods of water

shortage. However, water quality of the midstream deteriorates to unacceptable levels during periods of flooding. The pollution loads from suspended solids are increased by intense run-off and soil erosion in the mid-reach of Tuman River during floods. In particular it is exacerbated by the branch streams to the middle part of the River which bring sediments such as ore residue.

Water quality of Chongchon River

The Chongchon River is influenced by industrial wastewater and domestic sewage in the Anju City water area. Nitrogen levels exceed environmental standards (see Table 3.4). Substantial amounts of top soil and sediment enter the river during flood events as a consequence of deforestation, steep slope agriculture and other unsustainable land management practices. In addition to increased turbidity, heavy rain and flooding contribute to elevated water pollution by flushing sediments into river systems and disturbing accumulated waste and organic sediment that had precipitated on the bottom of slow moving waterways.

Heavy rain and floods have become more frequent in recent years, possibly as a consequence of climate change (see Chapter 6).

3.2 Drivers and pressures

The reduced water quality of some rivers and streams is a consequence of increased waste water volumes due to economic development and population growth, inadequate investment in water and waste treatment facilities, insufficient measures to effectively regulate and manage effluent release, and technical limitations. These factors are exacerbated by flooding and droughts.

Table 3.4
Annual average water quality indicators for the Chongchon River at Anju City (2008))

Indicator	COD (mg/l)	BOD (mg/l)	NO2-N (mg/l)	PO4-P (m/l)	Oil (mg/l)
Value	2.67	3.56	0.13	0.51	11.4

Source: Environment and Development Center 2008

Population growth

Continued population growth, especially in rural areas, has increased water consumption and resulted in increased sewage loads for the water treatment system. Existing facilities are not sufficient to provide complete wastewater treatment in some areas, resulting in increasing volumes of untreated waste entering river systems.

Industrial development

The water treatment capacity of some factories and enterprises located within river basins is inadequate to maintain healthy waterways. The development of water treatment plants and introduction of advanced treatment technologies have not kept up with the growing need.

Deforestation and inadequate riparian zone management

Deforestation and poor riparian zone management are resulting in the loss of topsoil and the sedimentation of waterways. Exposed soils have reduced water retention and filtering capacity. This reduces soil moisture levels and slows groundwater recharge. Consequently during dry periods of the year water for agricultural, industrial, domestic uses is in short supply.

During periods of intense rain, soils in deforested areas are easily carried into waterways and eventually

accumulate in riverbeds and dam catchments or are carried out to sea. Transported sediment raises the turbidity of rivers and streams making the water expensive to treat and affecting habitat for fish and other freshwater species.

3.3 Response

Legislation

Protecting freshwater quality and ensuring adequate supply has been an important policy requirement for the government. An extensive framework of laws and regulations exists. Increasingly there has been a shift to encourage greater direct involvement of citizens to undertake water management projects. The government adopted Cabinet Decision No.15 "Regulations on Management of Rivers and Streams" and established mid- and small-size rivers and streams arrangement weeks every spring (March 1st-end of April) and every autumn (November 1st-end of December) as a nation-wide campaign to improve and rearrange rivers and streams.

Laws relating to water management include:

- Law on Prevention of Taedong River Pollution , DPR of Korea
- Law on Water Resource, DPR of Korea
- Law on Environment Protection , DPR of Korea
- Law on River and Stream, DPR of Korea
- Law on Forest , DPR of Korea
- Law on Land Planning , DPR of Korea

Important requirements pursuant to the "Law on Rivers and Streams" and the "Law on the Water Resource" are:

- to establish a scientifically based water use plan that improves the arrangement of rivers and streams, improves water efficiency and ensures high quality supplies for domestic use and economic development;
- to carry out river management, such as bank stabilization, dredging and realignment, and motivate people to protect water resources;
- to give priority to river management and water resource protection and increasing national investment in the water sector; and
- to strengthen international cooperation in river management and water resource protection, and meet the conditions of bilateral agreements, treaties and contracts.

Box 3.1 Taedong River Protection Program

The government regards the protection and improvement of the Taedong River as an important indicator of sustainable development in the country's river basins. The Taedong River, as a major river, is attracting considerable effort to ensure its protection.

The "Law on Prevention of Taedong River Pollution, DPR of Korea" was adopted in 2005, which regulates water quality and ecosystem protection, conservation and improvement. In 2008, the government established the "Integrated Management Plan for Land and Environment in the Taedong River" to improve the water quality, prevent flood damage, and supply water and electric power to different branches of the national economy.

River improvement projects have included dredging the riverbed to remove accumulated pollutants, bank stabilization, wastewater treatment capacity building, water quality monitoring, periodic water exchange with clean upper stream water, and tree planting in riparian zone. Taedong River water quality has been temporarily improved by flushing reservoir water from Mirim Dam in spring and autumn.

The "Law on Prevention of Taedong River Pollution, DPR of Korea" regulates water quality and ecosystem protection, conservation and improvement. It also specifies that reforestation must be undertaken in the catchment area to prevent sand, mud and waste flowing into the river. It requires regular management of the banks of the Taedong River, the removal of sediment, ore, sludge, and hydrophytes, and development of scientific research to monitor water quality and prevent pollution of the river while introducing modern technologies.

The "Law on Environment Protection, DPR of Korea" requires that the central guiding agency for land and environment protection establish a national environmental monitoring system, regularly assess the environmental status of the country, and devise an annual plan including giving guidance for its implementation.

However, technical and financial limitations have impeded the achievement of desired outcomes in some cases. Waste and sewage water treatment technologies are not keeping up with the latest global trends, and more advanced techniques and instruments are required. Further improvement in water treatment will help to address these limitations and produce the desired outcomes.

Water supply measures

In order to help meet growing water demand, the government of the DPR of Korea has developed strategic policies for maximizing storage and effective use of the country's water resources. These efforts include a policy for the efficient use of water resources, and an groundwater use policy to help overcome supply problems associated with abnormal climatic phenomena.

Box 3.2 Using *Pistia Stratiotes* to improve river water quality

Research in the DPR of Korea has shown that the cultivation of *Pistia stratiotes* in rivers can play an important role in improving water quality in degraded river systems. The plant is also an excellent fodder for livestock. Recently the plant has been cultivated in a limited area in Potong River in Pyongyang City from early April to late October and used as fodder in nearby farms. These trial cultivation areas are expected to be increased as further evidence supporting the strategy is collected.

To address irrigation water shortage in the western farming areas of the country, the government has constructed several waterways and reservoirs including the large-scale Kaechon-Taesong and Miru Waterways. These waterways maximize storage and facilitate the effective distribution of water resources.
The government also has a program to improve water supply and drainage. One element of this program is the construction of lock gates, dams and other facilities such as the West Sea barrage and Taechon Power Plant dam. Dams and reservoirs have been an important component of providing both water and electrical power. Attention needs to be given to reservoir management as its effectiveness is subject to climatic conditions and sediment and pollutant loads.

Water quality measures

Agriculture related response

Measures have been introduced to prevent environmental degradation by agricultural chemcical through policies such as the "Law on Environment Protection" (1986), the "Law on Agricultural Chemicals" (2006), and the "Law on Prevention of Sea Pollution" (1997) which regulate pollution prevention. The measures include:

- Prohibiting production or import of pesticides that pollute air, water and soil or affect human health.
- Prohibiting the spraying of harmful chemicals such as herbicides and insecticides around catchments, reservoirs and drainages.
- Ensuring that agricultural guidance bodies, relevant agencies, enterprises and groups store and use pesticides according to the regulations, and prevent pesticide from contaminating rivers, lakes and reservoirs, land or marine areas.
- Requiring permission from land and environmental protection agencies to spray pesticides by airplane.

The "National Implementation Plan for the Stockholm Convention on Organic Pollutants" (2008) has been formulated specifying a strategy and action plan, institutional framework, education and public awareness activities for the phase-out of toxic agricultural chemicals such as DDT and hexachlorobenzene. The government encourages organic farming and promotes research and development of organic fertilizers and pesticides which are less harmful to the environment and human health. Research institutions including the Academy of Agricultural Science are developing complex microbial fertilizers, Hookbosan fertilizer (an organic fertilizer) and other agricultural chemicals.

Location of industry and residential areas

Efforts have been made to locate factories, enterprises and residential areas in a purposeful way that considers the topography and state of local water resources.

Factories and enterprises are required to carry out their production activities in a manner that will prevent water pollution. Some are equipped with water-treatment facilities to ensure that hazardous wastes and pollutants do not enter streams. All factories are required to monitor effluent flows and water quality.

Establishment of EIA and permit systems

The government has established an "Environmental Impact Assessment System" to prevent water pollution caused by construction. The government has also introduced a pollutant discharge permit system that allows for the discharge of wastewater from existing projects under the condition that pollutant levels are within National Discharge Standards.

Reforestation and riparian management programs

The government, mindful of the interdependence between forest cover and water quality, has placed renewed emphasis on reforestation and afforestation

efforts in watersheds. This strategy includes measures to protect existing forests and actions to modify stream alignment and bank structure to maximize benefits. Every spring and autumn there is a mass mobilization of people from factories, enterprises, schools and government agencies to this effort during the period of the "General Mobilization for Land Management".

Ground water response

The government adopted the "Law on Water Resource" in 1997 and has taken various political measures to protect groundwater resources and to develop and use them rationally. To address shortages due to severe drought, the government has promoted drilling wells to access ground water across the country in order to meet agricultural and drinking water demands in the dry season while additional irrigation systems are built. Government policy has emphasized environment protection in developing and utilizing groundwater in urban areas. The "Law on Environment Protection" prohibits extracting groundwater in a way which results in negative environmental impacts such as ground subsidence. To implement the groundwater regulations an audit and permit system has been established for urban areas.

The government strictly controls pollution to avoid contamination of groundwater. The "Law on Environment Protection" requires waste water treatment and prohibits polluted effluent discharge. The government has also established strong measures to prevent pollution from persistent organic substances such as polychlorinated biphenyls and other toxic chemicals while also launching public awareness raising activities.

CHAPTER 4

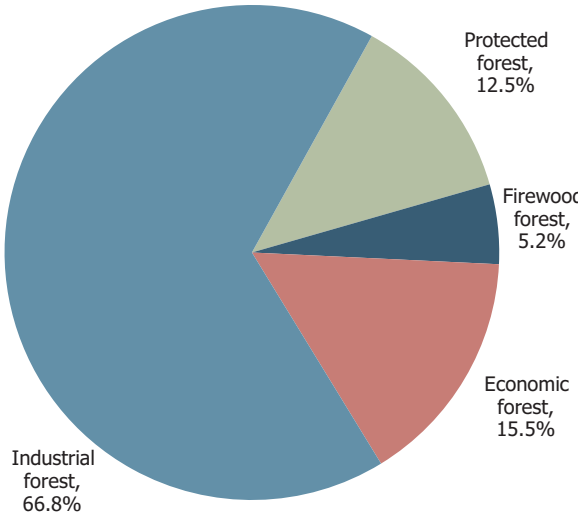
Land, Forests and Soil

4. Land, forests and soil

Healthy and abundant forests and productive soils are essential to the provision of food, building materials, energy and ecosystem services. They are a necessary condition for food security and sustainable socioeconomic development.

The protection of forests and agricultural soils is an important environmental issue in the DPR of Korea. Deforestation and land degradation resulting from unsustainable farming methods and forest management and development have been compounded by an increasing occurrence of floods and droughts. The natural productivity and regenerative capacity of the land has been diminished in certain areas, a condition worsened by economic difficulties, lack of financial resources and contamination from sewage and industrial waste. Although progress has been made, forest and soil protection remains an important environmental issue.

Figure 4.1
Categories of timber forest use in 2005

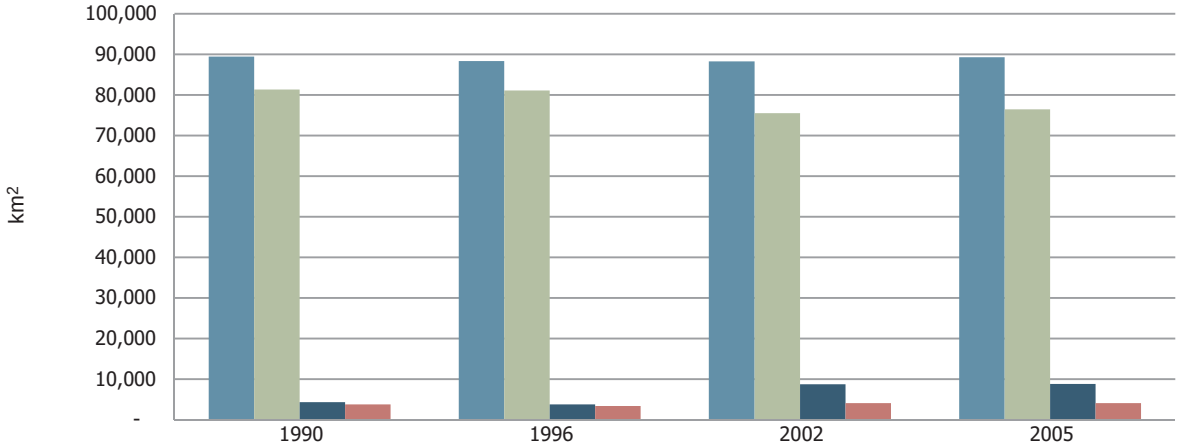


Source: Central Statistics Bureau 2009

4.1 State of land, forests and soil

The DPR of Korea is a mountainous country, with the exception of lowland areas in the south west and along the central east coast where much of the country's agriculture and population exists. Most of the country has historically been covered in forests. In 2005, forested land covered 89,273 km^2 and the agricultural land 20,421 km^2. On a per capita basis this amounts to approximately 0.4 ha of forested land per person and just 0.08 ha of agricultural land. Consequently, to ensure adequate food for a growing population there is persistent pressure to convert forested land into agricultural land. This pressure has been exacerbated by a decline in soil productivity over the last several decades.

Figure 4.2
Variation of forest cover 1990-2005



	1990	1996	2002	2005
Total forested land	89,455	88,324	88,285	89,273
Timber forest	81,333	81,154	75,541	76,432
Non-timber forest	4,324	3,769	8,707	8,768
Non-forested area	3,798	3,402	4,036	4,073

Source: Central Statistics Bureau 2009

Forest cover and quality

In 2005 the area of timber forest was about 76,432 km^2. This includes industrial, economic, firewood and protected forest uses as shown in Figure 4.1. Industrial forest refers to the forest for timber production used for props, sleepers, furniture and other items. Economic forests provide raw materials for production of oil, medicine, fibre, perfume, pulp, and wild fruit. Protected forests are those dedicated to the protection and conservation of biological diversity. Firewood forests produce firewood for rural energy.

Deforestation and forest degradation

Forests make an important contribution to socio-economic development and play a key role in the provision of ecosystem services and the maintenance of biodiversity. Although the DPR of Korea has a rich heritage of forests, this natural bounty has been under pressure as a result of encroachment and conversion to agriculture and other activities, particularly during the mid-1990s when economic difficulties led to shortages of energy and food.

As previously mentioned, most of the rural population depends on firewood for energy. Table 4.1 shows household firewood use for heating and cooking. Forests planted specifically for firewood doubled in area from 1,944 km^2 in 1990 to 3,988 km^2 in 2005.

Canopy cover and tree density have been affected by harvesting for fuel and building material. The quality of many stands has declined due to flooding, droughts, forest fires and pests.

Between 1990 and 2002, the area of timber forest was reduced at a rate of approximately 480 km^2 per year and fell from a total of 81,333 km^2 to 75,541 km^2. The decline in forested land has been reversed in recent years due to an active tree planting campaign as Figure 4.2 illustrates. By 2005, the area of non-timber forests had increased by 5,000 km^2 compared with 1996 levels. The area of timber forest has been expanding since 2000, but has not re-established former levels of coverage that existed in 1990 and earlier.

On the whole, progress has been made in forest conservation and rehabilitation, but there remains a deficiency in forest management, in particular, regarding the introduction of methods and technologies for advanced forest management. Further, some of the reforestation effort has not been efficiently implemented. Gaining an accurate assessment of deforestation is difficult given the scale and complexity of the related issues.

Table 4.1
Households dependent on firewood in 2009

	Heating	Cooking
Urban	919,000	984,000
Rural	1,738,000	1,774,000
Total	2,657,000	2,758,000

Source: Central Statistics Bureau 2010

Pest and forest fire damage

Forest fires and pests cause considerable damage to forest ecosystems. In 2000 and 2002, 365 forest fires were recorded affecting 128 km^2 of forests and resulting in a loss of 21,000 and 16,000 cubic meters of wood respectively. Over the same period approximately 300 km^2 of forest were damaged by pests including *Dendrolimus spectabilis, Cecidomyia brachyntera, Dendrolimus sibiricus, Acantholyda sp., Matsucocus pini, and Lymantria disbars albescens* (MLEP, 2006).

Impact of deforestation and forest degradation

Forest depletion and degradation have significant impacts on human and ecosystem health. The loss of forest cover reduces water infiltration, increases soil erosion and land slides, and contributes to the sedimentation of rivers as discussed in Chapter 3.

Deforestation releases CO_2 into the atmosphere and reduces carbon sequestration potential. Biodiversity is also adversely affected as discussed in Chapter 5. Furthermore, due to the slow growth rates of forest stocks, rapid rates of deforestation represent a transfer of natural resources away from future generations towards current ones.

Agricultural soil productivity

Agricultural land use

Total agricultural land is the sum of arable and non-arable land areas. Arable land refers to land that can be cultivated for crop production. Non-arable land is not suitable for cultivation. The total agricultural land area of the DPR of Korea is 20,421 km^2. The area of arable land is 18,390 km^2, most of which is used in dry field farming (10,050 km^2), followed by paddy fields (5,740 km^2). Orchards cover about 1,440 km^2 and mulberry farms about 850 km^2. The allocation of arable land among agricultural uses in 2004 is shown in Figure 4.3.

Steep slope agriculture

Although much of the dry field agriculture is located on slopes less than 15 degrees, steep slope farming is widespread in the DPR of Korea. Approximately 15 percent dry field agriculture occurs on slopes of between 15 and 30 degrees, and 3 percent on slopes greater than 30 degrees as Figure 4.4 illustrates. Soil erosion is common on slopes above 10 degrees. The loss of soil by erosion on sloping lands is about 40 to 60 tonnes/ha per year, but in severe cases it exceeds 100 tons/ha per year. This has reduced agricultural productivity in some areas.

Soil erosion and degradation

Agricultural top soil is being lost to wind and water erosion. Soil depths have declined which has reduced productivity. In coastal areas, some tideland rice fields that are characterized by low nutrient soils are exhibiting declining silicon content from continuous freshwater irrigation. This has negatively affected soil dynamics. These fields have been cultivated for decades and have become degraded. Yields of grain from these fields have been affected.

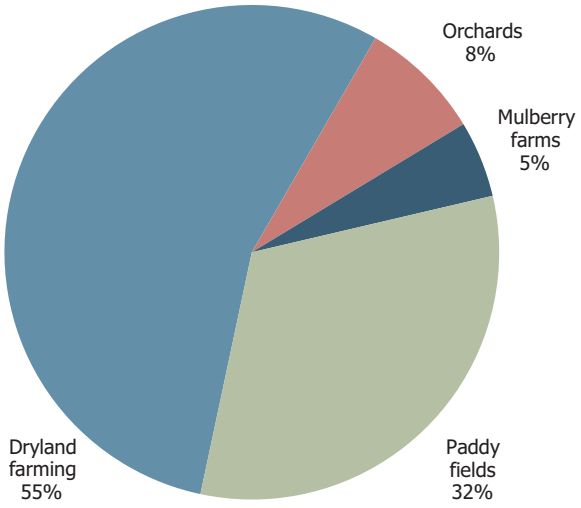
Soil contamination

In the DPR of Korea, land is usually not seriously affected by soil contamination. Laws exist to regulate waste from factories and enterprises, including requirements for site-based purification of liquid waste. These laws are strictly enforced. However, domestic waste and fly ash from cities are often applied to arable land around cities for the purpose of preventing soil acidification and to enhance the structure of soils. Sludge from wastewater treatment plants is used as an organic fertilizer.

Urban waste and sewage are probably the primary source of soil contamination at sites where they are applied. The average content of heavy metals in urban waste and sludge from Pyongyang city in 2005 and 2006 was high (Table 4.2).

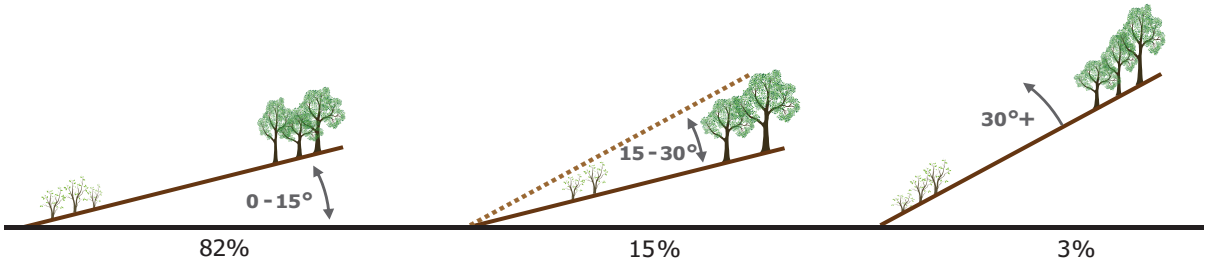
Figure 4.3

Allocation of arable land between agricultural uses in 2004



Source: Central Statistics Bureau 2006

Figure 4.4
Percentage of agriculture by slope



Source: Central Statistics Bureau 2006

The municipal solid waste generated by residents and industry in Pyongyang is estimated to be 580,000 tons per year (Paek Ok In, 2009). Some of this waste is processed and used as fertilizer in farming areas around Pyongyang city. Most of the remaining untreated solid waste is disposed of in a landfill near the city.

