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Strategies to Comply with the Kyoto Protocol in Korean Agricultural Sector

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FOREWORD

Ever since the IPCC evaluation reports on greenhouse effect were announced, most of the nations designated reduction of greenhouse gas as top priority project. With respect to execution of Kyoto Protocol in which a nation should mandatorily reduce greenhouse gas as to each nation's circumstances, Korea is exempt from the mandatory reduction until 2012, it becomes highly probable that the country would need to perform mandatory reduction from the second phase starting in 2013. Thus, appropriate countermeasures for reduction of greenhouse gas by each industrial sector become confronting matters. In the agriculture sector, due to increase in number of breeding livestock, methane gas is expected to be increased in livestock industry whereas arable farming sector is expected to generate less greenhouse gas due to decrease in cultivated land and expansion of environment-friendly farming. Actual execution of reduction of greenhouse gas as a whole will yield to provide new opportunity and challenge.

This report as a follow-up research for *Impact of United Nations Framework Convention on Climate Change on Agricultural Sector* published in 2006. Benchmarked major countries'examples on preparation for reduction of greenhouse gas, it proposes counter-strategy by stage including roadmap and core action plans in agricultural sector. By all means, I expect this report to contribute to establishment of counter-strategy in agricultural sector as per *the United Nations Framework Convention on Climate Change*.

I would like to specially thank everyone involved in this report including professor Kim Man-Keun at University of Nevada, Dr. Jason Anderson, senior fellow at Environment Institute of EU, professor Cho Yong-Sung at Korea University, and Mr. Baik-Hee, at Ministry for Food, Agriculture, Forestry and Fisheries contributed as research consultants.

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Abstract

Strategies to Comply with the Kyoto Protocol in Korean Agricultural Sector

The comprehensive consideration of the internal and external changes in conditions pertaining to the post-2012 Kyoto Protocol scheme indicates that Korea is highly likely to be mandated to reduce greenhouse gas emission from the second commitment period (2013~2017). In the agricultural sector, greenhouse gas emission has been on the decrease, and it also has carbon sinks. Therefore the new emission cut mandate under the Kyoto Protocol to Korea could serve as a good opportunity depending on how we are reacting. This study is a follow-up of the analysis of the impact of the Kyoto Protocol implementation on the agricultural sector and has the purpose of presenting systematic and step-by-step responding strategies in preparation for the implementation of the Kyoto Protocol.

In the introduction of the report, the need of the study, purpose and scope of the study, review of literature, and analytic methods are described. Chapter 2 explains the details of the Kyoto Protocol and the implementation mechanism, discussion trends and forecasts of the Post-2012 scheme. Chapter 3 takes a look at the greenhouse gas emission in the agricultural sector and management means. Chapter 4 analyzes the impact of the mandatory greenhouse gas emission cut on the agricultural sector and the potential capability of greenhouse gas reduction by emission cut means. The impact on the agricultural sector is briefly summarized using the result of the first year analysis. Chapter 5 shows the examples of reactions by major countries related to the implementation of the Kyoto Protocol including Japan, Denmark, German, Britain, and the United States. Chapter 6 sets forth the agricultural sector's basic direction of reactions to mandatory reduction, practical strategies, and core tasks. Lastly, Chapter 7 delivers summary and conclusion.

The highlights of the study are summarized as follows:

First, the participation of the agricultural sector in the emission trading program

is found to increase earnings and boost national economy. If carbon tax is imposed, in the short term, facilities plastic vegetable gardening and horticultural sectors, which are highly dependent on fossil fuels, will be put under great pressure of increasing management costs.

Second, regarding mandatory emission reduction under the Kyoto Protocol, major countries (Japan, the United States, Denmark, German, and Britain) have marked significant achievements with the agricultural sector's voluntary participation to meet the goal of greenhouse gas reduction. Except for Denmark among the concerned countries, the proportion of the agricultural sector in the greenhouse gas emission is less than 7%, but the agricultural sector takes up a large portion of methane and nitrogen dioxide emission. These countries do not require the agricultural sector to manage their greenhouse gas emission in the form of mandatory requirement. Instead they encourage the agricultural sector to adjust and manage the greenhouse gas generated on the self-regulatory basis. Representative measures taken by the agricultural sector of these countries to cut greenhouse gas emission include facility support, fostering organic farming, utilization of bio-energy, R&D, and adaptation that can be benchmarked by Korean establishing its measures.

Third, the local study that has been conducted so far concludes that the agricultural sector's greenhouse gas emission cut technologies have the potential to achieve substantial amount of emission cut. The core technologies of emission cut are related to the methane reduction through intermittent irrigation, reduction of nitrogen dioxide in nitrogen fertilization, the use of organic carbon in soil, the cultivation of bio-energy crops, in-premise fermentation in the livestock sector, and improvement of livestock manure treatment facilities, and they are found to have the potential to make considerable contribution to greenhouse gas emission cut.

Fourth, systematic and step-by-step strategies for the agricultural sector are presented regarding the implementation of the Kyoto Protocol. In relation to this, five basic strategic directions are proposed including using the implementation mandate as an opportunity to build the sustainable agricultural system; proper combination between agricultural policy and greenhouse gas reduction policy; active and proactive response to internal and external negotiations; scientific analysis of greenhouse gas emission and absorption volume; and adaptation to global warming. Practical strategies will be in place under the three-step approach by period. The first period of 2008 to 2012 period will lay down the foundation. The second period of 2013 to 2018 will make a leap forward, and the last period of 2019 to 2030 will cement and finalize the achievements obtained so far.

Fifth, the core tasks of practical strategies are presented. They include the active pursuit of the 4th comprehensive measures of responding to climate change, the program development for active use of the Kyoto mechanism, the fostering of sound organic farming, continuous effort in the adaptation sector, the systematic R&D efforts, and the establishment of the integrated greenhouse gas management system.

Lastly, with the global warming emerging as a hot issue at home and abroad, the agriculture should be recognized as an infrastructure industry for effective management of greenhouse gas emission. To this end, dedicated personnel and organization should be expanded, and proper role sharing and use of experts among related organizations should be sought for active participation in the discussions on national tasks setting for climate change management.

The study does not estimate marginal costs by greenhouse gas reduction means and does not determine the priority among policy measures. These areas should be covered by future studies. In addition, an empirical study needs to be conducted to estimate actual reduction volume by applying the economic engineering method and the cost effective analysis by reduction means.

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Chapter 1. Introduction

1. Necessity of the Study

Before the Industrial Revolution, the carrying capacity of Earth and the amount of greenhouse gas emissions were kept in balance. Since the Revolution, however, the balance has been lost along with the rapid increase of greenhouse gases, mostly carbon dioxide, from the use of fossil fuels. The remarkable development of science and technology and the subsequent economic growth and increase of population have contributed to the improvement of the quality of human life, and the global environment which is the basis of human livelihood is now facing a difficult situation that cannot be solved solely by the carrying capacity of Earth. According to the *Intergovernmental Panel on Climate Change (IPCC)* under the auspices of the United Nations, if mankind keeps depending on fossil fuels such as oil and coal for their living, the Earth's mean temperature would rise by up to 6.4℃ and the sea level by up to 59㎝ by the end of the 21st century (2090~2099) (IPCC, 2007a). The IPCC announced in its analysis report that the Earth's mean temperature has risen by 0.74℃ for the past one hundred years (1906~2005). It presented analytical results that the probability of global warming caused by human activities is more than 90%. According to the analysis using a global meteorological forecasting model, it is expected that the Earth's mean temperature would increase by 1.8~4℃ by 2100 and that the Arctic glaciers would melt away; weather disasters such as scorching heat waves and downpours would become frequent; and tropical storms would become stronger. As such, it warns against the situation that if the Earth's mean temperature rises by 1.5~2.5℃, 20~30% of animal and plant species would be endangered and 77~200 million people in Africa would face a serious food crisis and lack of water by 2020. The IPCC report stressed that, in order to prevent global warming, CO_2 emissions should be reduced to 50~65% of 2000 levels by 2050.

In Korea, the global warming phenomena have become visible with the temperature rising higher than the world average rise, having impacts on the agricultural sector. With regard to greenhouse gas concentrations in Korea, CO_2 emission was 389ppm, which was higher than the world level of 379ppm. The mean temperature appeared to have risen by 1.5℃ since 1900 and by 0.6℃ from that of recent years (1971~2000). As such, the global warming has visible impacts on the agricultural sector of Korea including the seasonal changes of shortened winter and extended summer and changes in the flowering season and major producing areas of agricultural products (apples, green tea, tangerines, etc.) going north.

As an international measure to reduce greenhouse gases, the *United Nations Framework Convention on Climate Change* (UNFCCC) was adopted in June 1992. Following the UNFCCC, the *Kyoto Protocol* was adopted in 1997 as a concrete enforcement guideline for all countries of the world to decide who, how much, and how to reduce greenhouse gases, and officially took effect on February 16, 2005. The *Kyoto Protocol* requires developed countries (Annex I parties) to reduce their greenhouse gas emissions by an average of 5.2% below 1990 levels during the first commitment period (2008~2012), with different targets set for individual countries between -8～10% depending on their economic circumstances. Korea joined the UNFCCC in December 1993 as the 47th member and ratified the Kyoto Protocol of the UNFCCC in 2002. Having secured the status of a developing country (non-Annex I party) under the *Kyoto Protocol*, Korea does not have the obligation to reduce greenhouse gas emissions during the 1st commitment period. Whether Korea is going to participate in the mandatory greenhouse gas reduction or not during the 2nd commitment period (2013~2017) will be decided at the *Conference of the Parties* concerned. As a country ranking ninth in the world in greenhouse gas emissions as of 2004 and an OECD member, Korea will mostly likely be pressured by the international society to participate in the mandatory greenhouse gas reduction from the 2nd implementation period. By 2009 when the Post-2012 scheme will be established, all countries of the world will keep developing intense negotiation strategies to secure their own interests in the carbon market that will control their future national competitiveness.

Though it might be considered as an enforcement directive of the UNFCCC, the

Kyoto Protocol has a strong character of an economic agreement in that it has significant impacts on the national economy including production and consumption activities. Greenhouse gas generation is directly and indirectly related to a great many industrial activities. So, when mandatory greenhouse gas reduction under the *Kyoto Protocol* is actually implemented, it would have significant impacts on the agricultural sector. In particular, the agricultural sector has both a positive aspect of reducing greenhouse emissions and a negative aspect of increasing the emissions. Therefore, depending on how to comply with the UNFCCC, it might work either as a threat or as an opportunity for the agricultural sector.

In response to the UNFCCC, the government has established and operated government organizations such as the *Committee on Climate Change* (chaired by the Prime Minister) and related ministerial meetings. It has also established and implemented comprehensive measures against climate change since 1999. The government already spent USD 16,484 for the 3rd comprehensive measures (2005~2007) against climate change and is working out the 4th comprehensive measures for the period starting from 2008 (2008~2012).

With regard to the future implementation of the *Kyoto Protocol*, the agricultural sector can take it as a good opportunity because its greenhouse gas emission tends to decrease and it may contribute to emission reduction by providing greenhouse gas sinks. On the other hand, when mandatory greenhouse gas reduction is imposed resulting in the enforcement of relevant policies such as emission trading scheme, carbon tax, and regulations on energy use, it would have significant impacts on the cost of agricultural production, distribution of agricultural resources, and farm household income. Therefore, it is necessary to develop appropriate measures to comply with the *Kyoto Protocol*.

2. Purpose and Scope

This study is a follow-up study of the analysis of impacts of the UNFCCC on the agricultural sector for the purpose of presenting systematic and effective step-by-step measures for the agricultural sector to comply with the Kyoto Protocol.

The scope has been set to the agriculture and livestock sector. For the analysis of greenhouse gas emissions from the agricultural sector, methane and nitrous oxide were selected but carbon dioxide was not included. With regard to greenhouse gas emissions, methane was evaluated separately for paddy rice in the arable sector and rumen fermentation in the livestock sector, and nitrous oxide was estimated based on the usage of nitrogenous fertilizers and the decomposition of livestock manure. The carbon dioxide produced from fossil fuels and used for operating agricultural machinery and heating horticultural facilities was excluded from our study as it was not included as a source of greenhouse gas emission in the agricultural sector of Korea when the UNFCCC National Communication was prepared. The analysis of greenhouse gas sinks in the agricultural sector was limited to soil organic carbon that was officially recognized by the IPCC.

3. Review of Previous Studies

3.1. Studies on Measures to Comply with the Kyoto Protocol in the General Industry

In the overall industry, a great deal of research on the development of measures to cope with the Kyoto Protocol has been made. Based on the results of studying examples of major countries in search of measures to comply with the UNFCCC, Cho *et al.* (2002) suggested institutional improvement plans including plans to diagnose the problems of the Korean organization in charge of implementing comprehensive measures and proposing a bill on countermeasures against global warming.

Regarding the establishment of comprehensive national measures to comply with the UNFCCC, Lee *et al*. (2003) tried to analyze the measures to comply with the Kyoto Protocol and the emission allocation plan, evaluate the measures for emission reduction using an econometrics simulation model, and analyze systems and institutions to comply with the UNFCCC in major countries such as the UK, Germany, France and the Netherlands. In addition, Bang *et al*. (2004) evaluated the measures for emission reduction and estimated the potential of reduction in each sector with regard to establishing mid/long-term policies and strategies to comply with the UNFCCC. They presented an optimum combination of cost-effective policies for each reduction stage by establishing macro-policies for reducing greenhouse gas emissions and detailed implementation policies for each sector.

In their study to build up bases for preparing the 3rd National Communications for the UNFCCC, Im *et al*. (2004, 2005) presented statistics and forecasts on greenhouse gas emissions, an analysis of the effects of emission reduction policies in each sector, forecasts on each carbon reduction scenario, plans to build up a system to adapt to climate change, education plans for the UNFCCC, and plans to improve the PR system. Especially in his third-year study, Im *et al*. (2006) suggested a methodology to analyze the effects of various policies and measures to reduce greenhouse gases.

3.2. Study of Measures to Comply with the Kyoto Protocol in the Agricultural Sector

Until the mid-2000s, studies of measures to comply with the Kyoto Protocol in the agricultural sector had focused mostly on technology development.

With regard to the preparation of the National Communication on the UNFCCC, Yoon (1995) presented characteristics of greenhouse gas emissions from the agricultural sector, methods to estimate methane emission from rice fields and nitrous oxide emissions from the use of nitrogenous chemical fertilizers, and technologies to reduce greenhouse gas emissions. Tak (1995) estimated methane emissions from rumen fermentation, evaluated methane emission reduction technologies and reduction potential of each technology, and presented policy programs to reduce methane emissions in the livestock sector.

To study the policies for complying with the Kyoto Protocol, Yang *et al*. (2005, 2006) examined programs to utilize the carbon emission trading scheme as a new source of revenue for the agricultural sector with regard to greenhouse gas reduction. They also presented plans to link Clean Development Mechanism (CDM) projects with the agricultural policy of production mediation system. Im, *et al*. (2006) tried to analyze the effects of greenhouse gas reduction policies in the agriculture and livestock sector. Using a functional formula based on production activities and prospects of the arable sector, he calculated the effects of greenhouse gas reduction measures and, concerning the livestock sector, he analyzed the effects of technological measures against rumen fermentation and livestock manure decomposition. Kim, Kim and Shin (2006) measured economic impacts of the UNFCCC on the agricultural sector using a dynamic CGE model. In their study, they suggested that if the mandatory greenhouse gas reduction by 5% below 2000 levels was imposed from 2013, emissions from the arable sector would be reduced below the allowable cap after 2013, resulting in surplus emissions that could be available for emission trading.

3.3. Study of Foreign Agricultural Sectors to Comply with the Kyoto Protocol

In the USA, Canada and the EU, in-depth studies to develop measures to comply with the Kyoto Protocol in the agricultural sector have been made actively in various fields.

Clark et al. (2001) examined the effects of agricultural techniques and technologies developed to mitigate emissions of nitrous oxide, methane and carbon dioxide from the agricultural sector, and evaluated their potentials for emission reduction. According to the result of this study, the effects of reduction could be observed in preservative agricultural techniques, reduction of number of cattle, and improvement of fertilizer efficiency, but there are still many temporal and spatial limitations in evaluating accurate mitigation effects. Schneider and McCarl (2002) analyzed various greenhouse gas reduction strategies available for farmers and livestock farmers in the

US, using an agricultural sector model. They also evaluated the potential to reduce greenhouse gas emissions in the US agricultural sector by building up an account for the agricultural environment completely separated from the external environments. According to their study, the US agriculture could make some contributions to greenhouse gas reduction, but the total reduction rate seemed to be very sensitive to the carbon price. Feibauer et al. (2004) analyzed the carbon storage potential that is technologically and economically feasible for the arable lands in the EU for the period between 2008~2012. They estimated the carbon capture capacity of each available carbon capture method per unit area of the arable land and analyzed the impacts of the methods on the environment and rural household income. In this study, they presented increased use of organic fertilizers, conservation of fallow lands, introduction of perennial trees and plants to produce bio-fuels, practice of no-tillage or less-tillage farming, and expansion of organic agricultural techniques as the most effective measures to enhance the carbon storage capacity of soil.

In his study of measures to comply with the Kyoto Protocol in Canada, Duke (2006) tried to analyze the effects of nourishment control on greenhouse gas reduction in both arable and livestock sectors in the Temperate Zones. Based on this analysis, he analyzed and presented the effects of nourishment control, livestock manure control, and various greenhouse gas reduction measures. With the households doing both arable and livestock farming in Canada, Smith and Upadhyay (2005) calculated the cost of diminishing marginal utility of each greenhouse gas reduction measure, using linear programming (LP). According to their study, though available methods of reducing greenhouse gas emission from those farms were limited, such farm control methods as no-tillage direct sowing and discontinuation of summer set-aside fields could be very effective and cost-saving in terms of technical convenience for carbon storage. For livestock farming, however, they suggested that there were a very limited number of cost-effective measures for greenhouse gas reduction except reduction of livestock numbers.

3.4. Differences between Previous Studies and This Study

Previous studies were mostly done as basic studies for the introduction of carbon emission trading scheme as a measure to comply with the mandatory greenhouse gas reduction under the UNFCCC and the Kyoto Protocol. On the other hand, this study focuses on presenting national measures in the agricultural sector based on the analysis of economic impacts of the UNFCCC on the agricultural sector (the 1st-year study).

This study tries to establish basic policies and present substantial policy programs, focusing on mid/long-term measures to comply with mandatory greenhouse gas reduction in the agricultural sector under the Kyoto Protocol for the period of 2013-2030.

4. Methods and Contents of the Study

In the 1st-year research to establish measures to comply with the Kyoto Protocol in the agricultural sector, Kim et al.(2006) established greenhouse gas reduction scenarios and examined their impacts on the agricultural sector. Using a dynamic computable general equilibrium (CGE) model, they evaluated the impacts of mandatory greenhouse gas reduction on each industrial sector, and estimated the cost of greenhouse gas reduction. Also, using a partial equilibrium model, they evaluated the impacts of carbon tax on paddy rice and on horticultural, floricultural and livestock sectors (Kim, Kim and Shin, 2006).

For this study, the 2nd-year research focusing on establishing measures to comply with the Kyoto Protocol in the agricultural sector, we reviewed the literature on establishing measures against the UNFCCC, including the reports by the Ministry of Agriculture and Forestry, the Rural Development Administration, the National Institute of Animal Science, and research papers by research organizations and academic circles such as Korea Energy Economics Institute and Korea Environment Institute.

In order to establish measures to comply with mandatory greenhouse gas reduction from 2008 under the Kyoto Protocol, we visited Japan (September 17~20, 2007), examined the background of "General Strategy of the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan to Cope with Global Warming" announced in June 2007, collected data about specific strategies, and had interviews with policy makers and related experts.

To reflect the experts' opinions in the measures to comply with the Kyoto Protocol in the agricultural sector, we collected the opinions presented and discussed at the *Advisory Committee on Climate Change* organized under the MAF. In addition, a road map of implementation strategies for R&D was drawn based on the opinions collected from the keynote speeches of relevant experts at the seminars on global warming hosted by the Rural Development Administration.

Especially in order to establish effective measures, we asked an expert at CDM (Mr. Han Seungho, CDM Certification Office, Korea Energy Management Corporation) to write an article proposing policies and measures concerning utilization of the Kyoto Mechanism in the agricultural sector. Also, in order to benchmark major countries' measures to comply with mandatory greenhouse gas reduction, we asked Prof. Kim Man-Geun of University of Nevada in USA to write an article on "the policies and measures to reduce greenhouse gas emissions in the agricultural and forestry sectors of the USA" and Dr. Jason Anderson of Institute for European Environmental Policy on "the measures to comply with the Kyoto Protocol in the agricultural sector of the EU" (for 3 member countries of the EU: Denmark, Germany, and UK). Regarding the Japanese measures against global warming, we used information collected through the overseas researches by the MAFF and Agricultural Environment Technology Institute. Collected articles and the comprehensive measures of the MAFF of Japan against global warming were compiled into "*Countermeasures for Confronting the UNFCCC in Major Countries' Agricultural Sector*" (Kim, Kim, and Lee, 2007).

This research report is composed of the following contents: Chapter 1, which is the introduction of this report, presents the necessity of this study, the background, purpose and scope of the study, a review of previous studies; and methods of this study. Concerning the research methods, the methods and contents of the 2nd-year research are illustrated in a flowchart along with a brief comment on the analysis method for each field <Figure 1-1>.

Chapter 2 presents the contents of the Kyoto Protocol, the Kyoto Protocol implementation mechanisms, and the trend and prospect of the Post-2012 scheme.