Between 2005 and 2009, there was an increase in the amount of heavy metals in soils that used processed domestic waste as a fertilizer (Table 4.3). While these levels are within national environmental standards, they indicate that soils contamination from heavy metals may become an environmental issue unless industrial waste entering the domestic system can be reduced.

While the heavy metal content of most soils in farming areas are below environmental standards, soils around refineries, chemical factories and mines are affected by mercury, cadmium and lead due to insecure treatment of waste and residues (Table 4.4).

Waste management

Economic growth in the DPR of Korea has resulted in an increase in production of products as well as waste. Improved living standards have been associated with a trend towards higher consumption and the use of less durable products, which results in greater production of waste. There is an urgent need to ensure safe disposal or treatment of waste and appropriate reuse and recycling.

Generation of waste

Waste generated in the DPR of Korea can be broken down into industrial, municipal solid (domestic) and hazardous waste. Industrial waste comes from mining, metal, machine, electric power, coal, chemical, rubber, plastics manufacturing, textile, paper and lumber, foodstuff and building materials industries, and agriculture. Hazardous waste includes toxic and radioactive materials and biohazard waste from hospitals.

Table 4.2
Heavy metal content in urban waste and sludge (mg/kg)

Element type	Cadmium (Cd)	Mercury (Hg)	Arsenic (As)	Chromium (Cr)	Lead (Pb)	Zinc (Zn)	Copper (Cu)
Urban waste	2.8	0.7	36.2	34.0	144.0	107.0	120.0
Sludge	3.2	1.6	42.6	57.5	171.0	625.0	127.0

Source: Environment and Development Center 2006

Table 4.3
Heavy metal content in soil enriched with municipal solid waste (mg/kg)

Element type	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)	Zinc (Zn)	Copper (Cu)
2005	0.80	42.6	47.6	88.4	43.2
2009	0.88	46.8	49.3	98.2	64.8
Standard	3.0	100.0	100.0	170.0	280.0

Source: Environment and Development Center 2009

Table 4.4
Heavy metal content in soils around selected refineries and mines in 2008 (mg/kg)

No	Sampling site	Cadmium (Cd)	Mercury (Hg)	Arsenic (As)	Lead (Pb)
1	Danchon refinery	3.4	4.5	47.0	261.0
2	Munpyong refinery	6.4	3.2	59.0	4.1
3	Chonma mine	3.4	6.3	38.0	130.0
	Standard	3.0	2.0	20.0	100.0

Source: Environment and Development Center 2009

Municipal solid waste includes domestic waste, enterprise waste, and public waste. Domestic waste derives from daily-use activities, while enterprise waste come from office-cleaning, fuel combustion, maintenance and repairs and public service. Public waste is generated from cleaning yards, roads, land and public places.

The amount and composition of municipal waste varies regionally according to the population, season, social habits, dominant fuel use and the geography of the region.

Figure 4.5 shows the composition of municipal waste in Pyongyang. Most of the municipal solid waste is composed of coal ash. In urban centres 64.3 percent of households use coal for heating and 63.4 percent use it for cooking. This generates a large quantity of waste ash, the volume of which increases substantially in the colder winter months. The remaining 36.5 percent of municipal waste is composed of fruits and grains, metal, waste paper, plastics, glass and rag. The generation of municipal solid waste peaks in November due to the large amount of coal ash and by-products of vegetable use.

Waste treatment and disposal

Industrial, domestic and hazardous waste are treated, disposed of, or recycled according to regulated procedures and methods. Industrial waste is to be recycled or reused as a rule. Waste generated at production sites is collected and sorted for use in the manufacturing of recycled products or mixed with raw materials to produce other products. Hazardous waste, such as heavy metals, are strictly controlled by national level regulations. Hospital waste is collected and burnt in incinerators at hospitals to prevent contamination of other waste and the spread of infection.

Under an integrated system, municipal solid waste is collected and disposed of, or recycled, in landfill sites and fertilizer production plants. The collection and disposal system requires reusable waste to be sorted and sent to the appropriate processor for recycling or reuse. Reusable material includes paper, glass, iron, rubber, cloth, plastics, bottles, and non-ferrous metals.

The reuse of waste is currently constrained by the lack of appropriate technologies. The recycling and reuse system reduces the burden on municipal waste disposal which conserves scare natural resources, minimizes the expansion of landfill sites and lowers production input costs. The system is based on voluntary public participation.

Recycled waste as a soil amendment

Coal ash is used as an input in the production of new building materials but is also mixed into soils to reduce acidity and improve physical qualities of the soil. Organic waste and sewage sludge are used to produce mulch, often without being treated. These practices

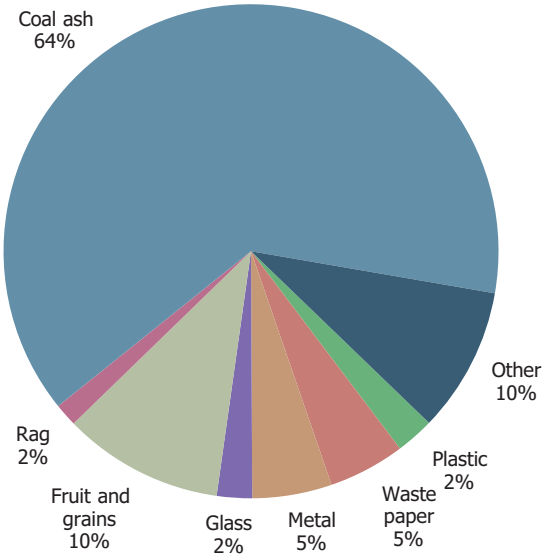
have the potential to result in chemical and bacterial contamination of agricultural soils. Soils closer to industrial areas and those that receive higher amounts of ash and organic amendments from municipal and industrial waste streams have higher levels of contaminants.

Mulching with municipal waste includes:

- direct transport to the fields without sorting,
- transport and manuring of fields by farms through self-sorting, and
- sorting, pulverizing and composting in a fertilizer plant to produce mulch prior to its application.

Direct use of organic waste is unsightly and gives rise to foul odors in addition to posing a risk of contamination of the soil and groundwater. Land filling of solid waste is likely to cause surface and groundwater pollution.

Figure 4.5
Composition of municipal solid waste in Pyongyang



Source: Central Statistics Bureau 2009

Impacts of deforestation on soil quality

Ecosystem services

Deforestation and forest degradation negatively impact a number of ecosystem services. These impacts include reduced water infiltration, increased soil erosion and a slowed rate of ground water recharge. Soil erosion reduces the levels of organic material and micronutrients in soils, rendering them less productive. At the same time it reduces water purification and contributes to sedimentation of streams and rivers which negatively impacts aquatic species including fish, birds and other wildlife and insects that require clean surface water. Deforestation releases previously stored carbon into the atmosphere at the same time it reduces the rate of removal of CO_2. Deforestation and forest degradation also reduce air purification by trees and remove food and habitat for forest wildlife.

Agricultural productivity

Degradation of agricultural land includes soil erosion, nutrient loss, acidification or re-chlorination, reduced soil water content, soil compaction and soil contamination. These outcomes directly affect agricultural productivity and soil carbon sequestration. Soil degradation is also a significant cause of sediment and pollutant transfer from land to watercourses.

Human and environmental well-being

Declining agricultural productivity and soil contamination have both economic and health consequences for local people. Lower crop yields mean less food is available for people, which often leads to the further conversion of forests and steep slopes to agricultural production in a negative cycle of impoverishment of people and the environment. Contamination of soils by chemical or biological agents has direct negative effects on the health of people who consume products or water that has been polluted by runoff.

The impacts of deforestation on people include an increased incidence of landslides, particularly during periods of heavy rain. It also increases the potential for ground water sources to be exhausted because rates of recharge are reduced. This can result in local people travelling longer distances to collect water or consuming water of a lower quality from nearby sources.

The main factors contributing to soil degradation are

forest depletion, over-grazing of forests by livestock, poor farming practices including growing crops on unsuitable soils, steep slopes or in the wrong season, and a failure to practice crop rotation and organic farming.

The net result of forest and soil degradation is instability of food production; reduction of ecological, water and energy resources; increased risk of natural disasters; biodiversity loss; and an increased contribution to global warming. Forest and agricultural land degradation leads to a loss of productivity and ecosystem services.

4.2 Drivers and pressures

Land use practices

Deforestation and forest degradation are primarily a result of food security and economic pressures faced by local populations. The root causes are complex and interrelated and include past national level economic difficulties, a lack of alternative energy sources, poor knowledge of appropriate land and natural resources management practices. Cutting down trees provides people with the immediate benefits of additional fuel wood and an increased area to grow crops. These benefits are not sustainable and in the long run lead to a deterioration of soil productivity, ecosystem services and water quality, all of which have had a negative impact on long-term economic progress and improved living standards. Individual pressures on forest resources are compounded by industrial activities and conversion to roads, reservoirs, mines and residential areas.

Degradation of agricultural land is a factor in the depletion of forests and a concern in its own right. As the quality of arable land decreases the pressure to convert forested land to agricultural land increases particularly because the area of land suitable for cultivation is limited in the DPR of Korea. Increased crop yields have historically been achieved through intensified agricultural production using machinery, fertilizers and pesticides as well as by reducing the time between crop rotations. Although this intensification increased output for many years, the long term effects on soil quality are now becoming evident, an outcome that is showing the importance of promoting organic farming.

Climate change

Agricultural productivity in the DPR of Korea is highly dependent on consistent climatic conditions including the timing, volume and location of precipitation and favorable temperatures. Intense storms and heavy rains have become more common. The outcome has been increased soil erosion and flooding. For example, 2,422 km^2 of farmland was damaged and agricultural production decreased by 23 percent in 2007 compared with 2006 due to flooding.

In the spring season, droughts are reducing agricultural production. Changes in precipitation and the occurrence of extended warm periods and more frequent high temperatures have led to recurrent pest outbreaks with effects on forests and crops. For example, in 2002 a larch caterpillar infestation affected 319 km^2 of forest nationwide.

Table 4.5 provides a summary of the primary drivers and related pressures on land resources, their state and the impacts on humans and biodiversity, and responses.

4.3 Response

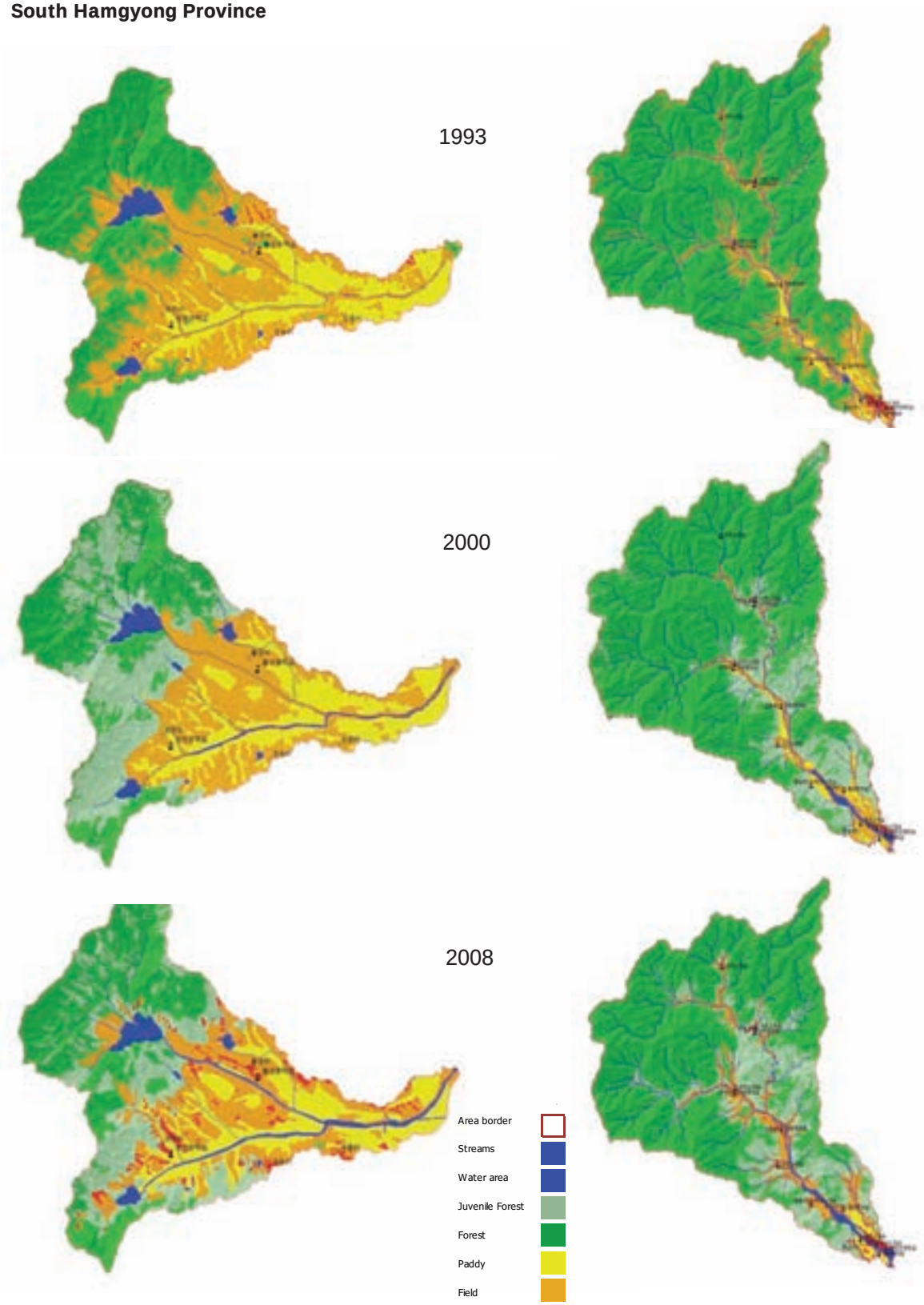
The government's land management policies seek to protect land resources and manage their use in an efficient and sustainable way.

The main objectives of land management policies are:

Box 4.1 Land use change maps for South Hamgyong Province

Jongpyong County
South Hamgyong Province

Yonggwang County



Source: Ministry of Land and Environment Protection 2010

Table 4.5
Drivers of forest and soil degradation

Drivers	Pressure	State	Impact	Response
Population growth	Forest conversion	Reduction of forest cover and biomass	Reduction of productivity	Intensification of policies/laws
Economic pressures	Overexploitation (timber and non-timber products)	Reduction of forest quality (forest fire, pests)	Reduction of ecological and public service	Institutional capacity-building
Food shortage	Overgrazing, unsustainable agriculture	Soil erosion	Increase of disasters such as flooding, landslide and drought	Capacity-building for public awareness
Increase in energy demand	Development activities	Reduced bio-function	Impact on the people's livelihood and sustainable development	Scientific research and technical exchange
Unsustainable land management practices	Infrastructure development	Conversion, degradation and encroachment	Biodiversity loss, economic and social impacts	Rational management of natural resources
Climate change	Forest fires, pests, droughts and flooding	Reduced quality	Biodiversity loss	Afforestation and reforestation

- to develop and use land resources in a far-sighted way, according to a general land construction plan;
- to develop new arable land without compromising existing land uses and to provide irrigation that will ensure productivity;
- to establish principles for farming that include appropriate management of mountains and rivers, particularly their rehabilitation;
- to improve living standards and contribute to economic development;
- to protect land from environmental contamination; and
- to introduce organic farming methods to improve and maintain soil fertility.

Legal mechanisms and regulations

The government of the DPR of Korea adopted the "Law on Land, DPR of Korea" on 29 April 1997, and revised it on 15 June 1999 to provide the legal basis for the protection, sustainable development and utilization of land resources. The Law on Land covers river improvement and reforestation, the overall principles and procedures for land use, land utilization activities under the national land development plan and public participation in land management. The Law on Land acts in conjunction with the Law on Environment Protection (1986), Law on Land Planning (2002), Law on Forest (1992), Law on Agriculture (1998) and Law on Water Resources (1997) to provide the legal foundation for preventing degradation of land resources and ensuring sustainable development.

Monitoring and assessment

The government of the DPR of Korea invests in the management and use of land resources through knowledge and information building based on a monitoring and assessment program. Land degradation is monitored and documented through an annual survey and measurement plan. A survey and analysis of land erosion is conducted every 4-5 years.

Regular monitoring is conducted to assess land contamination at fixed monitoring posts before further development. A sustainable environment management system to ensure contaminant-free agricultural products has been operational since 2007.

Public mobilisation

The government has declared a period of "General Mobilization for Land Management" that occurs every spring and autumn. The effort mobilizes people in factories, enterprises and other organizations to undertake reforestation, forest restoration, land realignment and river rearrangement activities according to a planned nation-wide campaign. The initiative has led to reforestation and agricultural productivity activities throughout the country resulting in hundreds of thousands of hectares of arable land and rivers being realigned for improved productivity. Paddy fields were improved in Kangwon, North and South Pyongan, South Hwanghae Provinces and Pyongyang city.

Box 4.2 Slope management and agro-forestry

At only 0.08 hectares per capita, arable land is a very limited resource in the DPR of Korea. This shortage of land for crops, combined with rural energy demands has led to the conversion of steep slope forests to agricultural production. Consequently, forest depletion and degradation has emerged as an important environmental issue. To address the problem, the government has established a policy to promote afforestation and reforestation and water conservation through partnerships with other organisations.

The Ministry of Land and Environment Protection has been implementing a sloped land management project with technical and financial support from the European Union, the United Nations Food and Agriculture Organization and the Swiss Agency for Development and Cooperation in order to ensure the ecological integrity of steep slopes and to satisfy rural demands for food and fuel.

A central objective of this partnership is to promote agro-forestry in which wild fruit trees with high economic and nutritional value are planted at regular intervals and essential crops are cultivated between them. Plants for animal fodder are distributed between the trees to prevent erosion.

These slopes are managed by a team of ten members organized by the national forest administration agency, who are responsible for the preparation and implementation of the forest land use plan.

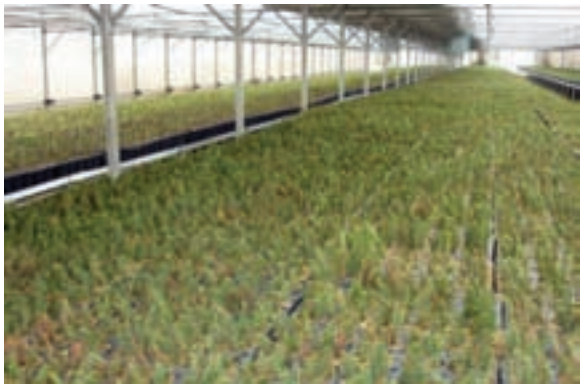
The project has stabilized soils, reduced erosion and land slippage, improved soil fertility, increased crop productivity and generated local economic opportunities. An emphasis on an integrated approach that includes a diversity of crops, crop rotation, organic fertilizers and spreading grass has been essential to the success of the program.

The slope management project is one important tool for forest recovery and for the improvement of local livelihoods, economy and food security.

Paddy and dry fields have been protected from flooding by earthworks, river bank stabilization and the dredging of riverbeds in smaller rivers and streams that flow around the fields in South Hwanghae, North and South Pyongan and South Hamgyong provinces.
With the construction of the Kaechon-Taesong Waterway, Paekma-Cholsan Waterway and Miru Waterway, sufficient irrigation water is now available for large areas of paddy fields and newly reclaimed tideland fields in the western areas of the country. Agricultural production has been enhanced with the provision of reservoirs.

Forests

In the DPR of Korea, concerted efforts have been made to rehabilitate forests and increase the standing volume of timber. It is a now a national priority of the DPR of Korea to prevent forest degradation, restore already degraded forest areas, and increase the rate of afforestation. The government of the DPR of Korea has prepared the "Long-term National Plan for Forest Development (1990-2020)" to protect and preserve existing forest and develop plantations to meet demand for timber and other forest products including firewood. Part of the plan has been the establishment



of an on-line forest fire and pest monitoring system that seeks to minimise forest losses by facilitating prompt responses to these events while also tracking trends over time.

The National Plan also seeks to reduce forest degradation by developing an advanced system for genetic improvement of plantation species, encouraging tree-planting of valuable economic species, and creating fuel-wood forests. Modern plant nurseries such as the Central Plant Nursery have been established and sapling production has commenced. Preparation of the Law on Reserve Management is in progress to improve management of forest reserves including natural forests. The institutional authority of the Department of Forest Management, Ministry of Land and Environment Protection (MLEP) has been strengthened to apply a unified and efficient approach to the protection and management of forest resources.

Waste management

The government has taken measures to establish a national waste management system and to promote the recycling and reuse of materials. These measures include:

- building a legal framework for waste management including the formulation of detailed regulations and standards for different types of waste,
- creating an integrated management system for municipal waste,
- developing and applying waste recycling technologies,
- generating energy and fertiliser from waste,
- establishing environment management systems in factories and enterprises to reduce resource consumption and waste and stimulate recycling,
- conducting scientific research and development

Box 4.3 SAICM Project and National Profile for Chemicals Management

In 2009, the government of the DPR of Korea launched a Strategic Approach to International Chemicals Management (SAICM) Project with the United Nations Institute for Training and Research (UNITAR). The project aims to assist the DPR of Korea to develop a comprehensive assessment of the legal, institutional, administrative, and technical aspects of chemicals management, along with developing a better understanding of the nature and extent of chemical availability and use in the country - a National Profile. This would include a thorough assessment of the existing capacity of different agencies and the creation of a National Chemicals Management Database. The purpose of the National Profile is to provide information about the chemicals in the country and to promote the exchange of information and experiences between agencies dealing with chemicals in order to enhance decision-making.