Chapter 3 describes the actual conditions of greenhouse gas emissions in the agricultural sector and the measures of emission control. In this Chapter, the actual conditions of greenhouse gas emissions in Korea are examined and analyzed, and the prospect of future emissions is estimated. Also, greenhouse gas reduction measures are outlined and the key measures for greenhouse gas emission control presented in the Kyoto Protocol are described.

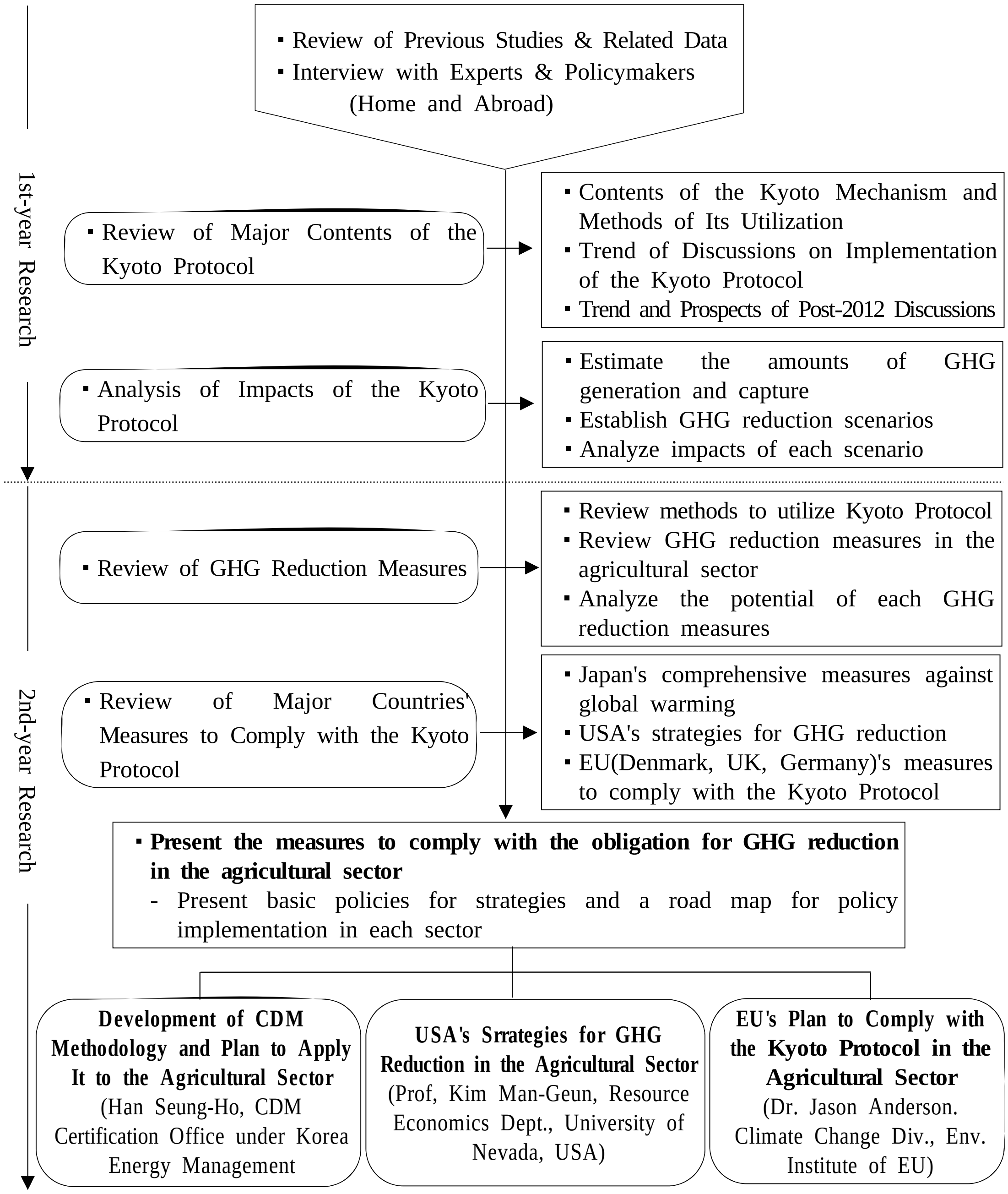
Chapter 4 analyzes the impacts of mandatory greenhouse gas reduction on the agricultural sector and the potential of each one of greenhouse gas reduction measures. With regard to the impacts on the agricultural sector, the results of the 1st-year research are briefly summarized. To evaluate the potential of greenhouse gas reduction, core greenhouse gas reduction measures in the agricultural sector are analyzed.

Chapter 5 presents examples of how major countries comply with the Kyoto Protocol. In this Chapter, examples of Japan, Denmark, Germany, UK and USA on which reduction objectives will be imposed from 2008 are examined.

Chapter 6 proposes measures to comply with the obligation of reducing greenhouse gas emissions in the agricultural sector. Described here are basic policies for establishing the measures, approaches to implementation strategies, and key problems in implementing the strategies.

Lastly, Chapter 7 presents a summary and conclusion, together with limitations of this study and brief suggestions for future research.

Figure 1-1. Flowchart of Research Methods



Chapter 2. Contents of the Kyoto Protocol and Trend of Post-2012 Discussions

1. Major Contents of the Kyoto Protocol

The UNFCCC aims ultimately at stabilizing greenhouse gas concentrations in the atmosphere so that dangerous and anthropogenic influences may not affect the climate system. It contains basic principles of equity in the obligation of greenhouse gas reduction based on "common but differentiated" responsibility and respective capability, cost-efficiency, implementation of measures to prevent climate change, and guarantee of sustainable development.

The UNFCCC was substantiated by the Kyoto Protocol in 1997. As detailed rules for its implementation were adopted in November 2001 at the 7th Conference of the Parties (COP7) concerned with the UNFCCC, the mandatory greenhouse gas reduction regime was established, requiring Annex I parties to reduce their greenhouse gas emissions by an average of 5.2% below 190 levels during the period of 2008~2012.

The Kyoto Protocol is a protocol annexed to the UNFCCC, which requires Annex I countries to reduce greenhouse gas emission levels. It is a legally binding international agreement by which the COP3 commits each developed country to a target to reduce greenhouse gas emission level on the ground of basic principles of the UNFCCC. Under the UNFCCC, Korea is classified as one of non-Annex I countries which are required to prepare and submit national reports containing statistics on their greenhouse gas emissions and progress of its implementation of the Convention. The country is exempted from the burden of greenhouse gas reduction specified in the Kyoto Protocol.

With regard to the mandatory greenhouse gas reduction, the Kyoto Protocol outlines specific activities for climate protection, consisting of a preamble, 28 articles and

2 annexes.

The Kyoto Protocol presents in detail definitions of major terms contained in the Convention, policies and measures for greenhouse gas reduction, reduction commitments for Annex I countries, common fulfillment of the reduction commitments, greenhouse gas calculation methods, preparation and submission of national communications, obligations of the Parties concerned, Kyoto Mechanisms for flexible implementation of the obligations under the Convention, reduction target for each developed country, and categories of greenhouse gas sources in each industrial sector.

The Kyoto Protocol clarifies the concepts of greenhouse gas source and sink. The Protocol defines greenhouse gas sources in the agricultural sector as any processes or activities that release greenhouse gases and these include rumen fermentation, compost management, rice farming, arable lands, scheduled incineration in the pasture, and incineration of remnants of farming on arable lands. As for the sinks that reduce global warming by removing or capturing greenhouse gases from the atmosphere, it presents land use, land-use change and forestry activities (LULUCF). Likewise, it presents the concept of reservoir, which measures a component or components where carbon can be stored, such as soils and the seabed.

Also, the Protocol presents various policies and measures for greenhouse gas emission reduction and these include the following: enhancement of energy efficiency; protection and enhancement of greenhouse gas sinks and reservoirs; promotion of sustainable forest management practices, afforestation and reforestation; promotion of sustainable forms of agriculture; research, promotion, development and increased use of new and renewable forms of energy, carbon dioxide storage technologies, and innovative and environmentally sound advanced technologies; progressive reduction and phasing out of fiscal incentives, tax reductions and exemptions and subsidies; and encouragement of waste recycling and international cooperation (Article 2 of the Kyoto Protocol).

In the agriculture, forestry and waste management sectors, the Protocol requires the formulation, implementation, publication and regular updating of appropriate regional programs containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change.

For the monitoring of the Parties' compliance with the commitments of the

Convention, the Compliance Monitoring Committee was organized with Facilitative Branch and Enforcement Branch. The Facilitative Branch aids and supports the Parties in complying with their commitments, while the Enforcement Branch takes appropriate measures against those who are not in compliance with their commitments.

2. Kyoto Protocol Implementation Mechanism

Recognizing that there are limitations for developed countries to implement greenhouse gas reduction commitments under the Kyoto Protocol in their countries, the Protocol gives a certain degree of flexibility in meeting their greenhouse gas emission targets by introducing Kyoto mechanisms including emission trading and joint implementation.

In order to help Annex I countries achieve their greenhouse gas reduction targets at the lowest cost, the Kyoto Mechanism allows three market-based mechanisms of international cooperation and these are Joint Implementation (JI), Clean Development Mechanism (CDM), and Emission Trading (ET).

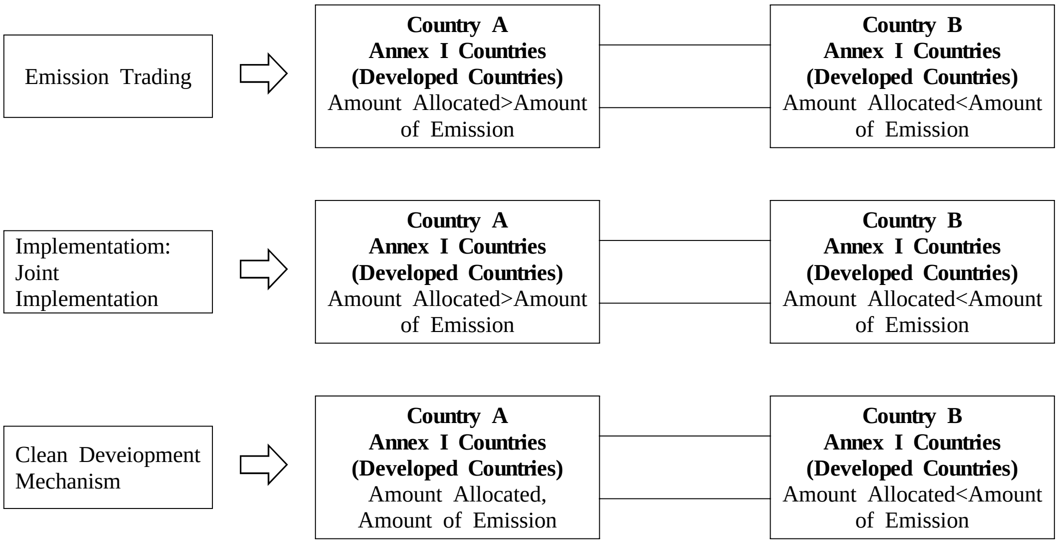
JI is a mechanism by which developed countries with emission reduction targets invest in greenhouse gas reduction projects and count the resulting Emission Reduction Units(ERUs) towards meeting their own target.

CDM is a mechanism by which the governments and private organizations of Annex I countries implement greenhouse gas reduction projects in developing countries and in return secure the right for emission trading in the form of Certified Emission Reductions (CERs). It promotes sustainable development of developing countries while assisting developed countries in efficiently reducing greenhouse gas emissions.

ET is a mechanism that gives Annex I countries emission quotas and allow them to trade among them.

JI and ET will take effect from 2008 and only Annex I countries can participate and CDM has been in force since 2000 and developing countries including Korea participate.

Figure 2-1. Operating System of the Kyoto Mechanism



The amount of greenhouse gas reduction can be determined either by a top-down approach or by a bottom-up approach. In a top-down approach, the government determines reduction target by calculating the reduction potential based on macro-economy index, while in a bottom-up approach the host of reduction calculates on its own the amount of reduction in the corresponding sector based on micro-economy and establishes its own reduction plan. Most developed countries adopt a top-down approach according to political decisions. In principle, in order to implement a top-down approach, an intermediate-level representative organization or agency that will establish plans for each sector is needed in addition to a long period of preparation.

Should Korea be bound by the obligation under the Protocol in the 2nd commitment period starting from 2013, the method of establishing the reduction target to be applied during this period will have significant impacts on the cost of compliance with the Protocol. So, profound review and discussions on a method of burden sharing appropriate for the actual circumstances of Korea are required. With regard to meeting the emission reduction target during the second commitment period, various burden sharing methods such as continuation of the Kyoto Mechanism, intensity method, approach by policies and measures, convergence mode, and multi-level mode have been suggested so far (Kiyeol Pang et al., 2004, pp.431-468). Major burden sharing methods have unique characteristics from environmental, political, economical, and technical perspectives. From the environmental perspective, all methods except the approach by policies and measures and the intensity method can set positive emission reduction targets. Methods of inducing early participation in or early implementation of emission reduction are available only for the convergence method or the approach by policies and measures. Evaluated from the political perspective, only the multi-level method meets the principles of equity in regard to capability, responsibility and sustainable growth. From the economic perspective, on the other hand, the intensity method can give flexibility to the economic growth of individual countries. The simplest methods from the technical perspective are continuation of the existing Kyoto Mechanism and the convergence method. Therefore, in order to settle a successful emission reduction mechanism, several methods of burden sharing should be combined.

3. Trend and Prospect of Discussions on Post-2012 Mechanism

With regard to Post-2012 when the first commitment period of the Kyoto Protocol ends, active discussions to achieve more comprehensive climate change mechanisms are under way to overcome the limits of the current Kyoto Protocol mechanisms. The discussions on a Post-2012 mechanism under way are largely divided into 'negotiation process' centering on UN and ‘process of major national assemblies’ centering on USA.

The negotiation process centering on UN launched the Dialogue to Address Climate Change at the COP11 in Montreal in 2005, which includes both developed and developing countries. At the COP12 held in Nairobi in 2006, Review Process was launched to review the appropriateness of the Kyoto Protocol. At the COP13 to be held in Bali, Indonesia in December 2007, it is expected that the Bali Plan of Action, a negotiation road map to Post-2012, will be adopted. The first Conference of the Parties to the Convention (COP1) was held in Washington with 17 top greenhouse gas emitters in attendance. The conference discussed basic policy of Post-2012, promotion of research and development of technologies, financial mechanism for spreading clean energies, land use(forest and agricultural lands), and energy efficiency adaptation.

It is expected that discussions on the post-Kyoto Protocol would be settled by three major variables, namely scientific agreement, political negotiation, and market activation. Negotiation, which is centering on UN process, has a time limit by 2009 and the COP process led by the US has a characteristic of supplementary meetings that will continue side by side with the negotiation until 2008 and then will be put together to the UN process after 2009. In relation to this, the standpoint of the new US administration which will be launched in January 2009 seems to have a significant influence. It is expected that the final result of the Post-2012 negotiation will most likely be a new international agreement containing new elements rather than an extension of the Kyoto Protocol.

Regarding Korea's implementation of the commitment to greenhouse gas reduction, the pressure from the international society to commit Korea to emission reduction during the 2nd commitment period has increased as the country is an OECD member ranked 10th in the world in greenhouse gas emission and energy consumption and 13th in its scale of economy (based on GDP) as of 2004. Also in 2007 Summit Talks, responsibilities and capabilities of advanced developing countries were emphasized, and in the UN High-Level meeting and the Session of the Subsidiary Bodies of the UNFCCC, Korea, Saudi Arabia and Singapore were required to share the burden of Annex I countries.

Chapter 3. Actual Conditions of Greenhouse Gas Emissions and Measures for Emission Control in the Agricultural Sector

To devise measures to reduce greenhouse gas emissions, actual conditions of greenhouse gas emissions in each sector should be diagnosed. In Chapter 3, the first part describes actual conditions of greenhouse gas emissions by industrial sectors and sources in Korea. Next, greenhouse gas emissions and sink structures in the agricultural sector are examined and changes in greenhouse gas emissions are reviewed for the arable and livestock sectors. Using 'Mid/Long-term Index for the Agricultural Sector Vision 2030,' the forecasts on greenhouse gas emissions from the agricultural sector are presented.

Regarding the measures for greenhouse gas emission control in the agricultural sector, greenhouse gas reduction measures are summarized and those specified in the Kyoto Protocol as key greenhouse gas control measures (such as emission trading, clean development mechanism and greenhouse gas reduction technologies) are presented.

1. Actual Conditions of Greenhouse Gas Emissions

1.1. Actual Conditions of Greenhouse Gas Emissions in Korea

Greenhouse gases are causes of global warming, which refer to carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons(HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride(SF_6), of which HFCs, PFCs and SF_6 do not exist in the natural world but are synthesized only by human activities. In terms of sources of greenhouse gas emissions, CO_2 is emitted mostly from industrial processes and the use of fossil fuels such as coal and oil; CH_4 from waste treatment and agricultural and livestock-farming activities; N_2O from industrial processes and the use of nitrogenous fertilizers; and HFCs, PFCs and SF_6 from coolants for refrigerators and air-conditioners, cleaning process in the plating industry, and electrical product manufacturing processes.

Greenhouse gas emission in Korea (as of 2005) totaled 591.1 million tCO_2, of which 558.3million tCO_2 was the net emission excluding 33.3 million tCO_2 that was captured by land use and forestry, and it was the world's top 10 level. The amount of greenhouse gas emission has increased by an average of 4.7% a year since 1990 <Table 3-1>.

Table 3-1. GHG Emissions from Each Industrial Sector

Unit: Million tCO_2

Classification	1990	1995	2000	2003	2005	1990~2005 Average Annual Increase Rate (%)
Energy	247.7 (79.8)	372.1 (82.2)	438.5 (83.0)	481.4 (82.7)	498.6 (84.3)	5.0
Industrial Processes	19.9 (6.4)	47.1 (10.4)	58.3 (11.0)	69.7 (12.0)	64.8 (11.0)	9.3
Agriculture	17.5 (5.6)	17.8 (3.9)	16.2 (3.1)	15.5 (2.7)	14.7 (2.5)	-0.7
Waste Treatment	25.5 (8.2)	15.7 (3.5)	15.6 (3.0)	15.6 (2.7)	13.0 (2.2)	-3.7
Total Amount of Emission	310.6 (100.0)	452.8 (146.0)	528.6 (170.0)	582.3 (187.0)	591.1 (190.0)	4.7
Land-use Change and Forestry (Sinks)	-23.7	-21.2	-37.2	-33.3	-33.3	2.4
Net Amount of Emission	286.8	431.5	491.4	548.6	558.3	4.9

Source: Korea Energy Economics Institute (2007).

Among all industrial sectors (as of 2005), energy sector accounted for 84.3% of greenhouse gas emissions, industrial process sector 11%, and agricultural sector 2.5%. Greenhouse gas emissions from the agricultural sector appeared to decrease by 0.7%

every year due to the reduction in farmland areas and use of chemical fertilizers.

As for the composition of greenhouse gases, CO_2 and CH_4 accounted for 92.0% of the total emission. The percentage of CO_2 in greenhouse gas emissions was increased from 83.2% in 1990 to 87.7% in 2005, recording an average increase of 5.1% a year since 1990. The percentage of N_2O was 2.6% in 1990 but increased to 3.5% in 2005 with an average increase of 7% a year, while that of CH_4 has been decreasing at a rate of 3.7% a year since 1990 from 13.9% in 1990 to 4.3% in 2005.

Table 3-2. Changes in Greenhouse Gas Emissions[1)]

Unit: Million tCO_2 (%)

	1990	1995	1996	2000	2003	2005	1990 2005 Increase Rate (%)
CO_2	258.3 (83.2)	401.0 (88.6)	438.3 (86.8)	464.9 (87.9)	510.7 (87.7)	517.9 (87.7)	5.1
CH_4	43.2 (13.9)	28.5 (6.3)	30.6 (6.1)	26.4 (5.0)	25.8 (4.4)	25.7 (4.3)	-3.7
N_2O	8.0 (2.6)	11.9 (2.6)	12.6 (2.5)	14.9 (2.8)	18.2 (3.1)	20.9 (3.5)	7.1
HFCs	1.0 (0.3)	5.1 (1.1)	5.7 (1.1)	8.3 (1.6)	7.7 (1.3)	7.1 (1.2)	15.2
PFCs[3)]	-[2)]	-	1.0 (0.2)	2.3 (0.4)	2.5 (0.4)	3.1 (0.5)	15.4
SF6[3)]	-	6.3 (1.4)	17.0 (3.4)	11.7 (2.2)	17.4 (3.0)	15.9 (2.7)	12.1
Total	310.6 (100.0)	452.8 (100.0)	505.2 (100.0)	528.6 (100.0)	582.3 (100.0)	590.6 (100.0)	4.7

Note: 1) The emission amount does not include the amount of emissions/capture by land-use change and forestry.

2) - indicates unavailability of the corresponding data.

3) As for PFCs, the increase rate was of 1996 ~ 2005 and for SF6, it was of 1994 ~ 2005.

Source: Korea Energy Economics Institute(2007).

1.2. Actual Conditions of Greenhouse Gas Emissions in the Agricultural Sector

Greenhouse gases produced in the agriculture and livestock sector are mostly methane and nitrous oxide and partly carbon dioxide.

Methane is a colorless, odorless combustible gas generated from soil in oxygen-less fresh water as in the case of paddy used for cultivating rice. It is also generated from rumen fermentation, which is a microbiologic fermentation process, and livestock manure decomposition process in the livestock sector. Nitrous oxide is a colorless gas with odor and sweet taste, which is generated from the use of nitrogenous fertilizers and the decomposition of livestock manure. Carbon dioxide is generated by the combustion of fossil fuels such as coal, oil and gas in the agriculture and livestock sector. Energy use in the agricultural sector includes both direct energy use for operating agricultural machines, appliances and facilities and indirect energy use for producing fertilizers and pesticides.