The National Chemicals Management Database would benefit government, industry, and civil society by providing the government authorities with useful data for setting environmental management priorities, enhancing knowledge within different industries about inefficient and wasteful production processes, raising public awareness about potentially toxic chemical releases, and increasing the ability of all stakeholders to participate in environmental decision-making. Through the implementation of the project an interministerial coordination mechanism will formally be established for chemicals management and national SAICM priority setting will be undertaken.

into technologies for waste recycling,
- improving the system for collecting, sorting, transporting and disposing or treating domestic waste and encouraging environmentally safe landfill,
- improving environmental monitoring of the disposal and treatment of waste,
- disseminating information on appropriate waste management by means of mass media, public awareness activities and the introduction of pilot projects, and
- establishing a national registration and permit and monitoring system for imported waste.

CHAPTER

5

Biodiversity

5. Biodiversity

Biodiversity is the degree of variation of life forms within a given ecosystem, and as such represents the principal measure of the health of biological systems. It provides economic, cultural and aesthetic value to people's lives.

Human existence and biodiversity are intimately connected. Animals, plants and microorganisms are components of natural ecosystems which provide the materials that enable economic development. The diversity of the biotic component of ecosystems is an indicator of the system's integrity and correlates with nature's capacity to provide the ecosystem services upon which people rely for their wellbeing and economic prosperity. This diversity encompasses ecosystem, species and genetic scales.

5.1 State and trends

Ecosystem diversity

The DPR of Korea has rich biodiversity relative to its size and many species are unique to the country. The country can be classified into dominant ecosystem types comprising forest ecosystems, inland freshwater ecosystems, marine and coastal ecosystems, agro-ecosystems and wetland ecosystems.

Forest ecosystem

Almost three quarters of the land in the DPR of Korea is forested. Forest ecosystems are especially important because of their abundance, the vast numbers of species that they support, and their relationship to other ecosystems.
Forest ecosystems can be categorized based on the dominant variety of tree as shown in Figure 5.1. Coniferous trees are dominant in 42 percent of forests, followed by broad leaf trees in 36 percent, with the remainder of forest being a mix of the two types. Table 5.1 illustrates the relative proportion of different tree species across all forests.

Conversion of forests to agricultural land and the extraction of timber and fuelwood are major factors affecting the extent of natural forest cover. Encroachment by infrastructure such as roads, industrial and residential areas also contribute to forest loss.

Protected forest

Forest protection encompasses several different categories including forestry reserves, genetic reservoirs, erosion control forests, and scenic forests. The total area of protected forests in the early 1990s was 11,200 km^2. This fell to 9,535 km^2 (or 12.5 percent of forested land) by 2005 as protected forests were reallocated to the production of timber or converted for infrastructure and industrial developments such as roads, coal mines and hydro-power production (MLEP, 2010).

Inland fresh-water ecosystems

The density of inland freshwater systems is very high with over 100 natural lakes, 1,700 man-made reservoirs, and numerous rivers and streams. Inland water ecosystems cover five percent of the country and represent an important habitat for many species of plants and animals (DPR of Korea, 1998).

Several rivers are over 400 km long including the Amnok, Tuman and Taedong. The watershed area of the Amnok River is more than 60,000 km^2 and the rest of the rivers are between 10,000 - 40,000 km^2. The next largest rivers are the Chongchon, Kumya, and Ryesong (Un Chel Nam, Rim Chu Yen, 2002) .

The outflow drainage coefficients of rivers in the DPR of Korea are very high due to the prevalence of mountainous terrain throughout the country. Many upper tributaries are narrow, steep and fast flowing.

Due to climatic and topographic differences, the composition of biological communities differs greatly depending on whether they are located on the upper, middle and downstream sections of the river. Freshwater inland ecosystems serve as an important

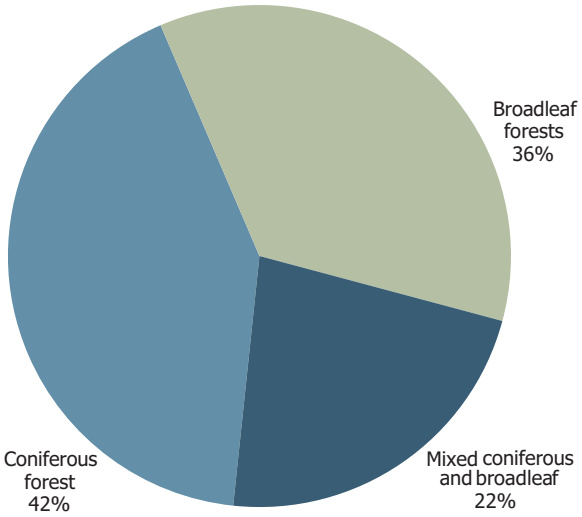
habitat for wild animals and plants, including a large diversity of fish and bird species.

Marine and coastal ecosystems

The DPR of Korea is bounded to east and west by ocean. The continental shelf extends over the much of the sea floor on both the east and west sides of the country. The Pacific Ocean strongly influences the marine environment around the DPR of Korea, although the east and west coasts differ greatly. On the east, the coastline is largely made up of exposed erosion areas, while the western shoreline is largely depositional with wide areas of tidal flats.

Both seas are rich in biodiversity. The eastern waters contains over 450 species of 295 genera of 140 families while the western waters have 250 species of 181 genera of 108 families. The primary commercial species in the west are anchovy and mackerel in offshore waters and shrimps and mollusks in coastal waters. The east coast

Figure 5.1
Forest cover by dominant tree variety



Source: Central Statistics Bureau 2005

Table 5.1
Forest cover by dominant tree variety

Type	Oak	Larch	Pine	Deodar (Fir, Spruce, Picea)	Korean pine
Tree variety as a percent of total forest cover	29.5	17.5	12.7	8.2	5.8

Source: State Academy of Sciences 2007

has cold-current fish that include herring, pollack, cod and sailfin sandfish. The eastern waters also have 546 species of seaweed that are of high economic value, including 329 species of red algae (DPR of Korea, 2005).

The DPR of Korea has over 7,000 km^2 of tidelands. The west coast encompasses several bays such as Sochoson Bay, Taedong Bay, Haeju Bay and 2,500 islands. An important aspect of coastal ecosystems are tidal flats and wetlands, which serve as habitat for migratory birds of Northeast Asia, particularly the Red-crowned Crane (*Grus japonensis*), the Black-faced Spoonbill (*Platalea minor*) and the Chinese Egret (*Egrettaeulophotes*): all endangered species. More than 180 species of migratory birds, including 26 rare species, have been recorded in the western tidal flats and coastal waters. About 70 species of waterfowl have been observed in the area of the West Sea Barrage in the Taedong River estuary including rare species such as the Whooper Swan (*Cygnus cygnus*), Bewick's Swan (*Cygnus bewickii*), Mute Swan *(Cygnus olor*), Common Green Shank (*Tringanebularia*), Chinese Egret (*Egrettaeulophotes*) and Saunder's Gull (*Larussaundersi*) (Un Chel Nam, Rim Chu Yen, 2002).

Wetland ecosystem

Wetland ecosystems in the DPR of Korea are generally distributed in tidelands, estuaries, large lakes, and peat land. On the east coast, wetlands are distributed at estuaries of the Kumya river. The main plant species are *Salicornia europaea, Suaeda japonica* and *Phragmites* (DPR of Korea, 1998).

The biological productivity and number of invertebrate species in tideland ecosystems is very high. The wetland areas of the east and west coasts are transit sites for migratory birds of North East Asia. The main tracts are: Dongrim ri, Mundok County of South Pyongan Province; the mouth of Chongchon river, Haejung ri, Kumya County, South Hamgyong Province; the mouth of Kumya river; Daedong bay between Ryongyon county, Taetan county and Ongjin county, South Hwanghae Province; September the 18th Reserve of Chongdan county, South Hwanghae Province; and lake area of Razin-Sonbong, North Hamgyong Province.

Agro-ecosystems

Agro-ecosystems consist of paddies, dry fields, grasslands and related communities. Studies of

Box 5.1: Koryo Insam (ginseng) of Kaesong

From remote days the Koryo insam of Kaesong has enjoyed worldwide fame as a medicinal plant. Pharmacologically the Koryo insam of Kaedong is incomparably better than other kinds of ginseng owing to the particular soil and water conditions and the meteorological factors peculiar to the Kaesong area and the singular methods of cultivation and processing.

The roots of insam used as medicine often resemble the form of the human body. According to the methods of processing, Koryo insam is grouped into three kinds: hongsam, paeksam, and tangsam. They are of high quality and have exceptional medicinal properties.
The Koryo insam of Kaesong contains ten kinds of glucoside essential to health and longevity and contains essential oil, amino acid and other organic acids, vitamins, as well as radium and microelements.

Insam protects the five vital organs, has a beneficial effect on brain, heart and blood vessels, stimulated the glands of internal secretion and promotes the metabolism. It serves as a panacea and is used as the main ingredient of traditional Korean medicines.

Insam has an invigorating and fatigue-relieving effect. It increases mental and physical efficiency and is especially effective in promoting health and longevity. According to recent data the Koryo insam of Kaesong is effective against radiation and cancer due to the specific medicinal properties of its ingredients. This widens its fields of application.

Insam contains 0.05 per cent of aromatic matter and has a specific aroma. It is used in making several hundred kinds of tonics for promoting the health of the working people.

Several hundred kinds of products are made from the Koryo insam of Kaesong. These include tonics, tablets, injections, candy, liquor, wine, cosmetic cream and toothpaste.

Table 5.2

Number of plant species in different taxonomic groups in the DPR of Korea

Taxonomic group	Seed plants	Ferns	Bryophytes	Lichens	Fungi	Algae
Number of species	3,360	230	780	580	2,300	2,700

Source: Biodiversity Center, State Academy of Sciences 2005

Table 5.3

Assessment of endangered and threatened status of higher plants in the DPR of Korea

National criteria	1st grade	2nd grade	3rd grade	4th grade	Total
IUCN criteria	Critically Endangered	Endangered	Vulnerable	Near Threatened	
Gymnosperms	1	2	3	3	9
Angiosperms	15	29	48	52	144
Total	16	31	51	55	153

Source: Biodiversity Center, State Academy of Sciences 2005

Table 5.4

Number of species of major groups of animals in the DPR of Korea

Taxa	Species	Genera	Families
Mammal	107	69	28
Aves	416	190	61
Reptile	26	17	11
Amphibian	17	8	8
Pisces	865	188	45
Mollusc	518	227	123
Insect	5965	2157	327

Source: Biodiversity Center, State Academy of Sciences (2005)

Table 5.5

Endangered and threatened species of vertebrates in the DPR of Korea

Classification	EX	CR	EN	VU	Total
Mammalia		3	9	16	28
Aves	2	2	26	48	78
Reptilia			4	9	13
Amphibia			3	6	9
Piscea		3	4	26	33
Total	2	8	46	105	161

EX=Extinct, CR=Critically Endangered, EN=Endangered, VU=Vulnerable

Source: Source: MAB National Committee, State Academy of Sciences, DPR of Korea (2002)

farmland wildlife have focused on vermin and weeds that affect agriculture. This research has identified at least 163 species (67 families and 19 orders) of vermin and around 450 species of weeds (110 in the paddy fields and 340 species in the non-paddy areas). Besides these undesirable species a great number of other wildlife, particularly birds, forage and live in these ecosystems (DPR of Korea, 2005).

Agro-ecosystems are by their nature highly influenced by the methods of agricultural production. Agricultural production has long been associated with reducing species diversity to ensure the least amount of competition with target crops or livestock. Agro-ecosystems have for many decades been influenced by pesticide, herbicide and fertilizer use, with purposeful impacts on species diversity. In many cases this type of agricultural production has reduced the productivity of agro-ecosystems over time. Contemporary research indicates the importance of improved species diversity as a way of stimulating production and also minimizing pests and diseases.

The government of the DPR of Korea is striving to promote an intensive and stable agricultural production system that conserves biodiversity while improving crop yields by applying ecosystem-based agricultural techniques. Much of this effort focuses on introducing organic farming methods that are in conformity with the specific features of the local ecosystem.

Species diversity

Species diversity represents the heritage of evolution and constitutes a central element of biodiversity. The DPR of Korea has 9,950 species of plants, 1,610 species of vertebrates and 416 species of birds (3.2 percent, 4.5 percent, and 4.5 percent of world species respectively). This level of species diversity is high relative to the country's size. Many species are not widely found outside of the DPR of Korea.

Plant diversity

Nearly 10,000 species of wild plants have been documented in the DPR of Korea. Table 5.2 on the previous page shows their breakdown into different taxonomic groups. The largest numbers of species occur within the seed plant, fungi and algae groups.

Over recent years scientists and technical experts in the DPR of Korea have investigated endangered and rare plant species and published a Red Data Book on seed plants in 2005. Using the standard for classifying endangered and rare species set by the Species Conservation Committee (SCC) of the International Union for the Conservation of Nature (IUCN), the DPR of Korea recorded 47 endangered or critically endangered species of flowering plants within its borders (see Table 5.3 on previous page). A further 106 species are considered vulnerable or near threatened.

Animal diversity

There are more than 9,970 documented animal species in the country, including 1,610 vertebrates and 8,360 invertebrates (see Table 5.4). Two species are extinct, 8 are critically endangered, 46 are endangered and 105 are considered vulnerable (see Table 5.5).

Invasive alien species

The DPR of Korea has undertaken several assessments of invasive alien species. The alien species of greatest concern include desert false indigo (*Amorphafruticosa*), orchard grass (*Dactylisglomerata*), honey clover (*Melilotusalba*), domestic animal fodder plants, and common ragweed (*Ambrosia artemisiifolia*). Ragweed

is a significant concern because it grows rapidly to about one meter in height, and its wind-dispersed pollen is a strong allergen for many people.

To date, a comprehensive investigation of alien animal species has not been undertaken. Studies have only focused on insects and fish related to agriculture and forestry. Invasive insects are causing considerable harm to agricultural ecosystems and forests. The chestnut gall wasp disrupts twig growth, reduces nut production and ultimately kills the chestnut tree. *Matsuscoccus pini* survives on host pine trees and is considered to be one of the primary causes of pine forest losses in the north, while subfamilies of pitch midges (*Cecidomtia brachyntera*) and the rice water weevil, from the south, have damaged forests and agriculture.

Also of concern are plants and animals that act as disease vectors. These include 79 species of insects and 63 species of plants (Bak Yong Sen, 2009). A-class pan-continental epidemics such as mad cow disease are the focus of strict quarantine procedures. Veterinary and plant inspections are undertaken at border crossings through a strict national system to intercept potential threats.

Genetic diversity

The DPR of Korea has rich genetic diversity of farming crops such as rice, millet, foxtail millet, beans, sorghum, vegetables, fruits and spices. The genetic diversity of rice, beans and vegetables is especially rich.

Since ancient times, the Korean nation has used various herbs in Koryo medicine (traditional Korean medicine), and has kept extensive records of their applications. These herbs encompass 604 varieties of 377 species from 113 families.

Studies of animal genetic diversity in the DPR of Korea have mainly focused on domesticated animals such as cows, pigs, chickens, rabbits, silkworms, fish and others that are of economic value. There are seven species of major livestock including 50 breeds of cow, pig and donkey, and more than 30 species of chicken, duck and other poultry.

Biodiversity trends

Despite efforts to conserve it, biodiversity in the DPR of Korea is being lost through the degradation of ecosystems. A number of plant and animal species are threatened. Some important examples are:

Plants threatened with extinction: *Rheum coreanum, Diola westerii, Ajuga apectabilis, Juniperus coreana, Sapium japonicum, Panax schinseng, Pinguicula vulgaris, Pacedria scandens, Gastrodia elata*
Indigenous plants: Echino sophora koreensis, Pentactina rupicola, Keumkangsania asiatica

Endangered and rare plants: *Forsythia densiflora, F.ovata, Ligustrina faurei, Saussurea rectinervis, S.calicola, Abelia mosauensis, Iris minitorea and Goodyera repeus*

Fish: *Gonoproktopterus mylodou, Coreoleuciscus splendidus, Thymallus*

Amphibians: *Rana coreana*

Reptiles: *Eumeccs coreensis*

Mammals: *Pantera tigris, Cervus nippon, U rsua arctos, Martes zibelline, Lutra lutra, Moscshsu moschiferus, Nemorhaedus goral*

Aves: *Dryocopus javensis richardsi, Platalea minor, Egretta eulophotes, Grus japonensis, G.vipio, G.monacha, Dendrocopus martius, Ciconia byciana, Aythya baeri, Larus sasundsersi and birds of prey*

5.2 Drivers and pressures

The reasons for biodiversity loss are complicated but can mainly be attributed to human activity influencing natural processes. In general, drivers and pressures affecting biodiversity are population growth, habitat conversion, alien species intrusions, environmental pollutants, soil and water loss, and unsustainable extraction of natural resources. Table 5.6 summarizes threats to biodiversity in the DPR of Korea and their underlying causes.

Unsustainable use of the natural resources

Unsustainable use of natural resources is closely related to population growth. In the DPR of Korea, population density is 180 per km^2, which is higher than China (131 per km^2). Population growth, in rural areas in particular, has led to unsustainable rates of deforestation for heating, cooking and construction purposes. In rural areas, more than 75 percent of households use wood for cooking and heating.

Timber forests have decreased by six percent from 81,154 km^2 in 1996 to 76,432 km^2 in 2005, although non-timber forest increased in the same period from 3,769 km^2 to 8,768 km^2. The main factors contributing to the reduction of forested land are the expansion of land for agriculture, and damage from forest fires and pests. In addition to extraction of timber, large amounts of medical herbs are being harvested from forests.

Loss of soil

Forest degradation from unscientific timber extraction is impacting the ecosystem service function of forests. Soil loss and reduced water infiltration are leading to unstable soils that are prone to land slides. This is producing high sediment loads in waterways.

In the DPR of Korea, 60 percent of annual precipitation occurs in summer months of July and August with heavy rain frequently falling in elevated areas that are prone to erosion. It is therefore difficult to prevent soil loss without the protection of forest cover.

Loss of habitat

The abundance of biodiversity is intimately connected to the condition and variety of available habitat. Species diversity requires micro-ecosystem diversity to provide the conditions favorable to their survival. The DPR of Korea's Biodiversity Protection Goal 2010 focuses on reducing habitat destruction and slowing the loss of species, biotic populations and gene diversity.

Priorities to protect wildlife largely relate to habitat protection. In the context of the DPR of Korea habitat protection includes:

- the prevention of forest ecosystem destruction and conservation of biodiversity in mountainous areas;
- the protection of biodiversity in coastal areas and the conservation of coastal wetland ecosystems; and
- the protection of agricultural biodiversity in arable lands.

Degradation of forest ecosystems lead to habitat fragmentation and impact the survival of large mammals such as brown bears (*Ursus arctos*) and Asiatic black bears (*Ursus tibetanus*). The degradation of river ecosystems threatens species such as the European otter (*Lutra lutra*).

Table 5.6

Threats to biodiversity in the DPR of Korea and their underlying causes

Threats	Causes
Loss / fragmentation / isolation of habitat	• Forest degradation (agricultural development or expansion of croplands, and forest exploitation) • Industrial development, including underground resource exploration • Construction and expansion of residential areas and roads • Displacement by alien species that are either intentionally or accidentally introduced • Prioritization of economic benefits of consumption over environmental benefits of biodiversity conservation • Insufficient public awareness of ecosystem processes and importance
Unsustainable exploitation of resources	• Harvesting or hunting of rare and endangered wildlife • Unsustainable harvesting of medicinal herbs • Unsustainable resource conversion due to shortages of food and energy
Unsustainable agriculture	• Insufficient understanding of the value of traditional genetic resources
Natural calamities	• Floods • Droughts • Wild fires • Sandstorms
Decreasing quality of habitat	• Unscientific application of agricultural chemicals

Coastal wetland ecosystems have high biological productivity and function as a natural flood control mechanism and water purification system. Large areas of wetlands need to be conserved to protect threatened birds such as the red-crowned crane (*Grus japonensis*), white-naped crane (*G. vipio*) and hooded crane (*G. monacha*). The loss of wetlands has greatly reduced the numbers of these species of cranes. Apart from cranes, swan goose (*Anas cygnoides*) and Baikal teal (*Anas formosa*) use the estuary of Chongchon River on the west coast of the DPR of Korea during their migration from North-east Asia to Australia. In these areas, the major threats to habitat integrity are the reclamation of the tidelands, the overuse of aquatic plants such as cane and slipperwort (*Calceolaria sp.*), and damage to habitat which provides food for birds.

Other factors

Pollution, invasive alien weed species and climate change also constitute threats to biodiversity. The construction of dams can affect river flows and depths and are likely to have resulted in the loss of several species of fish.

Observations of climate change in the country to date include increased annual average temperature, greater incidence of droughts and floods, and more frequent heat waves and forest fires. Climate change and its impacts on biodiversity are discussed in more detail in Chapter 6.

5.3 Responses

The DPR of Korea is taking measures to protect biodiversity, including assessing the factors contributing to biodiversity loss and establishing a legal framework for improving conservation and management.

Responses span multiple levels from local community initiatives to national and international actions.
The DPR of Korea is a party to the United Nations Convention on Biological Diversity. As part of its obligations under the Convention, the DPR of Korea has developed a plan to protect areas for biodiversity. The protection measures are contained in the "General Plan for Land Management" and are intended to increase the size and diversity of protected areas while also preventing the loss of biodiversity in non-protected areas.

Laws and policies related to the protection and sustainable use of biodiversity

Article 57 of "The Socialist Constitution of DPRK" stipulates that measures should be taken to protect the environment, conserve and enhance natural resources, and prevent environmental pollution. The DPR of Korea has proclaimed a series of major laws relevant to biodiversity conservation and sustainable resource use. These include:

- Law on Environmental Protection (1986)
- Law on Forestry (1992)
- Law on Land (1995)
- Law on Water Resources (1997)
- Law on Prevention of Sea Pollution (1997)
- Law on Boundary Inspection of Animals and Plants (1998)
- Law on Conservation of Useful Animals (1998)
- Law on Fish Culture (1998)
- Law on Agriculture (1998)
- Law on Veterinary Inspection (1998)
- Law on Public Hygiene (1998)
- Law on Medicinal Herbs (2004)
- Law on Land Planning (2006)
- Law on Environment Impact Assessment (2006)

Box 5.2 Mundok Sanctuary for Migratory Birds

A protected area for migratory birds has been established in Mundok, in Ryongo ri Mundok County, South Pyongan Province. The area is stopover for migratory birds including cranes which pass the western coast of the country in winter time. The protected area includes wetlands, fields, tidelands and coastal areas. The protected area plays an important role in both national and international migratory bird conservation efforts.

The government of the DPR of Korea has prepared a National Forestry Strategy Plan (1992) with the objective of reversing land degradation through reforestation and productive agriculture throughout the country. The Plan includes work programmes to restore degraded urban environments by planting trees in cities and villages. It also seeks to combine mountain and water catchment management, taking into account the ecological, economic and social values of reforestation.

For the sustainable use of its resources, the DPR of Korea has formulated the "National Biodiversity Strategy and Action plan of the Democratic People's Republic of Korea", 1998. The plan places emphasis on meeting the urgent need for rural energy by reforesting for firewood production and developing alternative renewable forms of energy.

To reduce pressure on fisheries that are being harvested at unsustainable rates, the DPR of Korea is expanding aquaculture of certain commercial fish species. In most cases this involves netting wild fish and bringing them to inshore locations where they are raised before being harvested.

The risk of introduced pests is serious concern given the country's heavy reliance on the agricultural sector. To safeguard farm production, further actions are required including a comprehensive assessment of all invasive and high-risk alien species, and an intensification of existing detection, quarantine and eradication procedures. Special attention needs to be given to the intentional introduction of alien fish species because their positive contribution to wetland food productivity may be offset by their detrimental effects on indigenous biodiversity.

To address excessive harvesting of wild medicinal herbs, conservation measures are being introduced to regulate the harvest of wild plants and encourage their cultivation as small crops.

Box 5.3 Protecting *Texus Cuspidata* in Mt. Myohyang

Texus Cuspidata, which grows in high mountains, is known in the DPR of Korea for its positive medical properties. The trees are evergreen and 10-20 meters tall. Local people in Mt. Myohyang have traditionally used the tree trunks and branches to make toothpicks, spoons, chopsticks, massage bars and massage mats. The sale of these products to tourists has led to overharvesting. As a result the production of such products has now been prohibited throughout the country to prevent the loss of this species.

In situ conservation

Conserving biodiversity in situ is the most appropriate and effective approach. In situ conservation requires an effectively managed system of protected areas that are designed to protect the diversity and the integrity of the ecosystems contained in the reserves. Ideally, such systems should include areas of sufficient size to minimize the need for management interventions, be buffered from threats to their integrity and be linked as a network through wildlife corridors.

Protected areas in the DPR of Korea originated with the adoption of the "Order for the conservation of treasures, relics, archaeological site, scenic spots and natural monuments" by the North Korea Provisional People's Committee in 1946. More recently, the protected areas are categorized into reserves and special reserves in accordance with the "Law on the Protection of Environment, DPR of Korea" (April, 1986) and designated by the Cabinet.

It is desirable that protected areas encompass a minimum of 10 percent of all ecosystems and 20 percent of all ecosystems unique to the DPR of Korea or regionally at risk. This goal has not yet been achieved in the DPR of Korea, but expansion of protected areas and construction of wildlife corridors was foreshadowed in the master plan of land development (1999) and ten-year plan of reforestation (2000).

When the DPR of Korea became a party to the Convention on Biological Diversity in 1994, conservation reserves covered 6,956 km^2, or 5.7 percent of the country. They included nature reserves and natural parks, landscape reserves, plant reserves, animal reserves, seabirds breeding reserves, migratory bird reserves (wetland) and marine resource reserves. Additional protected areas were created in 2003 to bring the total area under protection areas to 8,792 km^2, about 7.3 percent of the territory (Bak U Il, Rim Chu Yen, et al., 2005).

Table 5.7 lists protected areas according to the criteria set by the IUCN (1993). Table 5.8 on the following page lists the protected nature areas in the DPR of Korea.

Identification, monitoring and management of protected areas and species

Essential to assessing and monitoring biodiversity in the DPR of Korea is the regular investigation of major ecosystems, key species and significant genetic resources including recording the results in a database to assist in the implementation of a management regime.

The DPR of Korea is in the process of developing a monitoring system that will enable the ongoing assessment of major ecosystems and key species. It has undertaken several assessments already.

- Every 10 years, the DPR of Korea conducts a national investigation of its forests.

Table 5.7
Nature Conservation Areas in the DPR of Korea

No	Classification	Name	Unit	Area (ha)
I	Strict Nature Protected areas	Mt. Oga, Rangrim & Kwanmo Peak nature reserves and others Core areas of biosphere reserves of Mts. Paektu and Kuwol	4 2	63,912 25,245
II	Natural park	Mt. Kumgang Natural Park Mt. Myohyang Natural Park Mt. Chilbo Natural Park Others	81	391,569
III	Natural monument area		127	191,157
IV	Habitat/species protection area	Plant Reserve Animal Reserve Migratory Birds (Wetlands/Breeding area) Reserve Sea-birds Reserve	25 25 24 7	25,698 58,767 26,918 215
V	Landscape protection area			
VI	Resources management protection area	Marine resources protection area Plant resources protection area Buffer zone in the Mt. Paekdu biosphere reserve Buffer zone in the Mt. Kuwol biosphere reserve	26 4 1 1	50,196 6,659 36,000 2, 940
Total				879,275

Source: Bak U Il, Rim Chu Yen, et al. , 2005

Table 5.8
Protected nature areas in the DPR of Korea

No	Protected areas	IUCN Criteria	Hectares
1	Core area of Mt. Paekdu Biosphere Reserve	I	24,000
2	Core area of Mt. Kuwol Biosphere Reserve	I	1,245
3	Mt. Oga Nature Reserve	I	4,286
4	Mt. Rangrim Nature Reserve	I	21,615
5	Peak Kwanmo Nature Reserve	I	3,407
6	Kyongsong Nature Reserve	I	29,604
7	Monggumpho Nature Reserve	II	7,340
8	Songdowon Nature Reserve	II	410
9	Lake Supung Nature Reserve	II	50,723
10	West Sea Barrage Nature Reserve	II	5,163
11	Lake Kumsong Nature Reserve	II	19,786
12	Mt.Kumgang Nature Reserve	II	47,838
13	Mt.Myohyang Nature Reserve	II	33,313
14	Mt.Chilbo Nature Reserve	II	27,754
15	Songchon Chestnut Tree Natural Monument Reserve	III	3
16	Maengsan Otter Natural Monument Reserve	III	40
17	Osudok Pinenut Tree Natural Monument Reserve	III	64
18	Kwanmo-ri Char Natural Monument Reserve	III	40
19	Is. Sinmi Plant Reserve	IV	2,283
20	CapeJangsan Plant Reserve	IV	1,792
21	Mt.Suyang Plant Reserve	IV	487
22	Peak Chail Plant Reserve	IV	4,366
23	Hwasong Thyme Plant Reserve	IV	8
24	Mt.Obong Animal Reserve	IV	3,088
25	Mt.Suryong Animal Reserve	IV	1,349
26	Mt.Taegak Animal Reserve	IV	3,239
27	Kumsok Animal Reserve	IV	13,507
28	Rinsan White Bellied Black Woodpecker Reserve	IV	1,007
29	Mundok Migratory Birds (Wetlands) Reserve	IV	3,715
30	Is. Sin Migratory Birds (Wetlands) Reserve	IV	2,500
31	Ongjin Migratory Birds (Wetlands) Reserve	IV	2,500
32	Kumya Migratory Birds (Wetlands) Reserve	IV	2,000
33	Waudo Big Water Hen (Breeding Place) Reserve	IV	1,000
34	Is.Tok Marine Birds Reserve	IV	10
35	Is.Rap Marine Birds Reserve	IV	20
36	Yangdok Pine Mushroom Resources Reserve	VI	2,427
37	Buryong Pine Mushroom Resources Reserve	VI	2,290
38	Orang Pine Mushroom Resources Reserve	VI	1,291

Source: Biodiversity Center, State Academy of Sciences 2007

- In 2009 it conducted a large assessment of wild animals across the country.
- In 1997, the DPR of Korea carried out a general investigation of wetlands. It is currently completing a more detailed investigation in order to meet the requirements of the Ramsar Convention.
- From 2000 to 2001, the DPR of Korea performed an investigation of protected areas in order to identify major threats to conservation.

Currently, some of the DPR of Korea's protected areas do not have sufficient trained personnel to implement programs or monitor biodiversity. Active participation of local people in management is important in achieving conservation goals and needs to be strengthened considerably.

Ex situ conservation and ecosystem recovery

The DPR of Korea is taking steps to improve the conservation of species and genetic resources in zoos and botanical gardens as well as to expand seed banks for the conservation of agro-genetic resources. Some success has been achieved in scientific research on *ex situ* conservation and the reintroduction of species into the wild. Ex-situ conservation of plants is the responsibility of the Central Botanical Gardens (in Pyongyang) and provincial botanical gardens and arboreta. The Central Botanical Garden includes collections of endemic species such as *Pentactinarupicola*., Korean forsythia *(Forsythia ovata*), Korean abelialeaf (*Abeliophyllumdistichum*),and *Stewartia Koreana*.

The central and provincial zoos play an important role in ex situ conservation of wild fauna. The Central Zoo in Pyongyang has been successful in breeding the Korean tiger (*Pantheratigris*), brown bear (*Ursus arctos*), yellow throated marten (*Martesflavigula*), and Chinese water deer (*Hydropotesinermis*). They have also bred Golden Eagles (*Aquila chrysaetos*), Red Crowned Cranes (*Grus japonensis*) and White-naped Cranes (*Grus vipio*).

As a zoo specializing in birds, the Wonsan Zoo in Kangwon Province takes charge of conservation of birds in the Korean eastern coastal zone. The ex situ conservation efforts of the Central Zoo and Central Botanical Garden are assisted by their research centres in close collaboration with relevant institutes of the State Academy of Sciences.

The Academy of Agriculture is the center for research and protection of agro-genetic resources and performs taxonomic assessments of genetic resources. The Academy registers and produces state-bred crop germ plasm, and provides this to professional plant breeders. The Institute of Microbiology at the Academy of Sciences plays a central role in the conservation of microbial genetic resources through research and conservation of samples.

With the government's emphasis on the protection of agro-genetic resources and their sustainable use, scientific species assessments have been undertaken of traditionally used genetic resources, newly-bred species and alien species. These have been entered into a database of genetic resources with the purpose of maintaining the stock of genetic diversity while improving productivity of agriculture and aquaculture to address food shortages. The government is in the process of developing a nation-wide program to adapt, cultivate and produce new strains of trees and high-yielding species well suited to the country's geography and climate. Nursery gardens, fish farms and propagation sites have been created to ensure the protection and continued survival of rare and endangered species.

The DPR of Korea has undertaken public awareness activities to protect biodiversity, including publishing a Red Book of Plants in 2005, which reports the status of seed plants, based on a national survey on rare and endangered species. Public education programs promote the conservation of endangered and threatened species.

CHAPTER 6

Climate Change

6. Climate change

There is widespread scientific consensus that anthropogenic activities are contributing to an enhanced greenhouse effect that is altering the global climate and increasing the average annual surface temperature (IPCC 2007). Projections of increased global average surface temperature range between about 2°C and 6.4°C depending on the emissions scenario and assumptions about carbon cycle and non-carbon cycle feedback effects. Global changes will not be uniform, there will be substantial differences in temperature, precipitation and sea level trends at a regional level.

This section of the report describes climate change observations, impacts and adaptation strategies in the DPR of Korea. Greenhouse gas emissions and mitigation activities are discussed in Chapter 2.

6.1 DPR of Korea climate overview

DPR of Korea's climate results from its mid-latitudinal and peninsular location. It is influenced by its proximity to the continental Asian land mass and by the surrounding oceans. Winter weather is characterized by cold, dry north-westerly winds originating over the Siberian region and low levels of precipitation. Summer weather is influenced by warm humid air brought by winds from the Pacific. The country's climate is strongly influenced by seasonal East Asian monsoons with more than half of annual precipitation occurring in July and August. The dry season is from April to June and the wet season is July and August. Annual precipitation is approximately 1000 - 1200 mm. Average annual temperature is 9-10°C with a summer (June-August) average of 24°C and a winter (November to February) average of -5.5°C.

Observations of climate change in the DPR of Korea

The climate of DPR of Korea exhibits considerable natural variability over years and decades. Nonetheless, trends in temperature and precipitation observations recorded over the last century suggest that the country's climate is changing. These changes include a long term warming trend punctuated by more frequent extreme temperature events as well as variation in the timing, frequency and volume of precipitation across the country. Climate change is expected to exacerbate existing stresses on both natural and human systems as a consequence of changes to temperature and precipitation patterns, as well as sea level rise.

Temperature trends

Over the period 1918 to 2000, the average warming rate in the DPR of Korea was 1.9°C (Figure 6.1). Over the latter part of the century (1971 - 2006) the increase in annual mean temperature was about 0.38°C per decade.

Warming has been relatively uniform across the country with the exception of the eastern coastal region where spring and summer warming is slightly greater than the rest of the country. The eastern coastal region of the DPR of Korea is affected by the oceanic and peninsula monsoon climate. Due to the influence of the ocean, which has a large thermal inertia, annual average temperatures for this region are lower than other areas. The climate is also related to various topographical conditions and marine currents.

Seasonal temperature change

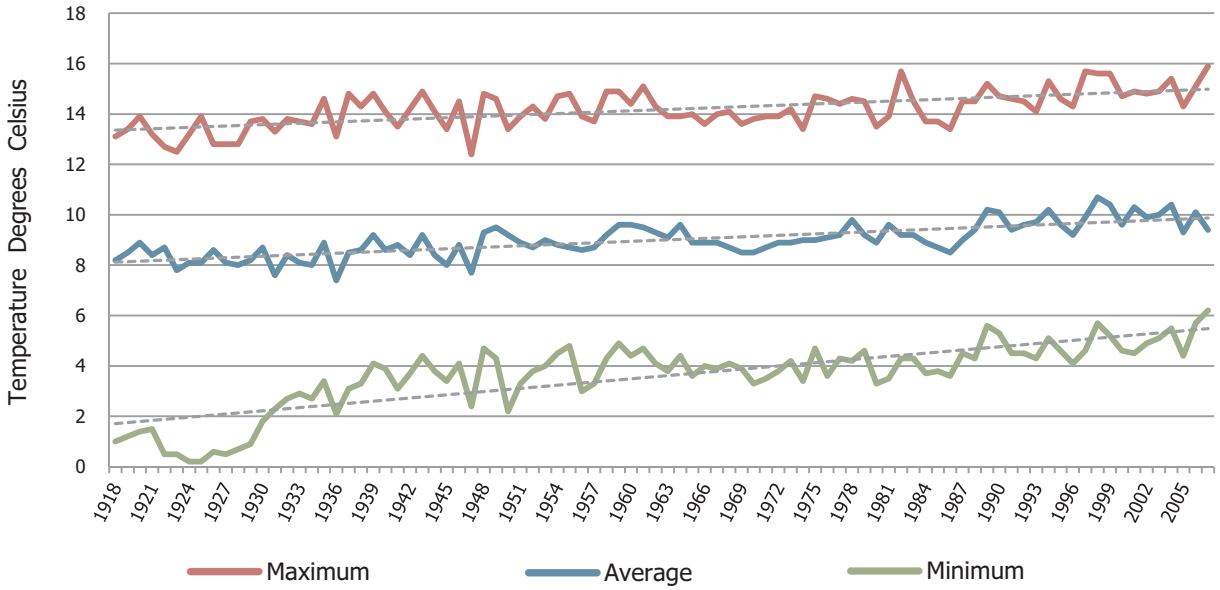
The observed warming trend is more pronounced in the winter and spring seasons (see Table 6.1). Over the 1918 to 2000 period, the average winter temperature increased by 4.9°C, while the average spring temperature increased by 2.4°C. There was a small increase in average autumn temperature and no discernible change in average summer temperature.

One implication of this warming trend has been a decrease in the duration of winter, shallower soil freezing depth and an extension of the agricultural growing season. It is now possible in many areas to harvest crops twice every year. Further, in the eastern region, there have been fewer observed losses from cold weather events. Other observations include that the seasons are becoming shorter in spring and winter and getting longer in summer and autumn. In the winter, it was common to see icicles hanging from building roofs. Over the last two decades these have become less common and are now seldom seen. There is a traditional Korean expression "Coldness for three days after warmness for four days in winter season". This weather relationship is no longer observed clearly.

Changes in plant and animal behavior have also been observed. For instance, persimmon trees now successfully grow in Pyongyang city where it had long been thought impossible since they only grew in warm southern areas such as Wonsan and Anbyon in Gangwon province. In the eastern coastal waters, Myongthae (Walleye Pollack) has traditionally been

Figure 6.1

Annual maximum, minimum and average temperatures in DPR of Korea (1918 - 2007)



Source: State Meteorology and Hydrology Administration 2010

a productive winter fishery. However, since the 1980s productivity has declined, possibly as a result of the sea water temperature rising.

Annual precipitation variation

Average annual precipitation in the DPR of Korea has exhibited considerable variation over the last century (see Figure 6.2 on next page). There has been an increase in the frequency of heavy rain events in recent years. This is contributing to severe floods, landslides and debris and mud flows. Over the period 1918 - 2007 there is no statistically significant observable trend in annual precipitation.

Extreme weather events

In the 20th century, the frequency of unusually low temperatures decreased gradually and high temperatures increased (see Figure 6.3 on next page). There has been an increasing frequency of extreme maximum temperatures with higher values in the 1980s and 1990s and a decrease in the incidence of record low temperatures, particularly for the period 1958 to 2001. Extremely hots days are defined as being greater than two standard deviations above the average temperature for the period 1920 to 1990, whereas extremely cold temperatures are defined as being lower than two standard deviations below the average temperature for the period. Abnormally high summer temperatures were recorded in 1994 and 1997 (23.8°C and 23.4°C) that were 1.7°C and 1.3°C higher than the average of 22.1°C. The extremely hot days that occurred in the summer of 1994 are the highest ever recorded. The highest annual average temperature was recorded in 1998, at 1.8°C higher than the 30-year (1941-1970) average.

Table 6.1

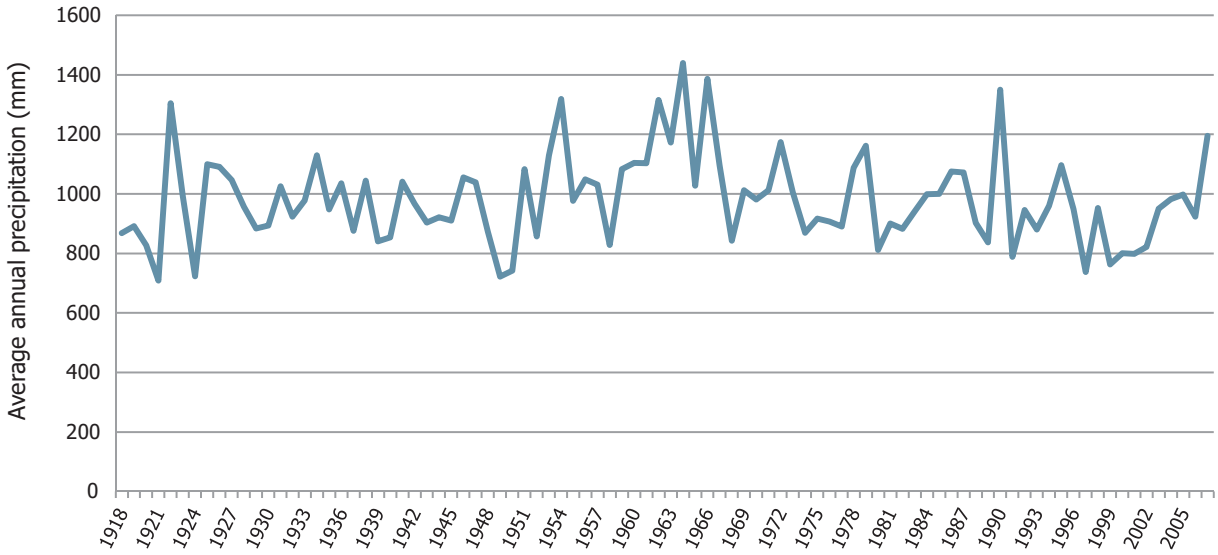
Long-term trends in temperature by season (1918-2000)

Season	Warming rate °C
Winter	4.9
Spring	2.4
Summer	-
Autumn	0.8

Source: State Meteorology and Hydrology Administration 2010

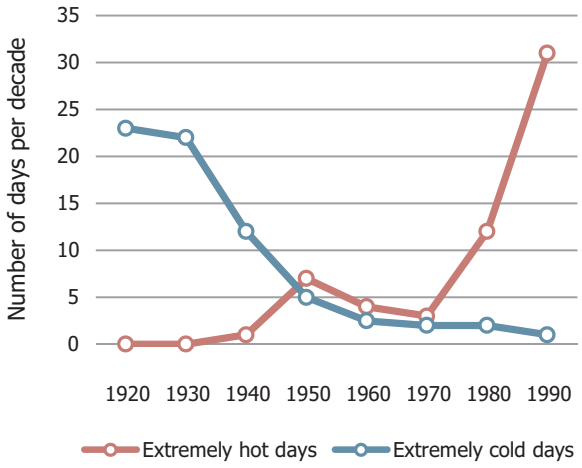
Abnormal flooding occurred more frequently in the 1960s, while droughts occurred more often in the 1990s. In 1995 and 1996, abnormally high rainfall was recorded. In 2006, 448 mm of rain fell between June 14 -16th, causing crop losses and soil erosion. This was followed by a country-wide drought in the latter half of the same year. In 1995, 1996 and 2007, frequent spells of heavy rain damaged hundreds of thousands of hectares of forest, reduced crop production in most regions, caused severe soil erosion and degraded hundreds of thousands of hectares of forests. The combination of severe drought and heavy floods have led to the proliferation of damaging forest insects which have reduced seedling production, undermined afforestation efforts, and led to economic losses.