In the agriculture and livestock sector, on the other hand, greenhouse gas capture can also be made possible by organic carbon sequestration during cultivation of energy crops and mulched crops. Greenhouse gas capture and storage in the agriculture and livestock sector include carbon dioxide capture by cultivation of energy crops such as rapes, soil organic carbon (SOC) sequestration by environment-friendly agricultural techniques and cultivation of mulched crops, and methane capture. However, greenhouse gas capture and storage in the agriculture and livestock sector have not yet been officially recognized by IPCC and thus are not included in the national statistics on greenhouse gases.

To calculate the amount of greenhouse gas emitted from the agricultural sector, the method for calculating greenhouse gas emissions in the agricultural sector suggested in “Base Research for Preparation of the 3rd National Communication of the Republic of Korea under the UNFCCC” (Jaegyu Lim, 2006) was used. Methane emission from the paddy rice and the livestock sector was calculated using the Tier 2 method, and nitrous oxide emission from the arable and the livestock sectors was calculated using the Tier 1 method.

As for the change in greenhouse gas emissions in the agricultural sector, methane emission was reduced by 8.6% from 7,509 x 10^3 tCO_2 in 2000 to 6,862 x 10^3 tCO_2 in 2005 due to a decrease in rice cultivation area in the arable sector, and nitrous oxide was reduced by 7.7% from 2,574 × 10^3 tCO_2 in 2000 to 2,376 × 10^3 tCO_2 in 2005 due to a decrease in the use of chemical fertilizers <Table 3-3>. In the livestock sector, methane emission was estimated to have increased by 3.6% from 3,086 x 10^3 tCO_2 in 2000 to 3,198 x 10^3 tCO_2 in 2005 due to an increase in the number of head of livestock, and nitrous oxide by 8.4% from 2,525 x 10^3 tCO_2 to 2,736 x 10^3 tCO_2 during the same period. Carbon dioxide emission from the agricultural and livestock sector appeared to have increased by 6.1% from 3,043 x 10^3 tCO_2 in 2000 to 2,958 x 10^3 tCO_2 in 2005. Therefore, it is shown that about 60% of greenhouse gas emissions in the agricultural sector are generated from the arable sector while the remaining 40% are generated from the livestock sector.

Table 3-3. GHG Emissions in the Agricultural Sector and Change in the Global Warming Potential (GWP)

Unit: 10^3 tons (GHG), 10^3 tCO_2 (GWP)

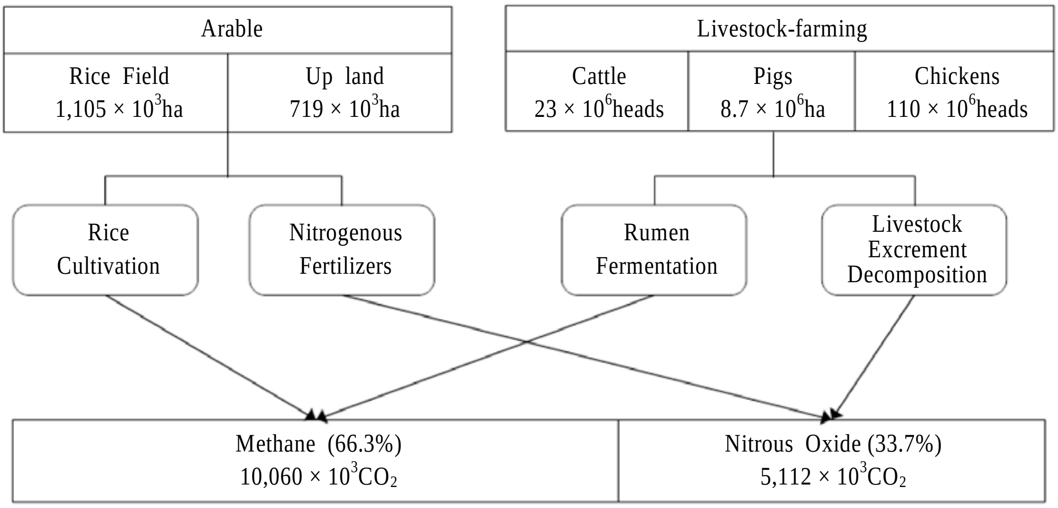
Year	Emissions in the Arable Sector				Emissions in the Livestock Sector				CO_2[1)]	Total (GWP)
	CH_4		N_2O		CH_4		N_2O			
		GWP[2)]		GWP[2)]		GWP[2)]		GWP[2)]		
2000	357.6	7,509	8.3	2,574	147.0	3,086	8.1	2,525	3,043	18,737
2002	351.3	7,377	7.1	2,213	139.7	2,934	8.2	2,546	2,907	17,977
2003	338.9	7,117	7.0	2,185	140.7	2,955	8.3	2,574	2,817	17,648
2004	333.9	7,013	7.7	2,401	146.9	3,085	8.4	2,619	2,861	17,979
2005	326.8	6,862	7.7	2,376	152.3	3,198	8.8	2,736	2,858	18,030

Note: 1) The amount of CO_2 emissions includes those from the use of agricultural machines and facilities and the production of fertilizers, pesticides and assorted feed.

2) Global Warming Potential (GWP) was calculated for each gas in equivalence to CO_2. According to 1996 IPPC GWP, GWP of 1 CO_2 is equivalent to 21 CH_4 or 310 N_2Os.

The UNFCCC targets only methane and nitrous oxide as greenhouse gases in the agricultural sector. Therefore, the total greenhouse gas emissions in the agricultural sector appeared to have decreased by 3.3% from 15,694 × 10^3 tCO_2 in 2000 to 15,172 × 10^3 tCO_2 in 2005. Of greenhouse gases generated in the agricultural sector in 2005, methane accounted for 66.3% with 10,060 x 10^3 tCO_2 and nitrous oxide 33.7% with 5,112 × 10^3 tCO_2 <Figure 3-1>.

Figure 3-1. GHG Emission Structure in the Agricultural Sector(as of 2005)



2. Forecasts on Greenhouse Gas Emissions in the Agricultural Sector

In order to forecast greenhouse gas emissions in the agricultural sector, the mid/long-term forecasts on arable lands and head of livestock presented in "Development of Mid/Long-term Potentials for the Agricultural Sector Vision 2030" (Jeongho Kim et al., 2007) were used.

Methane emission from rice cultivation in 2000 was 358 x 10^3 tCO_2, which can be calculated into the GWP of 7,509 × 10^3 tCO_2. As the rice cultivation area continues to decrease, it is forecasted that methane emission will decrease by 15.6% to 6,338x 10^3 tCO_2 during the period ending in 2010 and by 23.7% to 5,729 × 10^3 tCO_2 during the period until 2020<Table 3-4>.

Table 3-4. Forecasts of GHG Emission and GWP in the Agricultural Sector

Unit: 10^3 tons (GHG), 10^3 tCO_2 (GWP)

Year	Emissions in the Arable Sector				Emissions in the Livestock Sector				Total (GWP)
	CH_4		N_2O		CH_4		N_2O		
		GWP[2)]		GWP[2)]		GWP[2)]		GWP[2)]	
2000	357.6	7,509	8.3	2,574	147.0	3,086	8.1	2,525	15,693
2002	326.8	6,862	7.7	2,376	152.3	3,198	8.8	2,736	15,172
2003	301.8	6,338	7.2	2,247	170.1	3,573	9.6	2,981	15,139
2004	286.9	6,024	6.8	2,096	173.6	3,645	9.9	3,058	14,823
2005	272.8	5,729	6.4	1,977	175.8	3,691	10.0	3,105	14,503

Note: 1) Global Warming Potential (GWP) was calculated for each gas in equivalence to CO_2. According to 1996 IPPC GWP, GWP of 1 CO_2 is equivalent to 21 CH_4 or 310 N_2Os.

The nitrous oxide (N_2O) emission from the application of nitrogenous fertilizers to the arable lands was 2,574 × 10^3 tCO_2 in 2000, and it is forecasted to reduce by 12.7% to 2,247 × 10^3 tCO_2 in 2010 and by 23.2% to 1,977 × 10^3 tCO_2 in 2020.

In the livestock sector, the amount of methane generated by rumen fermentation and livestock manure decomposition was 147 × 10^3 tCO_2 in 2000, or GWP of 3,086 × 10^3 tCO_2. However, as the numbers of head of beef cattle, pigs and chickens are expected to keep increasing except dairy cattle, the GWP in this sector is also expected to increase from 2000 by 15.7% to 3,573 × 10^3 tCO_2 in 2010 and by 19.6% to 3,691 × 10^3 tCO_2 in 2020. N_2O emission from the decomposition of livestock manure is also expected to keep increasing by 18.1% from 2,525 × 10^3 tCO_2 in 2000 to 2,981 × 10^3 tCO_2 in 2010 and by 23% to 3,105 × 10^3 tCO_2 in 2020.

Total greenhouse gas emission in the agricultural sector is forecast to be on a decreasing tendency after 2000 as the decrease in arable land area becomes larger in proportion to the increase in the emissions from the livestock sector. Greenhouse gas emissions in the agricultural sector in 2020 are estimated at 14,503 × 10^3 tCO_2, a 7.6% decrease from 15,693 × 10^3 tCO_2 in 2000. Therefore, if greenhouse gas emission could be reduced to 2000 levels, the agricultural sector would be able to have a surplus of about 1,190 × 10^3 tCO_2 to emit.

3. Key Measures for Greenhouse Gas Control in the Agricultural Sector

3.1. Means of Greenhouse Gas Reduction

Global warming can be addressed as a negative external effect caused by abusing the public capital of global environment as a means of seeking private profits excessively without limitations. In a liberal economic system aiming at maximization of private profits, there is no system to charge the cost of deteriorating the living environments of present and future generations to the parties responsible for engaging in economic activities producing GHG emissions. As a result, excessive levels of GHG have been emitted to threaten Earth and the entire mankind. If this tendency continues, the Earth ecology would likely to be irrecoverably destroyed, which was addressed at the heart of the 4th Evaluation Report of the UN IPCC (IPCC, 2007a).

Since main players of world economy continue to conduct economic activities without sufficient awareness of global environment issues, global warming is being accelerated by external effects. Therefore, in order to solve the problem of global warming, a system should be established so that it can internalize such negative externality and charge the cost incurred by the deteriorated global environment specifically to the responsible parties.

Solutions to global warming can be divided roughly into greenhouse gas reduction policies, policies to enhance capturability, and adaptation policies; and greenhouse gas reduction policies are divided into greenhouse gas reduction from input, greenhouse gas reduction from production processes, and greenhouse gas reduction from output.

In reality, it is almost impossible to implement the first-best solution to accurately measure the external effects of global warming and charge the economic costs to the concerned greenhouse gas emitters. Under this background, the second-best solution to develop relevant policy programs and form appropriate portfolios to approach is addressed as a practical method. Considering the given circumstances realistically, means for greenhouse gas reduction are classified into economical means, regulatory means, voluntary agreement, R&D and popularization, information provision, and promotion of public awareness.

Economic means refer to policies that utilize market mechanisms, such as charges, carbon tax (or greenhouse gas tax), emission trading scheme, and subsidy.

Greenhouse gas charge, a scheme to impose a charge equivalent to the input price for the unit emission of greenhouse gas to the concerned greenhouse gas emitters, is an ideal economic means to achieve efficient resource distribution using fiscal incentives. In order to put this scheme in force, greenhouse gas emissions of each emitter should be monitored and the emitter should be charged according to the actual amount of emission.

The taxes to reduce greenhouse gas emissions can be divided into carbon tax and greenhouse gas tax. Carbon tax is a system to impose tax in proportion to the carbon content of fossil fuels used. In reality, because of the convenience of assessment and collection, carbon tax has been put into practice in the form of product charge. Greenhouse gas tax differs from carbon tax in that the former is based on the amount of gas emission while the latter is based on the input amount (or production amount) of fossil fuel which is the source of gas emission. Though carbon tax is same as greenhouse gas tax in that both can maintain the input amount of fossil fuels at efficient levels, the former is more feasible as it sets the input amount of fossil fuels as its basis for taxation. Unlike greenhouse gas tax which requires the taxation office to monitor the accurate amount of greenhouse gas emissions, carbon tax requires the taxation office to monitor only the shipping stage or the distribution stage of fossil fuels for taxation. As tax is imputed to the fossil fuel price, the imputed price of greenhouse gas can be reflected in the end users' decision-making. Therefore, the administrative cost for putting carbon tax in force is relatively small.

Emission trading system is a scheme that sets emission credits based on total greenhouse gas emissions and permits the trade of the credits in the market. The demand and supply of emission credits is determined by the pricing function together with its market demand. If a certain greenhouse gas source can emit greenhouse gas at a lower cost, the emitter can reduce its emission, get as much emission credit as the reduced amount, and sell the emission credit at the emission trading market for a profit.

Subsidy is a system by which the government permits greenhouse gas emitters the right to emit greenhouse gas to a certain level and compensates them with subsidy if they give up a certain portion of the right granted to them. In order for the subsidy system to operate properly, the government should have a correct understanding of various information such as technology level, cost and reduction potential of the subsidized.

To ensure the appropriate operation of economic means that are based on the market function, reliable data and information should be collected regarding the social marginal cost of greenhouse gas emission, greenhouse gas emissions, and the social benefits of greenhouse gas reduction.

Direct regulation is a scheme in which the government regulates emission standards using various policies and measures under law to ensure that emitters can comply and meet the required greenhouse gas emission level. The emission standard is a policy measure that specifies total greenhouse gas emission cap for each source and ensures compliance of the emitters, which is simpler and clearer than other policy measures, so that the government can introduce it and put it into force without difficulty. Examples of regulatory measures applicable to the agricultural sector include emission cap, chemical fertilizer spraying standard, manure and liquid fertilizer spraying standard, and breeding density regulation.

Voluntary agreement is a non-regulatory policy measure by which firms (business establishments or farmers) and the government voluntarily agree on greenhouse gas reduction target, reduction plans, and scale of government support to achieve. Voluntary agreements for greenhouse gas reduction in the agricultural sector include Good Farming Practices (GFP) and voluntary development of resource-recycling villages by residents. Under the voluntary agreement scheme, greenhouse gas reduction target is determined by voluntary agreement, so there is no disciplinary measure against non-compliance with the target. Therefore, it might not be an effective policy measure in achieving the national greenhouse gas reduction target.

In addition, there are R&D and popularization of greenhouse gas reduction and capture technologies, and information provision and public awareness enhancement for greenhouse gas monitoring.

Each policy measure for greenhouse gas reduction has advantages and disadvantages with respect to economic efficiency, environmental effectiveness, policy adaptation and feasibility. Therefore, in order to put any policy in force, it is desired to establish a portfolio of mixed policies based on the comprehensive evaluation of given circumstances of each policy rather than to select and promote any one policy program. As it is not easy to pick one feasible policy mix, preliminary evaluation through policy simulation should be carried out and foreign cases where relatively successful policies are in force should be benchmarked.

3.2. Key Measures for Greenhouse Gas Control under the Kyoto Protocol

3.2.1. Emission Trading System

Greenhouse gas Emission Trading System (ETS) refers to a scheme that assigns greenhouse gas emission quota to each country, considers the assigned amount as an intangible product of emission credit, and permits countries to trade the credit directly or via exchange to reduce the cost of emission reduction and facilitate emission reduction. ETS can be divided largely into domestic emission trading and International Emission Trading (IET). IET is a flexible measure suggested by the Kyoto Protocol (Article 17), according to which Annex I countries are assigned emission quotas and those who fail to meet their reduction targets comply with their obligations by buying surplus emission quota from those who meet their targets.

Types of credits available in the IET market are Assigned Amount Unit (AAU), Emission Reduction Unit (ERU) and Removal Unit (RMU), which are assigned only to Annex I countries, and Certified Emission Reduction (CER) assigned to non-Annex I countries (UNFCCC, 2001) <Table 3-5>.

Table 3-5. Types of Credits Available in the Emission Trading Market

Unit of Trading	Mechanism	Limit available during the 1st Commitment Period	Banking Limit
Assigned Amount Unit (AAU)	Amount assigned to Annex I countries	No limit	No limit
Emission Reduction Unit (ERU)	Joint Implementation	No limit	2.5% of the amount allocated to the buyer country
Certified Emission Reduction (CER)	Clean Development Mechanism	1% of the amount assigned to the buyer country, for CER by sinks business	2.5% of the amount allocated to the buyer country
Removal Unit (RMU)	Emission unit generated for reduction by sinks in Annex I countries	Different limit for each country, for RMU for forestry	Banking not allowed

Source: UNFCCC, *The Marrakesh Accords and Marrakesh Declaration*, 2001

AAU refers to surplus emission unit of Annex I countries that emit greenhouse gases less than the allowed emission quota specified under the Kyoto Protocol. It can be sold to another Annex I country.

ERU refers to emission reduction achieved through joint implementation among Annex I countries. On the other hand, CER is emission reduction achieved through CDM projects, which are joint greenhouse gas reduction projects between an Annex I country committed to emission reduction and a non-Annex I countries without the commitment. RMU refers to emissions captured through reduction activities such as afforestation, reforestation and forestry. The emission unit that can be traded in connection with Clean Development Mechanism (CDM) in force in Korea is CER.

In early 2008, burden-sharing countries are to register the assigned emission amount less than the reduction amount corresponding to the reduction target of 1990 level to the national registration office. The credits that can be issued domestically are AAU and RMU. For AAU, the amount of credits that can be issued is fixed when the reduction target setting method is established and for RMU, there is a different limit for each country that can issue domestically. On the other hand, ERU and CER can be issued only through international projects. For CDM projects, CER can be issued up to 1% of the initial amount assigned to the buyer country and ERU can be issued by converting the corresponding amount from AAU or RMU of the other party of CDM project country. With regard to the banking of surplus reduction units to the next commitment period after meeting the national target, AAU can be banked 100% and ERU and CER up to 2.5% of the initially assigned amount, but RMU is not allowed for banking.

The emission reduction removed from sinks is expressed in RMU. Annex I countries can use RMU for meeting the emission target. However, to be used for this, RMU should be validated by an expert investigation team that verifies actual emission reduction through the evaluation report and procedure under the Kyoto Protocol.

'Carbon emission credit' in ETS refers to a right to emit greenhouse gas and has the characteristic of a financial product as it sets price to carbon and allows its trade at the market. Emission trading market can be subdivided into Kyoto Protocol compliance market, non-Kyoto Protocol compliance market, voluntary market, and retail market.

Basically, ETS can be operated on the condition that there is emission reduction target. As an example of domestic emission trading system, there is environmental credit trading scheme. With regard to the agricultural sector, there is a domestic emission trading scheme that gives credits and substantially compensate those in the agricultural sector who achieve emission reduction. For example, farm households that put environment-friendly agricultural techniques into practice are given credits as they contribute to emission reduction, and companies that emit greenhouse gas buy the credits from them. Such activities provide financial opportunities to farmers and induce them to invest in environment preservation activities by lowering the expenses for meeting the environment target.

3.2.2. Clean Development Mechanism (CDM)

CDM is a type of emission trading scheme under the Kyoto Protocol, which allows emission reduction results of business units to be traded as if they were emission credits. It refers to a mechanism by which developing countries explore and promote emission reduction projects to obtain CER credits, and sell them to developed countries. CDM is different from ETS in that the project is carried out in a non-Annex I country but the reduction results are traded to the Annex I country.

To ensure objective and transparent evaluation of CDM, Designated Operational Entity (DOE) has been established. The DOE is in charge of monitoring whether measurement devices are installed and operated according to the project plan and verifies the reduction results. Korea established CDM Certification Office under the Korea Energy Management Corporation in November 2005 and has been operating it so far.

To be promoted a CDM project should be evaluated in two stages: in the first stage, which is project planning stage, baseline emissions should be validated and in the second stage, actual reductions achieved during the project implementation process should be verified. Evaluation of baseline emissions should be done before the corresponding project is carried out and that of actual reductions after the project is finished based on the amount monitored by the business operator. Validation is to assess whether the amount of emission has been properly calculated under the condition that the project is not yet carried out. The projects that pass validation process are qualified to be registered to CDM Executive Committee and afterward can be issued credits depending on actual reduction results. The amount of credits will be determined by CDM DOE after it verifies the actual reduction results of the business operator.

The validation and verification of a CDM project proceed generally in 3 stages: document review, on-site evaluation, and verification of corrective measures.

The major contents of CDM Project Design Document (PDD) include general description of project activity, baseline methodology, duration of project activity and crediting period, monitoring methodology, estimation of greenhouse gas emissions by sources, environmental impacts, and stakeholders' comments.

The general description of project activity is to validate the proposed project activity from economic, environmental and technological perspectives. For baseline methodology, the methodology suggested by CDM Executive Committee is applied. The duration of project activity and crediting period are specified as maximum 10 years without renewal. Monitoring methodology refers to the justification of a monitoring plan chosen to decide the amount of emissions reduced by CDM project activity during the crediting period. The estimation of greenhouse gas emissions by sources is to evaluate the transparency and reliability of emissions and leakages. After this, environmental impacts are assessed to identify the impacts of project activities on regional development and the surrounding environment. In order to recognize how the concerned parties think, opinions of local residents on the project activity should be collected and the level of their satisfaction at it should be evaluated.