Figure 6.2
Average annual precipitation (1918-2007)



Source: State Meteorology and Hydrology Administration 2010

Figure 6.3
Trends of abnormal temperature by decade



Source: State Meteorology and Hydrology Administration 2010

6.2 Projected climate change

Observations over the last century suggest that the climate in DPR of Korea, like the rest of the world, is changing. Given the persistent and accumulative nature of greenhouse gas emissions in the atmosphere, the climate is likely to continue to change for decades and perhaps centuries before it nears a new equilibrium. Impacts from changing temperatures, precipitation patterns, storms events and sea level will have profound consequences on human and ecosystems. As such, it is important to develop projections of the potential extent of climate change to assess potential impacts and required adaptation measures.

Projections of climate change are strongly affected by several factors:

- the choice of global or regional circulation model used and its inherent values and assumptions;
- the emissions scenario used and the timing and volume of greenhouse gas emissions into the atmosphere;
- assumptions about climate sensitivity – the equilibrium global average surface temperature change resulting from a doubling of CO_2 concentrations in the atmosphere (climate sensitivity relates to feedback effects that are not well understood); and
- how far into the future the projection is being made.

Climate change modelling assumptions and method

The following section describes the results of climate change projections for the DPR of Korea made by CLIMSystems Ltd, New Zealand using general circulation model patterns and international climate data. To avoid the potential for bias from one particular general circulation model, the projections are based on the averaged output of 21 General Circulation Models (GCMs). The modelling uses a linked pattern scaling approach that combines statistically downscaled GCM patterns, baseline climate data, SRES emissions scenarios and low, mid and high range climate sensitivity values from the Intergovernmental Panel on Climate Change. The scenarios are shown below in the form of tables and figures. For a full description of the

modelling methodology see Annex 3 to this report. Climate change projections used in this report are based on an analysis of the region around the Korean Peninsula defined by a perimeter of latitude north 43° 40' to 32° 50' and longitude east 121° 45' to 135° 05'. This region includes the entire Korean Peninsula, as well as small areas of China, Russia and Japan.

The climate change scenarios produced for this report are for the years 2030, 2050, 2070 and 2100. For each year, three scenarios have been developed: a worst case scenario that combines a high global emissions pathway (A1FI) and assumes that the climate is very sensitive to emission concentrations, a mid-range scenario that uses a more moderate emissions pathway (A1B) and assumes a mid-range climate sensitivity value, and a low-range scenario which assumes a very low global emissions pathway (B1) and a low value of climate sensitivity.

Precipitation projections

Regional projection

Table 6.2 shows projections of the change in annual average precipitation for the region. The 21 GCM models on balance project that precipitation will increase. Projected increases are greater for higher emission scenarios or for dates further into the future. The change is not expected to be uniform across the region. Maps of the distribution of projected changes are shown in Figure 6.5 on the following page.

The projected rise in average precipitation could lead to increased flooding, landslides and mud flows if it occurs in the already wet summer months, or if it comes in the form of heavier rainfall events as have been observed in recent years.

Precipitation projection for Pyongyang

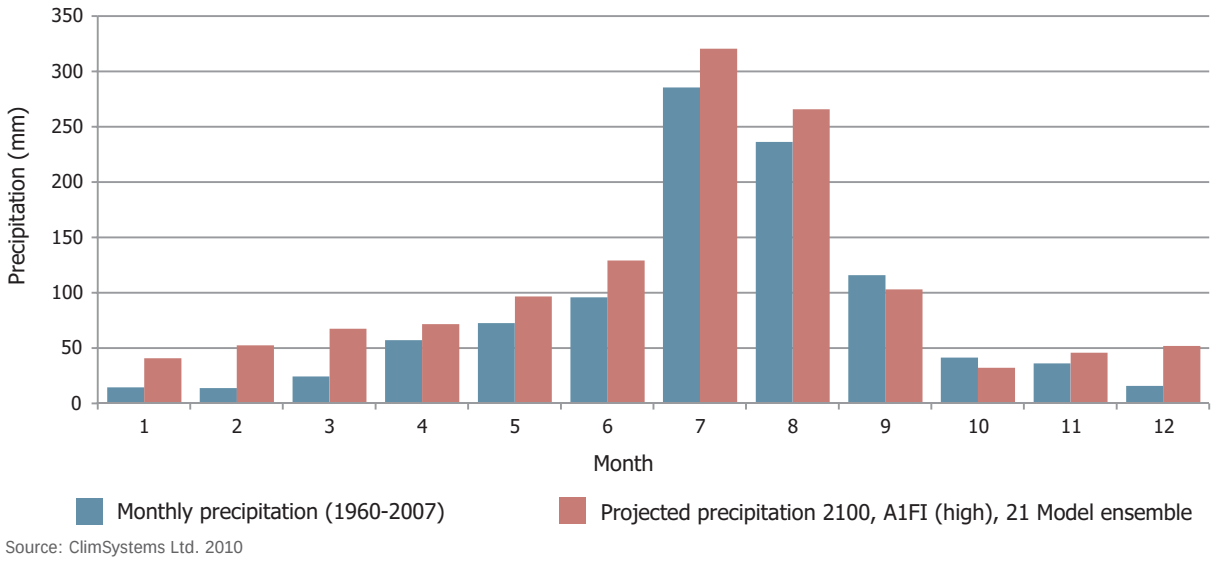
Figure 6.4 shows the long term historic monthly precipitation for Pyongyang and the projected

Table 6.2
Projected percent change in annual average precipitation for the entire region

Change in annual average precipitation	Baseline (1960-1990)	2030	2050	2070	2100
Worst case SRES A1FI (high sensitivity)	0%	+ 6.10%	+ 12.56%	+ 20.82%	+ 31.49%
Mid-range SRES A1B (mid sensitivity)	0%	+ 4.06%	+ 7.36%	+ 10.55%	+ 13.75%
Low SRES B1 (low sensitivity)	0%	+ 2.12%	+ 3.18%	+ 4.16%	+ 4.74%

Source: ClimSystems Ltd. 2010

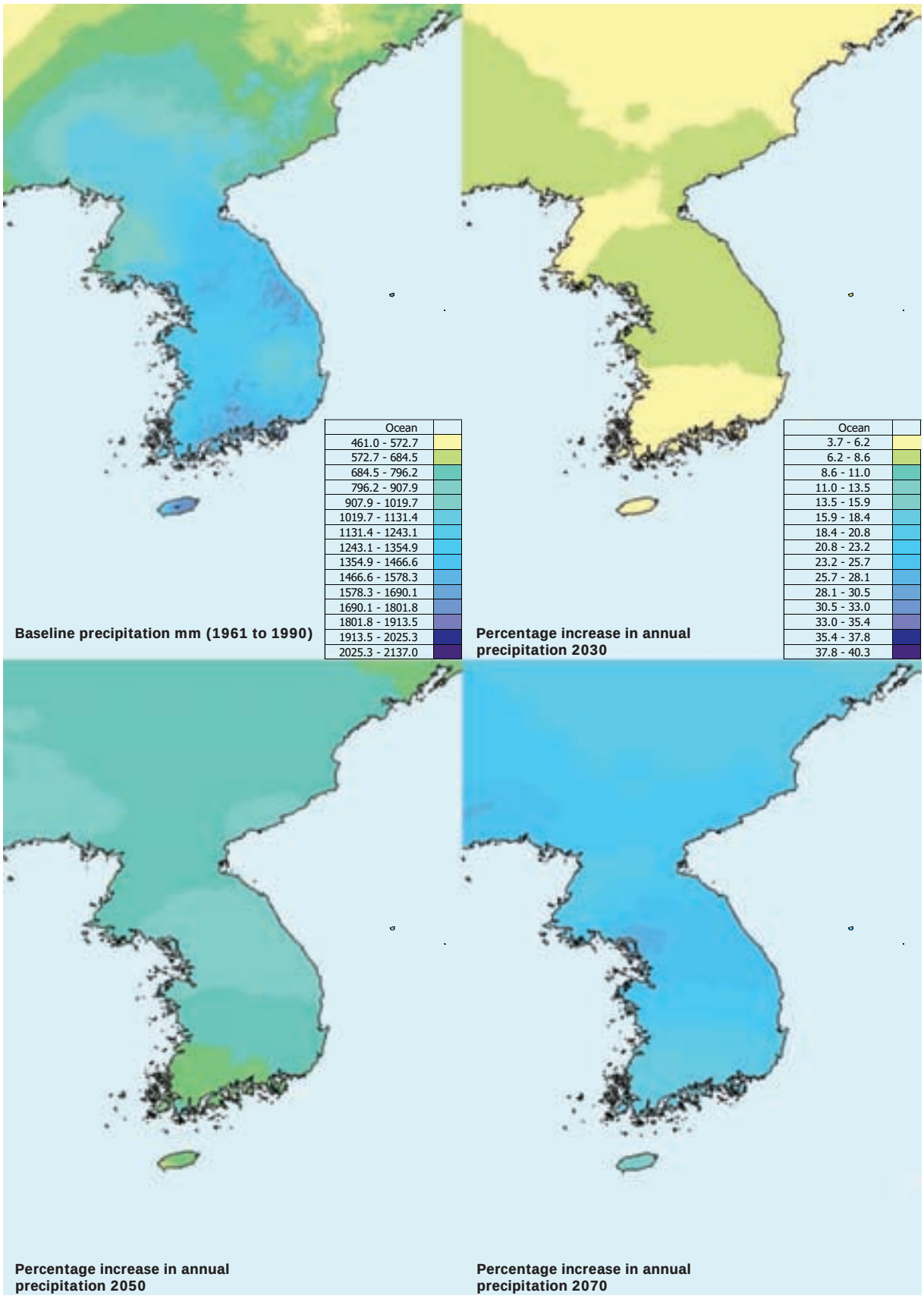
Figure 6.4
Historic and projected precipitation for Pyongyang



Source: ClimSystems Ltd. 2010

Figure 6.5

Maps of current and projected annual average precipitation for region



Source: ClimSystems Ltd. 2010, scenarios based on 21 GCM ensemble and A1FI SRES and High Sensitivity (worst case)

monthly precipitation for the year 2100, respectively. The scenario assumes high emissions and climate sensitivity. Most noticeable is the projected increase in precipitation in the wet months of July and August. These increases have the potential to increase flood related damage.

Temperature Projections

Regional temperature projection

Table 6.3 shows projections of the change in maximum temperature for the summer months of June, July and August. Maximum temperature takes the highest ten percent of temperature values over the three months and averages them. The 21 climate models on balance project that average maximum temperature for the summer months will increase by between 0.46°C and 6.84°C depending on the emissions scenario and time period. Projected increases are greater for higher emission scenarios and for dates further into the future. The temperature change is not expected to be uniform across the region. For maps of the distribution of the projected change, please see Figures 6.7.

Higher maximum temperatures will place considerable stress on crops and livestock, human health, infrastructure and forest and freshwater ecosystems. They could exacerbate drought stress and put pressure on limited water supplies during the spring period, and could also lead to increased pests and diseases in crops and forests.

Projected temperature change for Pyongyang

Figures 6.6 shows the long term historic maximum, average and minimum monthly temperatures for Pyongyang and the projected future temperatures assuming a high emissions scenario for the year 2100. Under that scenario, temperatures would increase in every month. The maximum temperatures in July and

Table 6.3

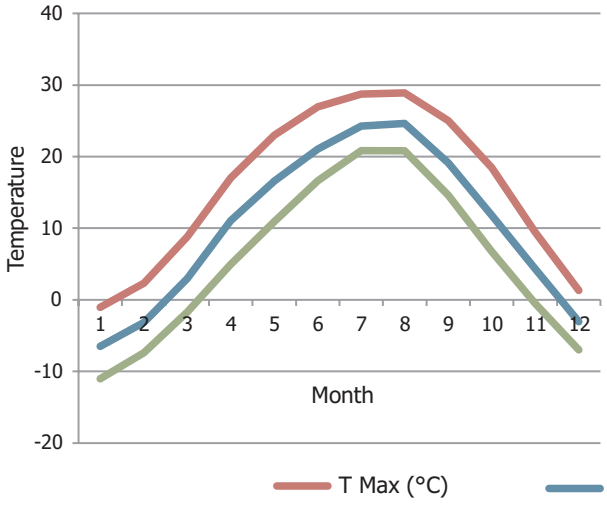
Projected change in maximum summer temperature for the region

Change in summer maximum temperature (June, July, August)	Baseline (1960-1990)	2030	2050	2070	2100
Worst case SRES A1FI (high sensitivity)	25.24°C	+ 1.33°C	+ 2.73°C	+ 4.53°C	+ 6.84°C
Mid-range SRES A1B (mid sensitivity)	25.24°C	+ 0.89°C	+ 1.60°C	+ 2.30°C	+ 2.99°C
Low SRES B1 (low sensitivity)	25.24°C	+ 0.46°C	+ 0.69°C	+ 0.91°C	+ 1.04°C

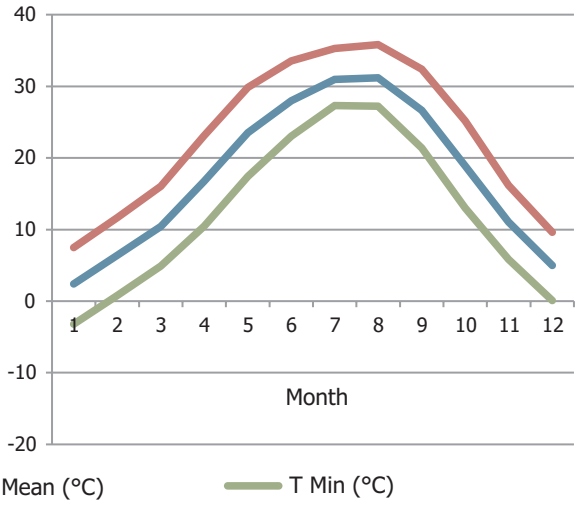
Source: ClimSystems Ltd. 2010

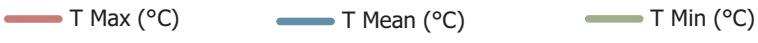
Figure 6.6

Minimum, average and maximum monthly temperatures - Pyongyang (1960-2007)



Pyongyang monthly temperature projection for 2100

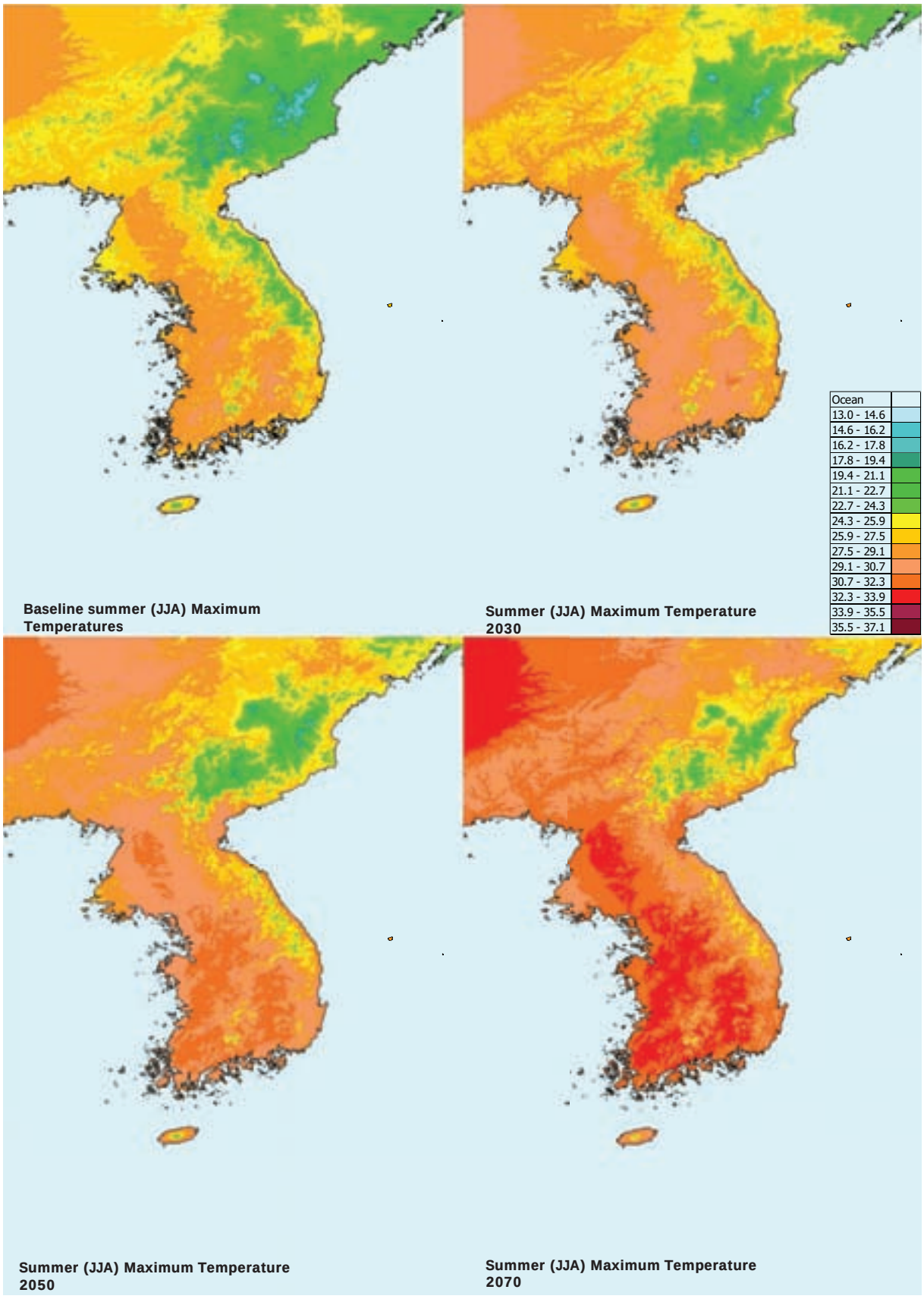




Source: ClimSystems Ltd. 2010

Figure 6.7

Map of current and projected maximum average temperatures for region



Source: ClimSystems Ltd. 2010, scenarios based on 21 GCM ensemble and A1FI SRES and High Sensitivity (worst case)

August would be more than 5°C warmer than current conditions by 2100.

Sea level rise

The total global sea-level rise in the 20th century was between 120 and 220 mm depending on the location. Sea level rise is not equal around the world due to the rotational effects of the earth and the differences in the thermal expansion component of sea level rise.

The rate of annual sea level rise has increased from 1.8 ±0.5 mm per year from 1961-2003 to 3.1 ±0.7 mm per year from 1993-2003 (IPCC, 2007). The IPCC projects between 50 and 60 cm of further sea level rise by the end of this century, although other scientists contend that it could be as much as one to two meters based on current levels of emissions. There is general agreement among scientists that the sea level will continue to rise for several centuries or more after greenhouse gas concentrations stabilise in the atmosphere (IPCC, 2007). Approximately half of the sea level rise will be due to thermal expansion and the remainder due to melting glaciers and ice sheets. Coastal areas, especially heavily-populated regions, will be at greatest risk due to increased floods from sea and rivers. Expected impacts include beach erosion and coastline retreat, damage to tidal lands (arable) and salt-fields, damage to coastal ecosystems and fisheries, agricultural losses and damage to residential and manufacturing infrastructure.

6.3 Anticipated impacts of climate change

Impacts on water resources

Climate models predict increased rainfall across the DPR of Korea (see Figure 6.5). A mid-range scenario of 14 percent more precipitation by the end of this century would result in considerably higher river flows. Studies estimate that the flow rate of the Daedong River would increase by 25 percent, Amnok River by 21 percent, and Tumen River by 18 percent. This would increase the potential for heavy flood damages in July and August when most precipitation occurs.

During heavy rain water quality is affected by increased soil erosion and agricultural nutrient and chemical runoff. Consecutive floods and droughts in recent years have deteriorated the water quality of rivers and streams and affected domestic, industrial and agricultural water supplies and people's livelihoods. Water quality indicators such as turbidity exceed prescribed standards during these events. Supply inlets become covered with sand and gravel sediment, affecting the operation of pumping stations .

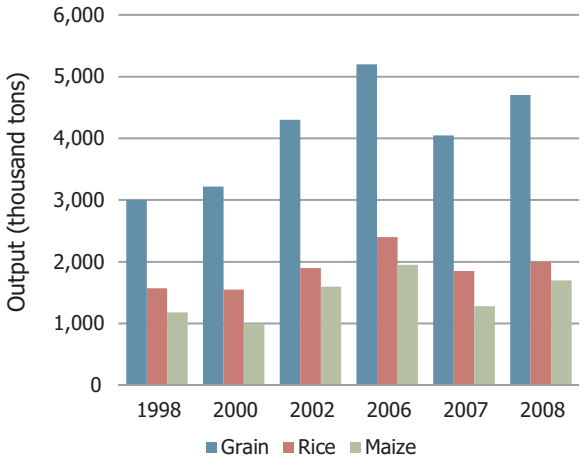
The higher temperatures in recent years, likely a consequence of climate change, are leading to increased growth of hydrophytes in waterways. Hydrophytes contain 0.31 per cent phosphorus, and when they decompose they cause eutrophication and secondary pollution to the detriment of recreation and economic activities in the river basins.

Impacts on agriculture

Agriculture is critical to the national economy and the wellbeing of people in the DPR of Korea. It is highly vulnerable to the climate change. Climate change is likely to result in an undesirable combination of longer and more intense heat waves, longer periods of drought, but also more intense rainfall events. Agricultural production would be negatively impacted by any combination of these changes.

The greatest risk is a change in the ability to provide a regular supply of water to crops and livestock, especially during hot periods. When temperatures are high, evaporation from soils and transpiration of water from plants increases. During prolonged hot periods, the provision of additional water through irrigation or rainfall is necessary to ensure that the plants growth and fruit production are not impaired. However, it is often difficult to provide sufficient additional water for irrigation during these periods since water levels in rivers and dams are likely to be low and demand

Figure 6.8
Variation of agricultural output for selected years and crops



Source: Central Statistics Bureau 2010

from residential and industrial users high. In addition, considerable water is lost during the transfer along irrigation networks in hot periods due to higher infiltration rates in to the dry soils and increased evaporation. Extended hot and dry periods hinder transplanting and increase the incidence of many pests while at the same time reducing the resilience of plants to them.

Of equal concern to agricultural productivity is the damaging effect of intense rainfall events. Intense rain can damage crops through impact on leaves or fruit. Inundation can result in an over-watering effect whereby the plant's roots begin to rot and the plant dies. Intense rain also washes away top soil and micronutrients, reducing soil humus content and soil depth. This is a particular concern for slope agriculture.

Intense rainfall events appear to be increasing in the summer months of July and August when the majority of the precipitation occurs. Intense rainfall during these months leads to particularly bad flooding, landslides and soil erosion with large effects on crop production. Figure 6.10 (on the previous page) shows the variation in crop production over the ten years from 1998 to 2008. After falling during the 1990s following a series of droughts and floods, agricultural output gradually increased until 2007 when it was set back by another devastating flood.

Floods

Most precipitation occurs at higher altitudes in the upper and middle sections of the country's largest rivers. These rivers are sensitive to heavy rain and are prone to flooding because of the steep slopes of the catchment area. Over the previous two decades flooding has occurred with greater frequency and caused tremendous damage. On October 10, 2001, 347 mm of rain fell in Wonsan area in just 12 hours. In July of 2006, 448 mm of rain fell over three days in Yangdok area. In the summer of 2007, large areas of North and South Pyongan Provinces, North and South Hwanghae Provinces, Kangwon Province and North and South Hamgyong Provinces suffered from torrential rain over three days which resulted in widespread damage to arable land and infrastructure and destroyed a large portion of agricultural production.

Heavy rainfall in deforested areas cause landslides that deposit large amounts of soil and sand in the valleys, cover or flatten forests, and raise the level of riverbeds causing subsequent flooding to occur more easily. In Yangdok County, there were several landslides in 2006 and 2007 that damaged railways and buried houses.

In 2007, rivers had reduced capacity to move large volumes of water due to high sediment loads from the previous landslides. Thousands of hectares of paddy fields were flooded.

Table 6.4 below provides some figures on damage and loss of life caused by flooding in 2007.

Table 6.4
Flood damage and deaths in 2007

Damage and loss of life caused by the major floods in 2007	
Damaged towns and counties (number)	150
Death (number)	454
Missing persons (number)	156
Wounded persons (number)	4,351
Residents affected by flood (number)	964
Homeless residents (number)	170
Area of damaged farm land (ha)	244,175
Destruction of road (roads / km)	2,507 / 678
Destruction of bridge (bridges / km)	2,247 / 89.3
Destruction of rivers (rivers / km)	2,575 / 1,507
Destruction of dams (dams / km)	62 / 67
Destruction of schools (buildings / m^2)	81 / 17,596
Pupils without schools (number)	27,746

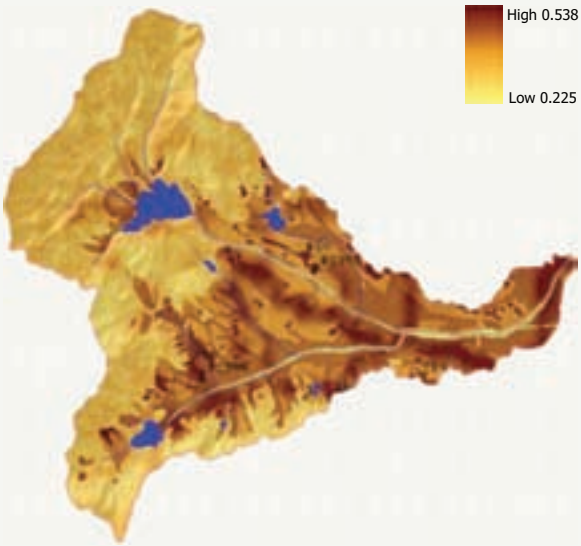
Source: Central Statistics Bureau 2010

Droughts

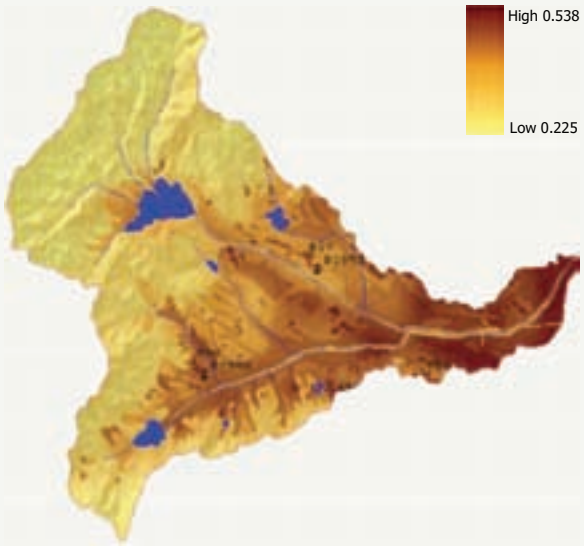
Over the 35 years from 1971-2006 the average annual temperature increased by 0.38°C per decade. More frequent hot days and heat waves have been occurring as climate change progresses across the region with severe effects on agriculture, forest and other ecosystems, biodiversity, soil structure and human health. If recent trends continue and most of the rain falls in intense high volume events, rather than being spread out more evenly, then the potential for drought will be increased. This will have a significant impact on agricultural production if irrigation is not able to meet the demand from this sector even as damage from flooding also becomes more common. There have been serious water shortages due to prolonged hot and dry periods in 1991, 1992, 1993, 1997, 1999 and 2000 some with disastrous effects on agricultural output. Water supply from the high demand Taedong River is becoming an important issue that is likely to grow more prevalent with continued population growth and economic development even as supplies become more variable due to climate change.

Box 6.1 Flood risk assessment maps

Flood risk assessment map for the valley of Jongpyong County, South Hamgyong Province

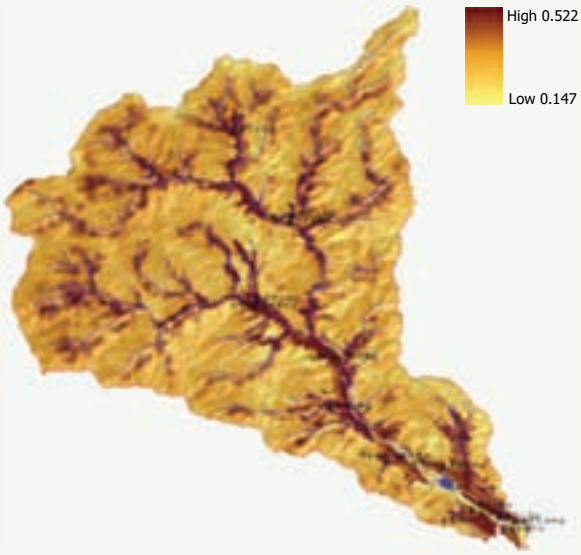


Flood risk assessment map for the streams of Jongpyong County, South Hamgyong Province

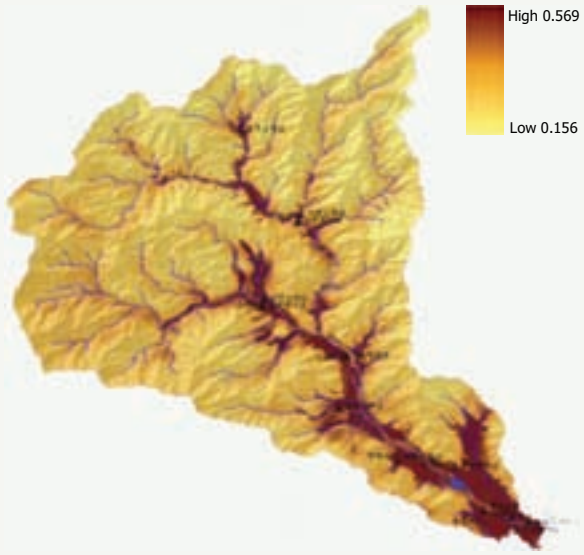


Source: Ministry of Land and Environmental Protection 2008

Flood risk assessment map for the valley of Yonggwang County, South Hamgyong Province



Flood risk assessment map for the streams of Yonggwang County, South Hamgyong Province



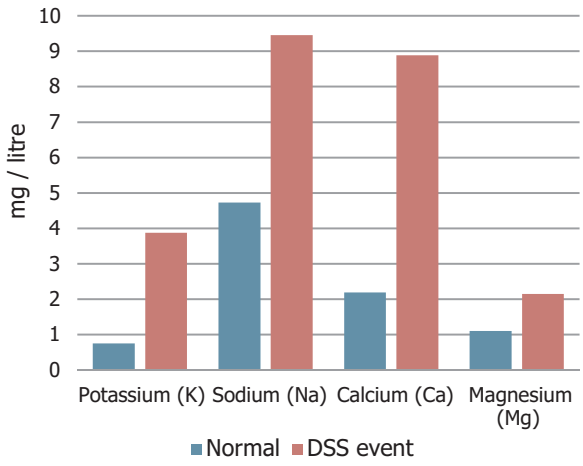
Source: Ministry of Land and Environmental Protection 2008

Damage by dust and sand storm (DSS)

Hotter drier conditions resulting from climate change are compounding human induced desertification in Asia and causing more frequent and intense dust and sand storm events that affect DPR of Korea as well as other countries. Dust and sand storms have a negative impact not only on human health and wellbeing but also on wildlife. Dust and sand storms can result in the outbreak of respiratory and eye diseases. These storms also impact water, soils and forests due to their high composition of sodium (Na), calcium (Ca), potassium (K) and magnesium (Mg). Figure 6.9 shows the differences in the chemical composition of water measured between normal periods and dust and sand storms.

Figure 6.9

Trends of metal content in water during dust and sand storm events



Source: Environment and Development Center 2002

Impacts on forests

Heavy rain in 1995 and 1996 did enormous damage, degrading several hundred thousand hectares of forests. If such events were to increase in frequency, the impacts on forest cover and quality would be considerable.

Forest growth rates are primarily a function of temperature and precipitation. Trees considered most vulnerable to the projected changes in conditions include: pine, larch and deodar. Several broad leaf varieties of trees may extend their range northwards, although this would occur slowly.

Risks to forests from fungi, fire, insects and wind may be greater as a result of warmer winters, less snow cover, shorter periods of frozen soil, and potentially drier springs.

Impacts on marine resources

Potential impacts on marine resources from warmer water are less well understood, but could include northward migration of cold water species such as cod, salmon and herring. Algal blooms may become larger and more frequent. Higher concentrations of atmospheric CO_2 will cause oceans to become more acidic with detrimental effects on many organisms, particularly those that have shells.

Impacts on biodiversity

Climate change will greatly affect biodiversity. It will advantage to some species and disadvantage others. The net result will be changed ecosystems, some of which humans will prefer and others which are less desirable. Increased carbon dioxide concentrations in the atmosphere have a fertilization effect on plants. They increase photosynthesis and improve the productivity of plants. If temperatures did not change, then in most cases plants would grow better under higher carbon dioxide concentrations. However, temperatures will change because higher carbon dioxide concentrations contribute to an enhanced greenhouse effect. Higher temperatures lead to higher rates of evapotranspiration from plants. It is likely that in most cases the declines in plant growth associated with higher rates of evapotranspiration will more than offset any gains from a carbon dioxide fertilization effect as CO_2 concentrations increase.

As temperatures increase, plants that were at the limits of their geographic range due to the cooler conditions at higher latitudes and altitudes may extend their geographic range. This suggests that some areas previously too cold to plant crops may become viable for agriculture in the future. Other areas may support two crops per season. In DPR of Korea, warmer temperatures will lead to the northward expansion of tolerable conditions for rice, corn and other crops as well as increasing crop production per unit area and gross crop yields. It will also likely bring about changes in crop distribution, the structure of agricultural production and regional modes of cultivation and sowing, and expansion of two-crop per year farming.

In the past, the climate changed gradually over very long periods of time, giving plants and animals time to adapt. Anthropogenic induced climate change is

occurring at a far more rapid rate and will likely change growing conditions more quickly than many plants can adapt. Many plants species are likely to become extinct. In particular, tree species will find it difficult to migrate as quickly as conditions are changing given that they often take longer to reach maturity. As temperatures increase at higher altitudes many species that found colder climate favorable will be at risk of extinction. Similarly, plants and animals reliant on cold water are at risk. It is important to note that as opposed to expansion to higher altitudes, expansion to higher latitudes is limited by the amount of available sunlight.

Forests are particularly at risk from climate change due to a combination of unfavorable growing conditions, a higher incidence of forest fires and increased pest populations. There is evidence of that these impacts are already occurring in the forests of the DPR of Korea. Pests such as the pine caterpillar moth, pine gall midge and others have caused significant forest degradation.

An increased threat to certain flora and fauna species is likely as a result of the combined effects of climate change and habitat fragmentation. Changing temperature and precipitation patterns will make conditions less favorable for the survival of some species and more favorable for others. Some species that are unique to the DPR of Korea will be at risk. The vegetation affected by climate change in DPR of Korea comprises of 16 critically endangered species, 31 endangered species, 51 vulnerable and 55 near threatened. A total of 159 species of fauna in the DPR of Korea is afftected by climate change. This includes 8 critically endangered species, 46 endangered species, and 105 vulnerable species.

Impacts on people

Climate change will directly affect people in the DPR of Korea through more intense heat waves, more frequent dust and sand storms, reduced water quality and quantity, and an increase in diseases through mosquitoes and other vectors. There are also likely to be increased death and injury from floods and landslides.

Climate change will indirectly affect people through economic losses caused by crop failure, livestock stress, and infrastructure damage from extreme storms and natural disasters. More people will be impacted by natural disasters such as flooding, typhoons, drought and forest fires. People living in coastal areas will be affected by sea level rise, including increased storm surge inundation.

Loss of biodiversity will have a direct impact on the people's livelihoods and sense of wellbeing. In rural and mountainous areas where people rely on firewood and other forest resources, there will be fewer resources for heating and building. Traditional herbs used in medical treatments may be affected as will marine food sources.

6.4 Adaptation to climate change

Adapting to climate change in the DPR of Korea will require responding to the incremental risk to existing vulnerabilities caused by climate change and taking advantage of new conditions where they are beneficial to human systems. Many of the actions taken to adapt to climate change will be the same actions necessary to reduce vulnerability from existing climate variability and unsustainable land use and resource management practices.

Projected increases in temperature and precipitation could result in the adoption of alternative cultivars that could be planted later in the season without risk of cold weather damage. In some areas the warming trend may

make multiple cropping systems viable. Longer summer conditions could promote rice productivity, however, higher evapotranspiration is likely to more than offset any increases in productivity. Increased pest damage and extreme heat and precipitation events are also likely to result in losses in agricultural productivity. Possible adaptive responses are listed below.

Agriculture

- Modify planting and harvest times to respond to changing temperature and precipitation patterns.
- Develop crop varieties that are better adapted to the emerging climate conditions.
- Increase irrigation of crops to compensate for moisture lost to evapotranspiration, particularly for corn crops.
- Increase fertiliser application to compensate for changed temperature or precipitation conditions.
- Adopt farming methods that provide greater environmental benefit while enhancing agricultural productivity .
- Develop and introduce high-yielding species and double-cropping methods.
- Integrate water resource management actions.
- Prevent land degradation by integrated basin management.
- Introduce sustainable slope management technologies.
- Introduce integrated pest management practices.

Forestry

- Develop or import tree varieties that are better adapted to projected climate conditions and have resistance to pests and diseases.
- Transfer best practice in tree and insect management from other countries.
- Improve management and care of existing forests and plantations and pursue agroforestry where appropriate to produce both commercial forest products and agricultural produce.
- Improve fire and insect monitoring and responses.
- Restore degraded forests.
- Afforestation, methane gasification, and introduction of alternative energy and higher thermal efficiency technologies to meet rural energy demands with less impact on forest resources.

Coastal zones

- Conduct research into the adequacy of breakwater structures in coastal zones.
- Develop strategies for infrastructure buffer zones to reduce the impacts of sea level rise and inundation during extreme storm events.
- Develop soft-engineering buffer zones such as

Box 6.2: Climate Change Adaptation Simulation for Crop Production

The Academy of Agricultural Sciences (AAS) has undertaken research to address climate change in order to ensure sustainable agricultural production in the DPR of Korea.

Since the beginning of 1990's, the Agricultural Information Technology Research Center (AITRC) of the AAS has conducted research programs to establish systems for forecasting crop growth and monitoring and forecasting pests & diseases according to climate conditions by use of crop growth simulation models. The crop variety yield trial database, and the land resource information database (comprising soil and climate data at the farm level across the whole country) are being built up and crop simulation models for major crops such as rice and maize are being developed.

Programs to divide the country's agricultural ecosystems into different zones on the basis of the analysis of the nationwide agricultural ecological resources have been undertaken, and programs for the research, development and extension of the computer-aided simulation techniques, which can scientifically support agricultural production, have been actively pursued since 1999.

Technical tools to support the adaptation of farming techniques to climate change in different agricultural regions, including the choice of crops and cultivars, the development of detailed farming plans and their implementation, crop yield forecasting and the analysis of farm management are being developed and introduced.

Since 2005, in order to give substantial assistance to farms to adapt to climate change, the AAS, in collaboration with the State Hydro-Meteorological Administration (SHMA) and the Ministry of Agriculture (MoA), established a National Crop Growth Forecasting System (NCGFS) to provide meteorological data, crop growth surveys and analysis, and pest & disease monitoring and forecasting data.

appropriate vegetation in areas at risk to climate change impacts.
- Develop options for planned retreat from areas at risk from sea level rise, storm surge and flooding.
- Conduct a vulnerability assessment for low lying sensitive areas and construct seawalls to prevent inundation, particularly in estuaries of Amnok, Chongchon, and Daedong Rivers.
- In order to reduce inundation due to land subsidence, limit the extraction of groundwater in coastal areas.
- Establish an integrated coastal zone management system to conserve habitat and preserve biodiversity.
- Ensure new coastal development is consistent with coastal zone conservation and rehabilitation objectives.

Facilities protection

- Identify and prioritize port, wharf, drainage system and water break infrastructure to manage expected sea and river level rise.

Education

- Develop and disseminate information on climate change and encourage public participation in addressing the issues. Target homes, schools, regions, and other points of leverage.
- Use a combination of print, television, radio and other methods to raise public awareness and engender action on climate change adaptation and mitigation and environmental conservation.

Climate change research and technology development

- Enhance research and training programs and efforts to develop appropriate technologies within the institutes of Meteorology and Hydrology Commission and universities and science academies in the DPR of Korea.

CHAPTER 7

Conclusions and Recommendations

7. Conclusions

7.1 The role of the ECCO report

The Environment and Climate Change Outlook Report (ECCO) is an important output in the ongoing process of environmental assessment and reporting in DPR of Korea (see Figure 7.1). The information and conclusions contained in the report include a synthesis of numerous studies and monitoring programs that have occurred since the preparation of the previous State of Environment Report in 2003. The ECCO report attempts to provide a comprehensive assessment of the environmental state and trends in the DPR of Korea and as such represents an important document on which an inter-agency response to socio-environmental issues should be based.

This chapter presents the main conclusions of the report and puts forward principles and objectives for an integrated response to priority issues.

Figure 7.1
Environmental assessment and reporting process

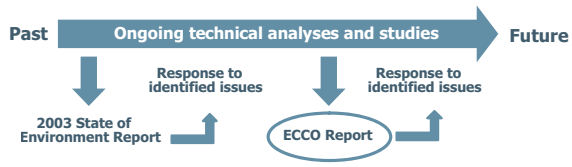
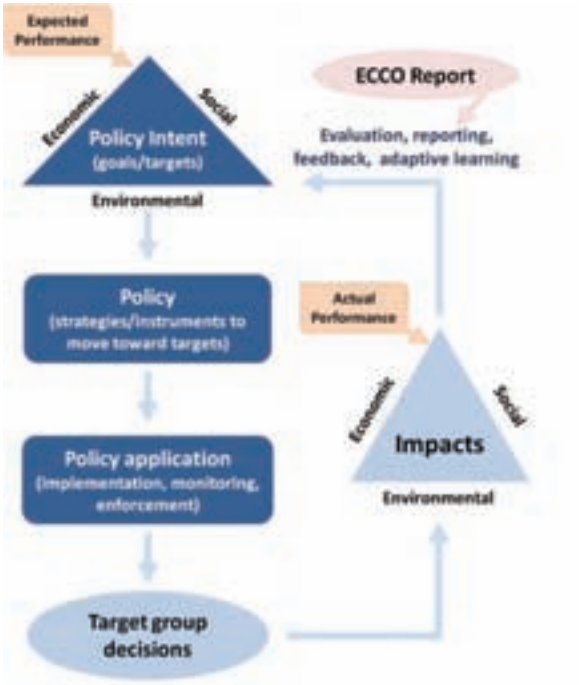


Figure 7.2 provides a generalization of the ongoing enhancement of the political response in environment management. Legislation and policy are formulated at national level and implemented by various government agencies. Often the policy implementation is faced with some obstacles, and in the case of environmental management, the desired environmental outcomes may not result. It is therefore particularly important to review the actual environmental trends, impacts and outcomes as described in the preceding chapters of this report to provide the basis for the ongoing evaluation of policy performance with the intention of identifying opportunities to improve environmental management responses.