Since the landfill utilization project of Brazil was first registered as a CDM project in 2004, a total of 844 CDM projects in 15 fields have been registered to and approved by the UNFCCC (as of November 26, 2007), and the three countries of India (289 projects), China (131 projects) and Brazil (113 projects) account for 63.2% of them. Korea accounted for 1.9% of them with 16 projects. Among the registered CDM projects, a total of 400 projects, which are equivalent to 93,850 x 10^3 tCO_2, were certified after their actual reductions were monitored. The contents of CDM projects consist of energy (53.2%), waste management (20.7%), agriculture (7.5%), fugitive emissions from fuels (7.8%), and others (11.0%). The CDM projects registered for the agricultural and livestock sector include livestock wastewater management, bio-gas system, and power generation using risk husks.

As of November 12, 2007, 37 CDM projects are registered for nitrous oxide reduction and for the development of alternative energies such as wind power, solar power, thermal energy, small hydro power and biomass.

Solar energy, a renewable energy mainly used by the agricultural sector, emits less greenhouse gases than other energy types. It plays the role of greenhouse gas sinks through the photosynthesis of plants and, therefore, is used throughout the world as an effective means of greenhouse gas reduction. For example, developing countries in South America and India are actively developing CDM projects to generate energy using the methane produced from livestock manure treatment facilities and are increasingly promoting projects to generate power using agricultural by products such as rice husks or sugar cane husks as fuel. Interests in CDM projects to substitute the existing transportation fuels like oil by producing bio-diesel or bio-ethanol from agricultural products are also increasing. Among 844 projects registered to CDM Executive Committee by November 2007, 79 were methane reduction projects for livestock manure treatment facilities and 149 were energy projects using biomass. It means that more than 30% of CDM projects are related to the agricultural sector, brightening the prospect of CDM projects for the agricultural sector. In Korea, greenhouse gas reduction activity in the agricultural sector is still in its early stages but appears to have sufficient potential. Therefore, if it could be developed into a full-scale CDM project in consideration of basic requirements such as baseline appropriate for the existing national circumstances, verification of additionality and monitoring plan, CDM project activity on greenhouse gas reduction could be utilized as a very effective means of greenhouse gas reduction in a country like Korea where greenhouse gas emissions are rapidly increasing. Agricultural fields available for CDM projects include reduction of methane and nitrous oxide emissions from arable lands, formation of pastures on lands in fallow, soil organic carbon sequestration, improvement of rumen fermentation, improvement of livestock manure treatment facilities, biomass use, and reduction of fossil fuel use.

3.3. Utilization of Greenhouse Gas Reduction Technologies in the Agricultural Sector

In order to expand and capture in the agricultural sector, various technologies for greenhouse gas reduction from arable lands, organic carbon sequestration in soil, improvement of rumen fermentation, biomass utilization, and fossil fuel use reduction have been developed and put into practice to considerable levels<Table 3-6>. Among many greenhouse gas emission reduction technologies, greenhouse gas emission reduction, organic agriculture and livestock farming, soil organic carbon sequestration, and bio-energy utilization are 4 most representative ones.

Table 3-6. GHG Reduction Technologies in the Agricultural Sector

Fields	Reduction Technologies
Reduction of methane and nitrous oxide emissions from arable lands	Expand organic techniques. and environment-friendly farming
	Reduce the usage. of fossil fuels through improved farming methods
Formation of pasture on lands in fallow	Afforest lands in fallow and form pastures.
	Cultivate mulched crops on lands in fallow.
Soil organic carbon sequestration	Perform conservation tillage (single tillage, no-tillage) and crop rotation.
	Substitute chemical fertilizers with organic substances (e.g., crop residue and sludge).
	Improve soil mulch and irrigation methods (water management methods).
Improvement of rumen fermentation	Improve energy content of feeds and digestion efficiency.
	Improve breeds of cattle and feed good-quality roughage.
	Apply the ruminant additive (feed additive and microbiological agent).
Improvement of livestock manure treatment facilities	Expand the facilities for aerobic treatment of slurry and install covers.
	Capture methane and turn it into resource
Utilization of biomass and reduction of fossil fuel use	Substitute fossil fuels by cultivating bio-energy crops.
	Expand bio-gas and biomass technologies.
	Power generation using rice husks

First, the emission reduction technology is a clean technology that reduces CH_4 and N_2O emissions by applying crop cultivation techniques such as fertilization control and water management, and livestock feeding techniques such as feed improvement and rumen additive application. The emission reduction technologies applicable to rice paddies in the arable sector include reduction of the use of nitrogenous fertilizers, expansion of the use of organic substances, conversion of irrigation method to simplified irrigation, and change of cultivation method to direct sowing on dry paddy. Those applicable to dry fields include reduction of chemical fertilizer usage and practice of environment-friendly farming techniques. In the livestock sector, there are rumen fermentation improvement technologies such as improvement of energy content and digestion efficiency of feeds, improvement of livestock breeds, feeding of good-quality roughage, use of rumen additives (feed additives and microbiological agents). In addition to these, there are livestock manure treatment facility improvement technologies that include expansion of the facilities for aerobic treatment of slurry and installation of the covers for manure storage tanks.

Table 3-7. Evaluation of Emission Reduction Effects in Organic Agriculture and Livestock Farming

Methods	CO_2	CH_4	N_2O
Environment-friendly use and management of arable lands			
- Permanent soil mulch	+++	-	+
- Sublation of soil tillage	+	-	+
- Restrict fallowing for semi-barren lands.	+	-	-
- Diversify crop rotation including livestock feed crops.	++	-	+
- Enhance the productivity of deteriorated soils.	++	+	-
Recycling of livestock manure and wastes			
- Recycle byproducts and composts within the region.	++	-	+
- Utilize bio-gas from slurry.	-	++	-
Environment-friendly livestock breeding and management			
- Extend the life of livestock.	-	++	+
- Limit the density of livestock breeding.	-	+	+
- Reduce the import of feeds.	+	+	-
Natural circulatory nourishment management			
- Limit the application of nourishment(by recycling the nourishment).	++	-	++
- Cultivate leguminous plants.	+	-	+
- Consolidate agronomy and livestock farming(linking).	++	-	+
Behavioral change to green consumers			
- Consume local produce.	+++	-	-
- Convert to vegetarian diets.	+	++	-

Note: +++ Very high potential, ++ High potential, + Low, -Not possible

Source: Prepared based on the table presented in IFOAM Report (Kotschi and Muller-Samann, 2004, p.37), with some modifications.

Second, the organic agricultural and livestock practice technology refers to a type of greenhouse gas reduction technology to reduce CO_2 and N_2O. Organic agriculture manages soils through crop rotation or by using byproduct fertilizers or organic fertilizers without using chemical fertilizers or pesticides. The core of organic agriculture lies in managing soil fertility through the promotion of soil microorganism activities, biological nitrogen fixation through the cultivation of leguminous crops and crop rotation, and minimizing external input and ensuring resource-recycling agriculture through the organic interaction between agronomy and livestock farming. It has been suggested that resource-recycling organic agriculture and livestock farming contribute to the reduction of CO_2 and N_2O emissions. According to an IFOAM report, organic agriculture and livestock farming greatly contribute to greenhouse gas emission reduction directly and indirectly through the environment-friendly use and management of land, recycling of livestock manure and wastes, environment-friendly livestock breeding and control, and resource-recycling nourishment management as well as behavioral change to green consumers (Kotschi and Muller-Samann, 2004). In reality, practices of organic agricultural methods proved to be capable of reducing CO_2 emissions by reducing the use of fossil fuels through soil and nourishment management to minimize the input of external agricultural materials and the use of external feeds.

The third is soil organic carbon (SOC) sequestration technology. SOC refers to a substance which was at first carbon sequestrated by photosynthesis of plants and then came into soil in the form of plant residue and is now in the process of decomposition within soil. While being slowly decomposed over a long time in soil, SOC plays an important role of controlling the relation between SOC sequestrated on the surface of the earth and CO_2 in the atmosphere (Dongyeop Kim and Changhwan Lee, 2005, p.3). SOC sequestration has an effect of offsetting the carbon emitted from the combustion of fossil fuels with organic carbon accumulated in soil. SOC sequestration technologies include soil management, mulched crop cultivation, conservation tillage, comprehensive nourishment management, no-tillage farming, and optimum crop cultivation in consideration of the environment.

The fourth is bio-energy utilization in the agricultural sector. Bio-energy means energy produced from biomass, and biomass refers to biological organisms such as plant bodies and fungus bodies produced by photosynthesis of plants and micro-organisms, and livestock bodies that live by those plant and fungus bodies. Biomass resources have various qualities and shapes and they include amylaceous resources (such as grains and potatoes), cellulose resources (such as herbs, trees, straws and rice husks), glucose resources (such as sugar canes and sugar beets), and protein resources (such as corpses and fungus bodies of micro-organisms). Therefore, bio-energy production technology refers to chemical, biological and combustion technologies applied to produce heat, vapor or electricity either by converting biological organisms into various gaseous, liquid or solid fuels or by burning them.

Bio-energies in the agricultural sector include bio-gas from livestock manure and food wastes; bio-diesel from rapes and oilseed crops; ethanol from corn, sugar cane, potato and sweet potato starch; and methanol from rice husks and sawdust (Changyong Kang et al., 2006, pp.8-9). Of these, representative bio-energy technologies expected to be used in the agricultural sector are bio-diesel production technology using rapes and oilseed crops and bio-gas plant technology that uses methane fermentation of livestock manure. A pilot project for rape cultivation to supply a raw material for bio-diesel will be executed for 3 years from 2007. Next to this project, bio-gas plant projects using livestock manure are being actively promoted at home and abroad. As for bio-gas generation facilities using livestock manure, there are German individual farmhouse facility and Danish joint-treatment facility. The German farmhouse type refers to a bio-gas generation technology that produces methane through anaerobic treatment of livestock manure of individual farmhouses, generates power using the methane, and uses all the leftover livestock wastes as liquid manure. The Danish joint treatment technology emerged as the demand for the treatment of organic wastes such as livestock wastes and food wastes increased (Sooncheol Park, 2006). Bio-gas plants energy using livestock manure can have such effects as renewable energy production, livestock manure treatment and greenhouse gas reduction.

With regard to various emission reduction measures in the agricultural sector, such as arable land and pastureland management, pasture improvement, organic soil management, barren land restoration, livestock management, compost and soil management, and bio-energy production, IPCC (2007d) presented the results of experts' evaluation of their greenhouse gas reduction effects and reliabilities for net reduction.

Highly-reliable measures that experts recommend regarding net greenhouse gas reduction in the agricultural sector are crop cultivation method improvement, nourishment management, and land-use change in the arable land management field. In pastureland management and pasture improvement, fertilization management for productivity improvement and nourishment management for applying nourishments appropriate for crops are recommended.

Concerning the organic soil management to enhance emission capture capability in the agricultural sector, drainage management and marsh avoidance are suggested. For soil restoration, erosion prevention and application of agricultural byproducts and nourishment to arable lands are suggested.

Regarding livestock management, experts recommend improvement of roughage-based cattle feed, use of feed additives to suppress methane production, and improvement of livestock breed as reliable measures for greenhouse gas reduction.