Figure 7.2
Political response enhancement in environment management



Source: Modified from Boyle, Kay and Pond (1996) as shown in UNEP GEO training manual

Figure 7.3
Evaluation in the environmental management cycle

Source: IUCN Best Practice Protected Area Guidelines Series No 6. (2000)

Figure 7.3 presents an idealized representation of evaluation as an iterative and ongoing component of environmental management. Evaluation occurs at each of the following stages:

- Vision: the guiding goals, values and objectives – encapsulates sustainable development
- Planning: legislation, policy and systems design: the mandate for management.
- Inputs: financial resources, technical resources, human resources, equipment and facilities
- Process: management and system processes, institutional and reporting arrangements, partnerships and cooperation.
- Outputs: the extent to which targets been met and work plans and programs implemented.
- Outcomes: the extent to which local and national goals and objectives have been achieved.

7.2 The principles of an effective response

Effectively responding to environmental conditions and trends in the DPR of Korea will require a comprehensive and integrated approach that combines goals, strategies and actions with adequate resources and technical capacity. Although some of these elements are in place already, advancing the objective of sustainable development will necessitate an iterative management process that emphasizes assessment, reporting, setting performance targets and taking action, monitoring and evaluating progress and revising management responses. Such an approach will be strengthened by the adoption of international best practice in environmental management and knowledge sharing across government agencies. Research, investment and policy responses should be assessed against sustainability principles and criteria and prioritized on the basis of their contribution to improvements in human wellbeing and ecosystem health.

- In general, the response should be consistent with the following principles:
- Improvements in the state of the environment are necessary for social, cultural and economic well-being.
- Information and recommendations from the ECCO Report should be integrated into planning processes across government agencies.
- Follow-up responses should be evaluated against the level of contribution they make to arresting negative environmental trends, restoring degraded ecosystems and improving human health and well-being.
- Emphasis should be placed on actions with co-benefits that improve food security, strengthen local livelihoods and provide alternative energy sources so as to reduce the drivers of ecosystem degradation.
- Effort should be made to encourage gains in resource use efficiency and provide incentives to switch to alternative lower impact inputs in industrial, manufacturing, residential and energy production processes.
- Legislation and policy should be accompanied by targets against which performance can be evaluated using clearly defined criteria, indicators and monitoring processes.
- A systems-based approach that encourages inter-agency cooperation, institutional learning and adoption of best practice will make more rapid progress in reversing negative environmental trends, restoring degraded ecosystems and advancing sustainable development objectives.
- An integrated environmental management approach should be adopted that includes Strategic Environmental Assessment (SEA) for the analysis of policies and development plans, Environmental Impact Assessments (EIA) for determining potential impacts and mitigations measures, and Environmental Management Plans (EMP) for the managing and monitoring of specific developments.

Issues and recommendations

7.3 Air and atmosphere

Air quality

Atmospheric pollution sources in DPR of Korea are associated with industrial processes and energy production, residential heating and cooking, and vehicle exhaust. The primary sources are industrial kilns, boilers, cooking and heating appliances and

vehicle engines. Increases in industrial production and population growth in the absence of improvement in combustion efficiency and pollutant capture increase the volume of air borne pollutants and the associated volume and composition of dust.

Atmospheric quality in cities is worse during colder months when additional coal is burned for heating and meteorological conditions are less favorable to pollutant dispersal. Air quality in urban areas sometimes exceeds environmental standards where it is measured, for example in a proximity to industry and thermal power station in Pyongyang. Air quality may be reduced in other areas but at present there is no comprehensive monitoring program that would provide such information.

Some of the vehicle stock in DPR of Korea is antiquated and has low combustion efficiency and little emissions reduction equipment installed. The environmental impact of this situation is minimized by the relatively low per-capita use of motorized vehicles in urban centers.

Ozone depleting substances and greenhouse gas emissions

The DPR of Korea is a party to the Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer, the United Nations Framework Convention on Climate Change, and the Kyoto Protocol. As part of its obligations under these agreements, DPR of Korea has made inventories of its sources of ozone depleting substances and greenhouse gas pollutants and has taken active steps to phase out the former and minimise the latter.

In 2007, DPR of Korea emitted a combination of greenhouse gases equivalent to about 94 million tons of carbon dioxide. That represented around 0.32 percent of the global emissions for that year. The primary source of greenhouse gas emissions in the DPR of Korea is the combustion of fuel (coal, oil and wood) for energy, primarily in electricity production and to a lesser extent in manufacturing and transportation. Fuel combustion accounted for 91 percent of emissions in 2007. Industrial processes, agriculture and waste related emissions made up the remainder. Emissions dropped significantly between 1990 and 2007 due to an economic contraction. Carbon sequestration from forests and land use fell over the same period due to forest conversion and deforestation. Emissions are projected to increase in the future as a result of increased economic output and population growth. The DPR of Korea hopes to minimize growth in its emissions by introducing new technologies and renewable energy, in part through participation in the Kyoto Protocol's Clean Development Mechanism or its successor.

Dust and sand storms

In addition to anthropogenic sources of air pollution, the DPR of Korea also experiences significant air quality disturbances from dust and sand storms originating in the desert regions of China and Mongolia where extensive deforestation and excessive use of water resources have occurred. Dust is carried over long distances by strong northwest winds gusting in the lower atmosphere.

Dust storms reduce visibility which affects aircraft and road transportation, and aggravate human respiratory conditions such as asthma and bronchitis. The dust can damage crops, interfere with industrial processes, contaminate waterways, increase sediment loads in waterways and may require the diversion of limited resources to clean up urban areas.

Recommendations

To address the issues mentioned above the following measures should be implemented.

- A comprehensive air quality strategy and implementation plan should be prepared and integrated into the national economic planning process. Air quality standards should be reviewed and established where absent. The strategy should set out a program to progressively reduce air pollution to meet target levels. The implementation plan should ensure that legal, institutional and financial measures of sufficient scale and scope are introduced in a timely manner.
- Clean production technologies should be encouraged through mechanisms such as emission permit systems and minimum technology standards. Emission standards covering both pollutant volumes and concentrations from industrial sources including boilers and industrial kilns should be enforced.
- National responses to reduce air pollution by motor vehicles should be strengthened. This would include improving the mass transportation system, encouraging the use of bicycles, introducing emissions limiting equipment and vehicles and

restricting the use of vehicles that discharge at excessive levels.

- Urban planning should prioritize pollution prevention and environmental protection in city development plans.
- Measures should be taken to reduce hazardous emissions from residential sources through improved cooking and heating technologies and the substitution of less polluting energy sources.
- Air quality monitoring should be expanded including developing inventories and databases of air pollution types and volumes by source. Research on dispersion rates and exposure levels should be conducted.
- Environmental Impact Assessments should be expanded to support decision making and avoid negative impacts.

7.4 Water

Water supply

Rapid economic growth has improved living standards in the DPR of Korea and increased demand for industrial, agricultural and potable water. Dams and reservoirs play important role in meeting the increasing in demand for water.. Some surface water is used to produce hydro-electric power. Industry consumes about 47.5 billion m^3 and domestic activities about 1 billion m^3.

The DPR of Korea is located in the East Asian monsoon region, giving it a humid summer and a dry winter-spring. This physical characteristic produces seasonal variation in the availability of water in rivers and streams. Precipitation is highest in July and August and more than half of the annual water flow volume occurs in rivers and streams in these months. In contrast, from December to March flows are much lower and represent a constraint on agricultural and industrial development. The shortage of water in spring can have negative impacts on the agricultural sector, particularly in the western and eastern low land areas. The primary challenge of water supply management is capturing water from heavy summer rains to avoid flooding and using the water during dry months when there are shortages. This has been partly achieved by the construction of dams and reservoirs.

Water quality

Water quality varies by location and also by season. Major rivers including the Taedong, Amnok, Tuman and Chongchon supply drinking, industrial and

agricultural water. However, the quality of these rivers has been reduced. The majority of water pollutants come from the discharge of industrial wastewater and untreated sewage, particularly in rural areas where facilities are inadequate or absent altogether. Runoff from agricultural land is another source of contaminants. Although industrial wastewater is a concern, the primary source of pollution is organic from human and animal waste. Deforestation has increased the sediment loads in waterways and has reduced the efficiency of treatment equipment. Without a comprehensive and integrated water management strategy, and investment in treatment and distribution services, the quality of water will not improve significantly. Population growth and industrial production will continue to increase the amount of wastewater and sewage entering waterways. The existing water quality monitoring program is limited and is unable to provide accurate information on the quality of water in different systems across the country.

Recommendations

- A comprehensive water quality strategy and implementation plan should be prepared and integrated into the national economic planning process. Water quality standards should be reviewed and established where absent. The strategy should set out a program to progressively improve water quality to meet target levels. The implementation plan should ensure that legal, institutional and financial measures of sufficient scale and scope are introduced in a timely manner.
- Integrated basin management strategies and plans should be prepared in order to manage water use and improve water quality in major rivers such as the Taedong, Amnok and Tuman.
- Groundwater utilization, control and supervision systems should be developed and the registration and permit system strengthened.
- A comprehensive water quality monitoring system should progressively be established that covers more areas and collects data on a broader set of water quality indicators. This should be supported by the creation and maintenance of a GIS database and distribution map to better protect and allocate water.
- The construction of large-sized hydro plants like Nyongwon, Wonsan Youth and Huichon Hydropower Plant should be promoted to store water and produce hydropower-using structures like Gaechon-Taesong Waterway and Mirubol Waterway. Expansion of dams and hydro-plants should be subject to Strategic Environmental Assessment (SEA) and Environmental Impact Assessments (EIA).
- Water consumption meters should be installed in agencies, enterprises and residences to improve water consumption monitoring and control and promote public participation in water conservation.
- Clean production and environmentally sound technologies should be introduced in factories and enterprises to reduce water consumption, wastewater discharge and energy use.
- Local wastewater purification plants should be constructed to meet existing shortcomings in domestic sewage treatment.
- Extensive reforestation and afforestation should be undertaken in degraded watersheds to reduce soil erosion and stream sedimentation.
- Action should be taken to remove the accumulated sediments from waterways including the Taedong River and Botong rivers.

7.5 Land, forest and soils

Deforestation and forest degradation

The DPR of Korea is mostly mountainous and has historically been covered in forests. In 2005, forested land covered 89,273 km^2 and the agricultural land 20,421 km^2. This relative scarcity of arable land has resulted in the conversion of certain forests to agricultural production in order to ensure adequate food for a growing population. This pressure has been exacerbated by a decline in soil productivity and a loss of agricultural land to residential and industrial areas, roads and other uses.

The quality and extent of forest cover has declined, especially since the mid-1990s when economic difficulties led to shortages of energy and food. Canopy cover and forest density have been affected by harvesting for fuelwood and building materials. The quality of many stands has also declined due to flooding, droughts, forest fires and pests. Reforestation efforts are underway to prevent the net-loss of forest cover and there are many examples of local successes including in the introduction of agroforestry on steep

slopes. Given that nearly three quarters of the rural population use wood as their primary fuel for cooking and heating, pressures on forest resources will continue until alternative forms of energy are introduced and food security improves.

Soil erosion and degradation

Agricultural top soil are being lost due to wind and water erosion. Soil depths have declined which has reduced agricultural productivity. In some coastal areas tideland rice fields are characterized by low nutrient soils and have declining silicon content from continuous freshwater irrigation. This has negatively affected soil dynamics. These fields have been cultivated for decades and have diminished productivity. Yields of grain from these fields have been reduced.

Soil contamination

In the DPR of Korea, land is usually not seriously affected by soil pollution. Laws exist to regulate waste from factories and enterprises and include requirements for site-based treatment of liquid waste. However, domestic waste and fly ash from cities are often applied to arable land around cities for the purpose of preventing soil acidification and to enhance soil structure. Sludge from wastewater treatment plants is used as an organic fertilizer. Urban waste and sewage result in soil contamination at some sites where they are applied.

Waste management

Economic growth in the DPR of Korea has resulted in an increase in production from factories and enterprises. Improved living standards have been associated with a trend towards consumerism and less durable products, which results in greater generation of waste. There is an urgent need to ensure the safe and sound disposal or treatment of waste and the appropriate reuse and recycling of recoverable waste.

Waste generated in the DPR of Korea is mainly comprised of industrial, municipal solid and hazardous materials. Industrial waste comes from the mining, metal, machine, electric power, coal, chemical, rubber, plastic manufacturing, textiles, paper and lumber, and building materials industries, as well as agriculture. Hazardous waste includes toxic and radioactive materials and biological waste from hospitals. Waste generated at production sites is collected and sorted for use in the manufacture of recycled products or mixed with raw materials to produce other products. Hazardous waste, such as heavy metals, is strictly controlled by national regulations. Municipal solid waste is collected and disposed of, or recycled, in landfill sites and fertilizer production plants. The reuse of municipal waste is currently constrained by the lack of appropriate technologies.

Coal ash is used as an input in the production of new building materials but is also mixed into soils to reduce acidity and improve the physical qualities of the soil. Organic waste and sewage sludge are used to produce

mulch, often without being treated. These practices are resulting in both chemical and bacterial contamination of agricultural soils. Soils closer to industrial areas and those that receive higher amounts of ash and organic amendments from municipal and industrial waste streams have higher levels of contaminants.

Recommendations

Forest conservation

- Deforestation and forest degradation have significant consequences for soil erosion, water infiltration and air purification, habitat quality, and carbon sequestration. Given the dominance of forests in the DPR of Korea and their contribution to economic, social and environmental integrity, preventing further forest degradation and undertaking large scale forest restoration is of critical importance and should continue. Attention should be given to rehabilitating vulnerable sites, including steep slopes and riparian zones. Agroforestry should be encouraged where steep slope agriculture is practiced. Dedicated plantation forests for fuel wood and construction material should be established to alleviate pressures on native forests. Encouraging afforestion should be emphasized. Research and capacity building for forest management should be accelerated including modernisation of nursery operations, and adoption of best international practice in pest and fire management and advanced harvesting techniques.

Waste management

- Measures should be introduced to control direct use of decomposable and untreated waste and sludge for mulch, including installation of waste fertilizer plants with organic waste separation and composting processes.
- Sanitary waste disposal guidance should be developed in order to prevent soil contamination by land filling or stockpile leakages.
- Integrated agricultural chemical management should be strengthened to control toxic agricultural chemicals such as DDT and HCB.
- Strict pollution control and technical measures should be taken to limit the introduction of chemicals from refineries, chemical factories and mines to the soil.
- Soil pollution monitoring should be expanded, and integrated with GIS database tools to identify contaminated sites and take appropriate measures.
- Integrated watershed management should be enhanced.
- Organic farming should be promoted including widespread use of organic fertilizer such as Hookbosan fertilizer and microbial pesticides, and crop rotation, etc. in particular organic fertilizer plants should be built in province and counties utilizing livestock waste and sewage sludge, etc.
- Sustainable land management issues should be included in regular educational curricula.
- Research on advanced land management technologies appropriate to local circumstances should be encouraged.
- Legislation and regulations on both hazardous and non-hazardous waste should be strengthened and more rigorously enforced. Strategies for integrated waste management should be reviewed and amended to improve all aspects of waste generation, collection, transport, treatment and disposal.
- Capacity for data collection and monitoring of waste generation and disposal should be improved and an inventory of waste materials, volumes, locations and type should be developed.
- The waste import licensing system should be expanded and the legislative and institutional framework strengthened to fulfill DPR of Korea commitment to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.
- Materials reuse and recycling should be encouraged but only where toxic materials have been removed from the waste stream and properly disposed of. Where possible, co-benefits should be pursued such as using waste to produce energy and composting organic waste as a soil amendment.

Box 7.1 Environmental Education and Awareness Activities

Capacity-building for environmental protection is fundamental to the successful management of environment.

In order to build human capacity and train experts in the field of environmental management, the government established a curriculum "Environment Engineering" at Pyongyang University of Construction and Building Materials (PUCBM) in 1985 and the Faculty of Global Environment Science at Kim Il Sung University in 2004. The curriculum at the Faculty of Global Environment Science provides students with courses in environment related subjects including the environment impact assessment, land planning and environmental management.

The environmental engineering program at the Pyongyang University of Construction and Building Materials is focused in technical engineering such as developing atmospheric pollution prevention technologies, wastewater treatment and bio-purification to remove contaminants from air, water and soil.

In the mid-1990s the government introduced environmental education into all universities and colleges. Students in environment related faculties carry out experiments and develop skills during the process of fellowship and joint research with relevant institutions and research centers including the Environment and Development Center (EDC).

Another example of environmental education in the DPR of Korea are the lectures provided by researchers in the academic institutions. Those who have PhD or masters degree are often invited to give lectures in universities or interviews on television.

Public awareness activities are usually topical, for example focusing on specific objectives such as biodiversity conservation, ozone layer protection and reducing atmospheric pollution.

The relevant agencies have also worked to introduce activities that have been shown to be effective in other countries in areas such as ozone layer protection. This includes periodic publication of the "Ozone Newsletter".

To increase the public awareness of dust and sand storm risks, programs explaining the potential hazards and appropriate responses are aired on radio and television. This is supplemented by teachers explaining the hazards and risks of the storms to children.

One of the largest challenges in environmental education and awareness in the DPR of Korea is that the professional knowledge of academics and others is not keeping pace with global best practice.

Capacity-building of academics and other experts is necessary as is increased attention to environmental education and extension activities.

- National and sub-national strategies should be developed to ensure that all new industry and infrastructure produces minimal amounts of pollution and existing equipment and facilities establish progressive pollution reduction targets and action plans to achieve them.
- Waste treatment facility output should be monitored against air, water and soil quality standards. Where these standards do not exist, they should be established. Investment in facility maintenance and new construction should be prioritized on the basis of greatest improvement to human and ecosystem health.
- Pollution should be reduced or eliminated at its source and toxic materials removed from the waste stream so that they do not contaminate materials destined for recycling and reuse.
- Investment in clean production technologies, particularly in energy and heat production should be emphasized.
- Air, water and soil monitoring programs need to be systematically reviewed and improved with a goal of increased coverage, effective data collection and management, and integration of the results into the policy and planning cycles.

7.6 Biodiversity

The DPR of Korea has rich biodiversity relative to its size and has niche ecosystems and species which are unique to the country. The dominant ecosystem type is mountainous forest which has been degraded by deforestation and climate change. This represents a significant threat to biodiversity in the country. Marine ecosystems and coastal tidal flats and wetlands are also important habitats for migratory birds of Northeast Asia. These areas are also under pressure from development and agriculture.
Unsustainable use of natural resources is closely related to population growth and the areas with serious biodiversity loss tend to be closer to human settlements. Fresh water systems are an example of this with water quality decreasing in proximity to settlements and industrial areas and in the lower reaches of rivers. This has negatively impacted freshwater biodiversity.

There are 2 extinct, 8 critically endangered, 46 endangered and 105 vulnerable species of animals in the DPR of Korea and 153 varieties of endangered plants. Although there is extensive legislation and regulations to protect biodiversity and manage natural resources, there remain rooms to enhance the response to prevent biodiversity loss. The system of protected areas that have been established do not represent the full spectrum of threatened species and habitats and are diminished by fragmentation and threatened by encroachment. Climate change is expected to exacerbate the situation.

Recommendations

- Efforts should be made to ensure that protected areas include a representative sample of ecosystem types and biodiversity, taking account of the influence of potential changes in climate.
- Connectivity should be provided between protected areas by way of wildlife corridors and riparian zones.
- An effective protected areas strategy will require improvements to the existing inventory of ecosystem types and biodiversity with consideration to their condition and relative abundance and emphasizing their vulnerability to threats.
- Action should be taken to bring underrepresented species under protection including within marine areas.
- Threats to biodiversity should be identified and plans established to manage them.
- The effectiveness of actions should be regularly monitored and evaluated and plans adjusted accordingly.
- Priority should be given to protection and conservation of areas of significant ecosystem service provision, and threatened or endangered biodiversity and to reducing encroachment on existing protected areas.
- The strategy should ensure the conservation of traditional Koryo medicines and the genetic diversity of agricultural seeds and livestock,

Box 7.2 Opportunities under the Kyoto Clean Development Mechanism

The DPR of Korea intends to develop renewable energy resources including solar, hydropower, wind and tidal energy to contribute to its commitment of reducing emissions under the UNFCCC. It established a Designated National Agency (DNA) in the November 2008 to oversee the information gathering and approval process for Clean Development Mechanism (CDM) projects in DPR of Korea.

The DPR of Korea has already developed a number of CDM Project Identification Notes and has completed several more detailed CDM Project Design Document drafts.

Given the current inefficiency in energy production, industrial processes and other areas there are many potential CDM investment opportunities by which Certified Emission Reduction credits could be earned. Some of these areas are listed below:

Electricity generation

- Design and construction of new hydro-power stations.
- Improvement of the generation efficiency of current hydro-turbines.
- Increases in hydro-electricity generation by more efficient use of water resources.
- Installing system for professional process management in combination with metering and auto-controlling.
- Supply side efficiency improvement of electricity generation and transmission.
- Converting pulverized coal boilers in to Circulating Fluidized Bed Combustion boilers.
- Improvement of energy efficiency by expanding co-generation facilities.

Energy efficiency improvement

- Modernizing old processes and facilities.
- Introducing a demand side energy management system based on metering, auto-controlling and usage analysis.
- Updating and improvement of air conditioning facilities such as motors, blowers and exhaust fans.
- Decreasing cooling and heating energy use in houses and industrial buildings by building design programs and installation of insulation and energy efficient windows.
- Decreasing fossil fuel consumption in cooking by use of heat insulation fireboxes and ignition coal technology.
- Decreasing electricity consumption of domestic electrical appliances including lamps, refrigerators and televisions.
- Improving efficiency of rolling stock such as trucks, tractors and tram cars.
- Automating control and signal systems, lubricant technology for rail and regeneration braking.
- Improving energy use by consumers by introduction card type watt-hour meters.
- Constructing energy saving houses.

Renewable energy

- Introduction of wind turbines and wind powered water pumps.
- Introducing tidal power generation.
- Expanding electricity generation by solar photovoltaic equipment, solar heat collectors, cookers, and solar heat ponds.
- Utilizing of livestock waste, municipal waste and industrial organic waste for fertilizer and methane energy production.
- Producing electricity from biomass gasification.
- Introduction more efficient biomass ovens and cookers.
-

Forests

- Afforestation and reforestation measures.

Box 7.3 Eco-friendly housing

Negative environmental impacts from the housing and construction sector can be reduced by implementing the concept of eco-houses and eco-cities. Using a life cycle approach, the buildings integrate economic efficiency, resource conservation, waste minimization, renewable energy use, ease of operation and maintenance and better access to community infrastructure, in order to improve the health and well-being of the residents.

Within this context, the government is encouraging the use of renewable energy for sustainable development and environmental protection through eco-housing initiatives. The development of eco-friendly houses was included in "DPRK's Five-year Plan for Science and Technology Development" adopted in 2002.

Eco-friendly houses were built in both urban and rural areas. A great effort has been made to use wind energy, solar active and passive concepts for space heating, and other energy saving measures such as insulation. Technologies were introduced to produce energy from biogas, harvest rainwater and produce organic fertilizer.

The country is now exploring how to implement an eco-friendly housing project with technical assistance from the United Nations Environment Programme (UNEP). Modern technologies will be applied to improve energy efficiency and lower greenhouse gas emissions. Successful components of the project will be replicated throughout the country.

The power system was combined with photovoltaic cells and a wind generator as shown below.

particularly native varieties, to promote resilience in the face of ecological change.

- Measures to control invasive and alien species should be taken.
- The use of Environmental Impacts Assessments should be strengthened to reduce development pressures on the environment.
- Natural resource management plans, particularly in the area of fisheries, forestry and agriculture need to be strengthened and integrated.

7.7 Climate change

Observations of climate change

Observations of long term temperature and precipitation trends in DPR of Korea suggest that the climate has changed over the last century with more rapid change occurring in recent decades. Over the period from 1918 to 2000 the average temperature increased by 1.9°C. This represents one of the fastest rates of warming among Asian countries. During the same period, extreme cold events have become less common while extreme hot events have increased in frequency. Abnormally high average summer temperatures of 23.8°C and 23.4°C were observed in 1994 and 1997 respectively.

Climate change is a significant concern since many human and environmental systems are already vulnerable to climate variability. Agricultural production is likely to be significantly affected by temperature and precipitation changes. One implication of the observed warming trend has been a decrease in the duration of winter, shallower soil freezing depth and an extension of the agricultural growing season. However, the benefits of a longer growing season may be more than offset by an increased incidence of high temperature events that coincide with low rainfall. Agriculture will also be affected by changes in the timing, frequency, location and intensity of precipitation. Floods and droughts over the past two decades have caused considerable damage and greatly reduced agricultural productivity. This has had disastrous effects on people's livelihoods and wellbeing and resulted in declines in the gross domestic product.

Heavy rainfall events have exacerbated soil erosion in areas where forest cover has been removed. This has led to the sedimentation of waterways and reservoirs, reducing water quality and increasing treatment costs. Flooding associated with heavy rain events has also caused considerable damage to infrastructure and affected living conditions of the people.

Forest quality is expected to be negatively affected by climate change due to warmer temperatures, more frequent extreme temperature and precipitation events, and an increase in forest fires, pests and diseases. This will have follow-on effects on local livelihoods and biodiversity. Given that much of the DPR of Korea is mountainous and forested, changes in the quality of forest ecosystems and warming at higher altitudes will alter species composition and disadvantage some flora and fauna. Many species that are already endangered will be at greater risk from changing climate conditions.

Projections of future change

An analysis of 21 global circulation model projections suggests that on balance precipitation will increase across the country. Projected increases are greater for higher emission scenarios and for dates further into the future. These projections range from increases of 5 to 31 percent by 2100. The change is not expected to be uniform across the region. Higher average precipitation could lead to increased flooding, landslides and mud flows if it occurs in the already wet summer months, or if it comes in the form of heavier rainfall events as has been observed in recent years. Extreme rainfall events are projected to increase in frequency.

Average, minimum and maximum temperatures are all projected to increase in the DPR of Korea. Projections of the change in temperature for the months of June, July and August suggest that average maximum temperature for the summer months will increase by between 0.46°C and 6.84°C depending on the emissions scenario and time period. Projected increases are greater for higher emission scenarios or for dates further into the future. The change is not expected to be uniform across the region. Higher maximum temperatures will place considerable stress on crops and livestock, human health, infrastructure and ecosystems such as forests and waterways. They could exacerbate drought stress and put pressure on water supplies when they are already scarce during the spring period. They could also lead to increased pest and diseases in crops and forests.

Adaptation to climate change

Ensuring that socio-environmental systems are resilient to climate change will require careful planning and adaptation. This will include developing crops and agricultural production methods that are capable of coping with greater extremes of temperature and precipitation, preparing health systems for new disease vectors and other impacts , upgrading infrastructure, reviewing the adequacy of protected areas and species in light of future climate conditions, and preparing a planned retreat from coastal areas that will be affected by sea level rise and coastal erosion. To date, a comprehensive analysis of adaptation needs and a strategy to build adaptive capacity have not been developed.

Recommendations

Mitigation

A national mitigation strategy should be developed that seeks to progressively decouple economic development from greenhouse gas emissions by investing in low carbon production, manufacturing, transportation and energy production technologies. This would include establishing clear sectoral greenhouse gas reduction targets and strategies to achieve them. In addition to reducing emissions, the mitigation strategy should place strong emphasis on restoring and enhancing forests, wetlands and other carbon sinks given the substantial co-benefits of this action including habitat restoration, ecosystem service provision and soil and water retention.

The following responses should be considered as part of a mitigation strategy:

- A national framework and institutional support structure should be strengthened to promote international investment in Clean Development Mechanism projects in the DPR of Korea.
- The DPR of Korea's Second National Communication to the United Nations Framework Convention on Climate Change should be completed and the inventory of greenhouse gas emissions and sources updated.
- Energy efficiency projects and renewable energy technologies should be promoted subject to Strategic Environmental Assessment (SEA) and Environmental Impact Assessments (EIA).
- Afforestation, reforestation and restoration of degraded areas including wetlands, grasslands, and coastal and riparian zones should be emphasized. Dedicated reforestation for the provision of fuel wood should be promoted where appropriate to avoid further clearing of native forests.

Adaptation

- To date, insufficient attention has been given to analysis of how existing vulnerabilities to climate variability will be exacerbated by climate change. As such, undertaking detailed assessments of risks related to agriculture, forestry, infrastructure, coastal communities and human health and evaluating the incremental risks posed by climate change should continue and be expanded. The findings of these studies should be used to prepare a national climate change adaptation strategy that identifies key risks in different areas that will occur over different time periods and formulates actions to minimize vulnerabilities. A central component of this strategy should be developing proactive measures to reduce incremental risks to existing vulnerabilities that are a likely to result from changing climate conditions.
- It will also be important to build adaptive capacity in government and communities to increase the resilience of socio-ecological systems.
- Actions to build adaptive capacity to address climate change will be similar to actions to build capacity for sustainable development generally: encouraging reflective institutions that learn from experience, introducing appropriate technologies, allocating adequate resources for adaptation, promoting public participation, combining systems-based approaches and integrated policy frameworks, introducing international best practice, developing multi-scale and inter-departmental partnerships, improving research

and access to information, pursuing no-loss and cobenefits strategies, restoring degraded ecosystems and enhancing ecosystem service provision, and preserving ecosystem and biological diversity.

- Climate change adaptation should be mainstreamed into planning at all levels to ensure that new developments and infrastructure will be able to cope with altered climate conditions including greater water flows and wind speeds, and more extreme temperature, precipitation and storm events and sea level rise. Generally, building to accommodate climate change at the outset will be less expensive and more effective than retrofitting at a later date. Consideration should be given to avoiding maladaptation by locking into path dependent technologies that will undermine long term sustainability.

Science and scenarios

- Proactive adaptation to climate change should be supported by research programs to document observations of climate change and progressively improve projections of regional climate change and its implications for human and environmental systems. This research should include mapping that combines climate change impacts with existing social, ecological and infrastructure vulnerabilities. Risk should be assessed as a combination of probability and consequence. Acceptable risk thresholds should be used to prioritize investment in adaptive measures. Research into the impacts of climate change on crops, livestock, forests, biodiversity and ecosystem services would also provide great value and form the basis for anticipatory adaptation actions.

7.8 Next steps

- Making effective use of the ECCO Report in environmental management in the DPR of Korea will require that the findings and recommendations of the report form the basis for planning and consultations across government agencies, with international organizations and with stakeholders in communities and industries. The proposed next step in this process is a series of consultations on the report to discuss its findings and determine how to address the various issue identified and make action plans to advance the recommendations.
- As previously indicated, the ECCO Report forms an important component in the environmental management cycle of planning, resource allocation, implementation, monitoring and evaluation and feedback. It is the iterative nature of this cycle that allows for improvements and institutional learning that produces better social, environmental and economic outcomes.
- The ECCO Report provides an opportunity to review the various dimensions of environmental management and cooperation across agencies, industry and communities to identify examples of best practice that should be replicated and potential barriers to progress that need to be overcome.

Planning practices which will utilize the findings of the ECCO include:

- Environmental strategy and action planning
- Forest management planning
- Biodiversity strategy and planning
- National climate change adaptation strategy and planning

In particular, the ECCO report results will be used in preparation of "Environment Protection Plan for the city Pyongyang" which is a demonstration plan for local province level environment planning in future. The results of the report will provide a basis for further strengthening the legislative framework for environmental management. The finding of the report will be used to identify a priority legislative area to be strengthened.

Public awareness and environmental education are important aspects of the application of the report's findings. Knowledge of and data on the environment state and trends, drivers and pressures needs to be used effectively for the preparation of references, books and mass media programmes.

Annexes

Annexes

Annex 1 References

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Annex 2 Climate change projection method

This annex provides a general introduction of SimClim climate model data generation method used by CLIMsystems Ltd. in the production of the regional climate change and extreme event scenarios in this report.

CMIP3 database of climate simulations

The dataset of experiments from 21 models (see Table A3.1 below) from research groups around the world is obtained from Coupled Model Intercomparison Project 3 (CMIP3) database (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php), representing a major advance for the evaluation of models and the generation of climate projections. The availability of a new set of systematic model experiments from the CMIP3 database represents a major advance both for the evaluation of models and the generation of climate projections. The database includes more than 21 models and more simulations of emission scenarios using each model. The model output is freely available to the research community, which has resulted in unprecedented levels of evaluation and analysis. The models in the CMIP3 database represent the current state-of-the-art in climate modelling, with generally more sophisticated representations of physical and dynamical processes, and finer spatial resolution. The CMIP3 database provides monthly mean temperature and precipitation data for all 21 models. Some models have single simulations for the 20th and 21st centuries, while others have multiple simulations (ensembles). For models with multiple simulations, ensemble-mean changes in climate have been computed. The simulations of 20th century climate were driven by observed changes in greenhouse gases and aerosols were used as baseline.

Generation of monthly precipitation and temperature patterns

Pattern scaling is based on the theory that, firstly, a simple climate model can accurately represent the global responses of a GCM, even when the response is non-linear (Raper et al. 2001), and secondly, a wide range of climatic variables represented by a GCM are a linear function of the global annual mean temperature change represented by the same GCM at different spatial and/or temporal scales (Mitchell, 2003, Whetton et al. 2005).
Pattern-scaling does not seem to be a very large source of error in constructing regional climate projections for extreme scenarios (Ruosteenoja, et al. 2007), however, in applying pattern-scaling, two fundamental sources of error related to its underlying theory need to be addressed: 1) Nonlinearity error: the local responses of climate variables, precipitation in particular, may not be inherently linear functions of the global mean temperature change; and 2) Noise due to the internal variability of the GCM. Based on the pattern scaling theory, for a given GCM, the linear response change pattern of a climate variable to global mean temperature change represented by the GCM, should be obtained from any one of its GHG emission simulation outputs. Pattern scaling may be described as follows: for a given climate variable V, its anomaly ΔV^{*} for a particular grid cell (i), month (j) and year or period (y) under an emission forcing scenario SRES A1B:

$$\Delta V^{*}_{yij} = \Delta T_{y} \cdot \Delta V^{'}_{ij} \qquad (1)$$

with ΔT being the annual global mean temperature change.

The local change pattern value ($\Delta V^{'}_{ij}$) was calculated from the GCM simulation anomaly (ΔV_{yij}) using linear least squares regression, that is, the slope of the fitted linear line.

$$\Delta V^{'}_{ij} = \frac{\sum_{y=1}^{m} \Delta T_{y} \cdot \Delta V_{yij}}{\sum_{y=1}^{m} (\Delta T_{y})^{2}} \qquad (2)$$

Where m is the number of future sample periods used, 10 year average as a period.

SRES A1B was used as a mid-range emissions scenario and was coupled with a mid-range IPCC (2007) climate sensitivity value. SRES A1B was used to represent the lower range of possible emissions scenarios and was coupled with a low-range IPCC (2007) climate sensitivity value. SRES A1FI was used to represent a higher end emission scenario and was coupled with a high-range IPCC (2007) climate sensitivity value. Together these emissions scenarios and climate sensitivity values combined with an ensemble of general circulation model patterns from leading international climate models allows for robust climate change projections including mid-range values and low and high extremes.

The global patterns are in 0.5 degree latitude * longitude grids interpolated from GCM original resolution, using bilinear interpolation method. The spatial resolution for country and local area are customized to fit the baseline climate data resolution.

Table A3.1 GCMs used in SimClim precipitation and temperature patterns.

No.	Originating Group(s), Country	Model	SimClim name	Horizontal grid spacing(km)
1	Bjerknes Centre for Climate Research, Norway	BCCR	BCCRBCM2	~175
2	Canadian Climate Centre, Canada	CCCMA T47	CCCMA-31	~250
3	Meteo-France, France	CNRM	CNRM-CM3	~175
4	CSIRO, Australia	CSIRO-MK3.0	CSIRO-30	~175
5	CSIRO, Australia	CSIRO-MK3.5	CSIRO-35	~175
6	Geophysical Fluid Dynamics Lab, USA	GFDL 2.0	GFDLCM20	~200
7	Geophysical Fluid Dynamics Lab, USA	GFDL 2.1	GFDLCM21	~200
8	NASA/Goddard Institute for Space Studies, USA	GISS-E-H	GISS—EH	~400
9	NASA/Goddard Institute for Space Studies, USA	GISS-E-R	GISS—ER	~400
10	LASG/Institute of Atmospheric Physics, China	FGOALS	FGOALS1G	~300
11	Institute of Numerical Mathematics, Russia	INMCM	INMCM-30	~400
12	Institute Pierre Simon Laplace, France	IPSL	IPSL-CM40	~275
13	Centre for Climate Research, Japan	MIROC-H	MIROC-HI	~100
14	Centre for Climate Research, Japan	MIROC-M	MIROCMED	~250
15	Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, Germany/Korea	MIUB-ECHO-G	ECHO---G	~400
15	Max Planck Institute for meteorology DKRZ, Germany	MPI-ECHAM5	MPIECH-5	~175
17	Meteorological Research Institute, Japan	MRI	MRI-232A	~250
18	National Center for Atmospheric Research, USA	NCAR-CCSM	CCSM—30	~125
19	National Center for Atmospheric Research, USA	NCAR-PCM1	NCARPCM1	~250
20	Hadley Centre, UK	HADCM3	UKHADCM3	~275
21	Hadley Centre, UK	HADGEM1	UKHADGEM	~125

Annex 3 Contributors

List of Participants of the National ECCO Consultation

DPR of Korea

№	Name	Designation
1	Song Se Il	Stuff, NCCE
2	Kim Yong Chol	Director, Department of Environment Protetcion, MLEP,
3	Kim Guang Ho	Head of Office, Department of Environment Protection, MLEP
4	Jang Chol Gun	Senior Official, Department of International Cooperation, MLEP
5	Bae Myong Hak	Scientific Secratry, EDC, MLEP
6	Ri Sol Jong	Head of Division, EDC, MLEP
7	Mun Nam Jun	Head of Division, EDC, MLEP
8	Han Jun Chol	Head of Division, EDC, MLEP
9	Kim Hyon Taek	Head of Division, EDC, MLEP
10	Ri Jong Suk	Head of Division, EDC, MLEP
11	Baek Ok In	Head of Division, EDC, MLEP
12	Kim Guang Chol	Head of Division, EDC, MLEP
13	Ri Mun Hyok	Researcher, EDC, MLEP
14	Rysng Song Il	Researcher, EDC, MLEP
15	Ri Gang Ho	Researcher, EDC, MLEP
16	Gang Nam Ho	Researcher, EDC, MLEP
17	Ri Myong Sun	Researcher, EDC, MLEP
18	Kim Chol	Researcher, EDC, MLEP
19	Ri Chol Ju	Researcher, EDC, MLEP
20	O Yong I	Researcher, EDC, MLEP
21	Jo Yun Mi	Researcher, EDC, MLEP

22	Kim Jong Ok	Researcher, Division of International Cooperation, MLEP
23	Kim Guang Pil	Researcher, Division of International Cooperation, MLEP
24	Son Guang Nam	Deputy Director, Institute of Land Planning, MLEP
25	Kim Won Ho	Head of Division, Institute of Land Planning, MLEP
26	Ri Ju Chol	Researcher, Institute of Land Planning, MLEP
27	Kim Sun Gil	Senior Official, Central Statistics Bureau
28	Sin Gunag Ho	Senior Official, Department of International Cooperation, AoS
29	Kim Hun	Head of Division, Institute of Thermal Engineering, AoS
30	Kim Ul Song	Head of Division, Institute of Thermal Engineering, AoS
31	Guak Man Su	Researcher, Institute of Thermal Engineering, AoS
32	Yun Chol Nam	Head of Division, Branch of Biology, AoS
33	Chae Sung Gil	Researcher, Institute of Botany, Academy of Forest
34	Ri Hak Chol	Researcher, Institute of Forest Management, AF
35	Ri Yong Jin	Head of Division, Institute of Forest Management, AF
36	Kim Su Hong	Instructor, Faculty of Geography, Kim Il Sung University
37	Kim Hyok Chol	Instructor, Faculty of Geography, Kim Il Sung University

United Nations Environment Programme (UNEP)

№	Name	Designation
1	Hendricus Verbeek	Senior administrator, Regional Office for Asia Pacific
2	Mahesh Pradhan	Programme Officer, Regional Office for Asia Pacific
3	Anna Stabrawa	Regional Coordinator, Regional Office for Asia Pacific
4	Purna Chandra Lall Rajbhandari	Senior Programme Officer, Regional Resource Centre for Asia Pacific

Preparation Committee for the ECCO Report

№	Name	Designation
1	Kim Yong U	Deputy-Secretary, NCCE
2	Song Se Il	Staff, NCCE
3	Jang Chol Gun	Senior Officer, Department of International Cooperation, MLEP

List of Contributors to the ECCO Report

DPR of Korea

№	Name	Designation
1	Jang Chol Gun	Senior Officer, Department of International Cooperation, MLEP
2	Jong Chang Gun	Deputy Dirctor, EDC, MLEP
3	Ri Sol Jong	Head of Division, EDC, MLEP
4	Han Jun Chol	Head of Division, EDC, MLEP
5	Baek Ok In	Head of Division, EDC, MLEP
6	Ri Mun Hyok	Researcher, EDC, MLEP
7	Ryang Song Il	Researcher, EDC, MLEP
8	Ri Gang Ho	Researcher, EDC, MLEP
9	Gang Nam Ho	Researcher, EDC, MLEP
10	Ri Chol Ju	Researcher, EDC, MLEP
11	O Yong I	Researcher, EDC, MLEP
12	Kim Chol	Researcher, EDC, MLEP

13	Jo Yun Mi	Researcher, EDC, MLEP
14	Ri Ju Hyok	Researcher, EDC, MLEP
15	Han Chol Nam	Researcher, EDC, MLEP
16	Kim Guang Pil	Researcher, Division of International Cooperation, MLEP
17	Kim Hun	Head of Division, ITE, AoS
18	Guak Man Su	Researcher, ITE, SAoS
19	Choe Song Chol	Researcher, ITE, SA0S
20	Yun Chol Nam	Head of Division, Branch of Biology, AoS
21	Bang Sun Nyo	Senior Officer, Hydrometeorological Bureau
22	Choi Bong Chol	Head of Division, Institute of Meteorology, Hydrometeorological Bureau
23	Kim Sun Kil	Senior Officer, CSB

International Organisations

United Nations Environment Programme

№	Name	Designation
1	Young-Woo Park	Regional Director ROAP
2	Anna Stabrawa	Regional Coordinator DEWA, ROAP Role: Technical support
3	Suho Seong	Senior Programme Officer, ROAP Role: Internal coordination
4	Christian Marx	Programme Management officer, ROAP Role : Administrative support
5	Jinhua Zhang	Programme officer, ROAP Role: Technical support
6	Purna Chandra Lall Rajbhandari	Environmental Affairs Officer, ROAP, Role: Project coordination and technical support

University of the Sunshine Coast, Australia

№	Name	Designation
1	Graham Ashford	Lecturer and Environmental Economist Role: ECCO Report Editor, Technical Advisor, Graphic Designer
2	Geoff Dews	Lecturer, Environmental Management and Marine Resources, Role: ECCO Report Technical Advisor
3	Bill Carter	Associate Professor, Heritage Resource Management Role: ECCO Report Technical Advisor
4	Tim Smith	Director, Sustainability Research Centre Role: ECCO Report Technical Advisor

CLIMSystems Ltd, New Zealand

№	Name	Designation
1	Peter Urich	Managing Director Role: Climate change scenarios analyst
2	Peter Kouwenhoven	Senior Scientist Role: Climate change scenarios modeller
3	Yinpeng Li	Scientist Role: Climate change scenarios modeller
4	Wei Ye	Scientist Role: Climate change scenarios modeller
5	Matthew Dooley	Head of software development Role: Climate change scenarios modeller

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