Besides, in the compost and soil management field, they suggest improvement of livestock manure storage and treatment, anaerobic digestion of compost, and effective nourishment management as reliable measures and in the bio-energy production field, they suggest cultivation of energy crops and utilization of livestock manure for bio-gas.

Though various technology means of reducing and capturing greenhouse gas in the agricultural sector have been suggested by IPCC, substantial reduction effects of each means may greatly vary country by country depending on their levels of technology development, popularization of developed technologies and implementation of related policies. Therefore, in order to decide proper policies and measures to comply with the commitment to emission reduction, it is essential for policy makers to verify developed reduction and capture technologies thoroughly at the actual fields of agriculture and popularize the verified and certified technologies.

Chapter 4. Impacts of Reduction Measures on the Agricultural Sector and Their Potentials

1. Calculation and Forecast of Greenhouse Gas Emissions in Agricultural Sector

1.1. Estimation of Greenhouse Gas Emissions and Allowable Emissions

Allowable greenhouse gas (GHG) emissions for each industrial sector in compliance with the obligation to reduce greenhouse gas emissions are assumed to drop 5% below baseline levels (2000), starting from 2013. Therefore, if greenhouse gas is emitted less than allowable emission cap, which is 95% of baseline, surplus emissions are generated and if they are emitted in excess of allowable emissions, reduction objective comes into existence.

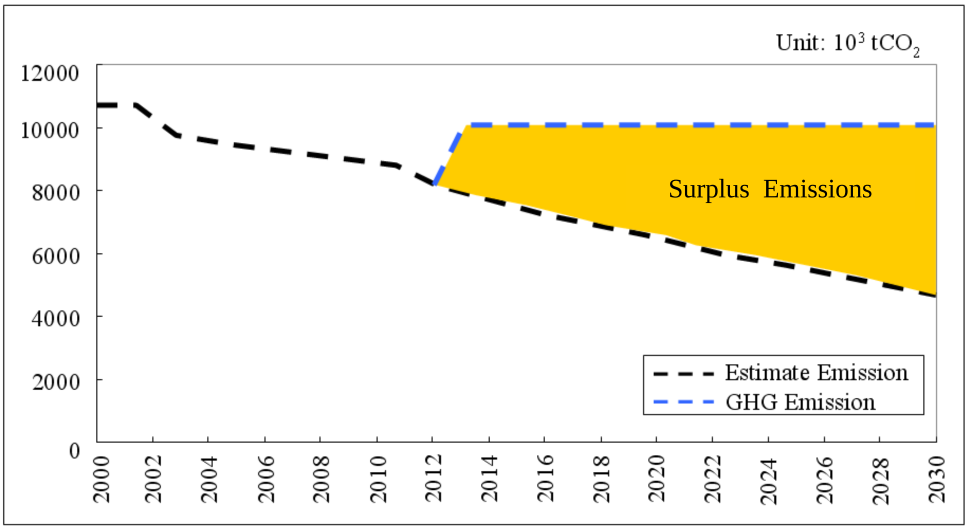
For the arable sector including rice, minor grains and vegetables, the baseline emission as of 2000 is 10,412 × 10^3 tCO_2, and the emission cap is 95% of the baseline, which is 9,892 × 10^3 tCO_2. Therefore, it is estimated that emission in 2013, when reduction commitment commences, will be 7,888 × 10^3 tCO_2, a 14.7% decrease from the baseline, resulting in a surplus emission of about 2,005 × 10^3 tCO_2. Also, as the emission from the arable sector is expected to keep decreasing after 2013, it is estimated that there will be surplus emissions of 3,528 × 10^3 tCO_2 in 2020 and 5,160 x 10^3 tCO_2 in 2030.

For the livestock sector, the baseline emission is 5,418 × 10^3 tCO_2, and the emission cap is 95% of the baseline, which is 5,148 × 10^3 tCO_2. Therefore, it is analyzed that emission in 2013 when reduction commitment commences will be 5,630 × 10^3 tCO_2, a 3.9% increase from the baseline, resulting in the reduction objective of about 48 × 10^3 tCO_2. It is expected that though emission will decrease slightly after 2013, it will still exceed the cap, having the reduction objective of 374 × 10^3 tCO_2 in 2020 and 256 × 10^3 tCO_2 in 2030, and thus impose a big burden on the livestock sector.

For the agriculture-related industries such as mixed feeds, fertilizers and pesticides, it is estimated that greenhouse gas emissions will keep decreasing after 2013 because of the reduction of the fertilizer and pesticide industry following the reduction of the arable sector, increasing surplus emissions up to184 × 10^3 tCO_2 by 2012, 303 × 10^3 tCO_2 by 2020, and 421 × 10^3 tCO_2 by 2030.

A comprehensive analysis of greenhouse gas emissions and allowable emissions in the entire agricultural sector shows that the surplus emissions secured from emission reduction in the arable sector exceeds the reduction objective imposed on the livestock sector. As a result, the total surplus emission in the entire agricultural sector is estimated to continue increasing to 1,705 × 10^3 tCO_2 in 2013, 3,456 × 10^3 tCO_2 in 2020, and 5,326 × 10^3 tCO_2 in 2030 <Figure 4-1>.

Figure 4-1. Allowable GHG Emissions and Surplus Emissions in the Entire Agricultural Sector



2. Economic Impacts of Each Emission Reduction Scenario[1]

2.1. Impacts of Emission Trading System (ETS)

In order to measure the impacts of 3 emission reduction scenarios on the industrial sector when the reduction commitment level in 2013 is set at 5% below 2000 emission levels, the dynamic CGE model, a general equilibrium approach, was used.[2]

Three types of emission reduction scenarios to comply with the UNFCCC were analyzed: Scenario 1 that implemented emission reduction objective individually; Scenario 2 in which all industrial sectors participated in ETS; and Scenario 3 in which only non-agricultural sectors participated in ETS <Table 4-1>.

Table 4-1. Emission Reduction Scenarios to Comply with the UNFCCC

Scenario	Description
Scenario 1	Each industry implements its emission reduction target individually (Reduction cost per ton in each industry)
Scenario 2	All industries meet their reduction targets through ETS.
Scenario 3	Non-agricultural sectors (food, manufacturing, service, and fossil fuel sectors) are allowed for emission trading, while the agricultural sector implements the reduction commitment individually.

Emission reduction costs appeared not to have significant differences among scenarios. For Scenario 1, the cost of reducing a ton of greenhouse gas in the in-

1 Measurement of economic impacts of emission reduction scenarios on the agricultural sector presented here is a brief summary of the results of the 1st year study. For detailed information about this, please refer to the 1st year study report (Changgil Kim, Taeyoung Kim, Yonggwang Shin, 2006).

2 Regarding the analysis of impacts on the agricultural sector from the macro-economic perspective under the UNFCCC, dynamic computable general equilibrium (CGE) model was applied to measure dynamic impacts before and after the application of reduction policies as well as static effects at the time of emission reduction (Changgil Kim, Taeyoung Kim, Yonggwang Shin, 2006, pp.41-42).

dustrial sector that exceeded the allowable emission level after 2013 was calculated at USD 2,522 for pig farming, USD 2,504 for poultry farming, USD 601 for cattle farming, USD 479 for the food industry, USD 404 for manufacturing and service industries, and USD 9.6 for the fossil fuel industry. For Scenario 2 that applied ETS for the entire industrial sectors, a single trading price of USD 35 per tCO_2 was fixed for all industrial sectors (as of 2013), which appeared to continue increasing as the reduction objective increased. As the entire industrial sectors participated in ETS, the price of emission trading in the livestock sector and food, manufacturing and service industries, whose reduction costs were very high at the time of individual implementation, appeared to decrease significantly, cutting down the cost of emission reduction. In Scenario 3 in which the agricultural sector implemented its reduction measures separately while non-agricultural sectors participate in ETS, the cost of emission reduction in the livestock sector which had reduction objective increased in comparison to Scenario 1 but in non-agricultural sectors except the fossil fuel sector, the price of emission trading appeared to rise slightly. In particular, the price of emission trading went up in the non-agricultural sectors if the agricultural sector did not participate in emission trading. Therefore, it appeared to have a positive influence on the non-agricultural sectors when the agricultural sector participated in emission trading.

If the economic effects of emission reduction by each scenario are compared, the economic effects of emission trading system (Scenario 2) over individual implementation (Scenario 1) appeared to be USD 74.3 million in the arable sector, USD 550 million in the livestock sector, and USD 7.7 million in the agriculture-related industry, totaling USD 632 million in the entire agricultural sector. Also, the economic effects in the non-agricultural industries amounted to USD 41,724 million in the manufacturing and service industry and USD 2,802 million in the fossil fuel industry, totaling USD 45,144 million. So, it was estimated that if all industrial sectors including the agricultural sector participated in ETS, an additional economic effect of USD 4,746 million would be generated.

On the other hand, if the economic effects of only non-agricultural sectors participating in ETS(Scenario 3) are compared with those of individual implementation (Scenario 1), no economic effects were created in the arable sector and the agriculture-related industry that did not have reduction objectives, but an additional reduction cost of USD 37 million was incurred in the livestock sector due to individual implementation, totaling USD 37 million of reduction cost in the entire agricultural sector. It was also analyzed that through participation in ETS the non-agricultural sectors would have economic profits of USD 40,915 million in the manufacturing and service industries and USD 4,723 million in the fossil fuel sector, totaling USD 45,638 million.

With regard to the income and expenses through the sales of emission credits by each sector participating in ETS, it was analyzed that the arable sector that had surplus emissions could not sell emission credits under the individual implementation scenarios (Scenario 1, Scenario 3) and thus did not generate any income. However, if the arable sector participates in ETS (Scenario 2), it would be able to keep generating an income of USD 74 million in 2013, USD 174 million in 2020, and USD 421 million in 2030 from selling CERs.

On the other hand, in the case of the livestock sector that has emission reduction objective, the reduction cost under Scenario 1 and Scenario 3 was very high, amounting to USD 642 ~ 679 million in 2013. However, when the agricultural sector participated in ETS (Scenario 2), the reduction cost decreased to USD 92 million, cutting down 85.7～86.4% of the total reduction cost. Even though the reduction cost of the cattle breeding industry, which accounted for 62.1% of the livestock sector, continued to decrease and thus reduced the cost difference between individual implementation and ETS, it was found to be advantageous for the livestock sector to participate in ETS.

As the agriculture-related industries had the same surplus emissions as the arable sector because of continuous reduction in output and improvement of energy efficiency, it would not be able to generate any income if they have to reduce emissions through individual implementation. However, it was analyzed that by participating in ETS they would be able to earn an income of USD 7.7 million in 2013, USD 15.8 million in 2020 and USD 35 million in 2030 from selling emission credits.

When the entire agricultural sector participated in ETS in 2013, the expenditure that the livestock sector spent to buy emission credits was more than the income that the arable sector and the agriculture-related industries earned by selling surplus emission credits by about USD 10 million. However, it was analyzed that as the income that the arable and agriculture-related industries earned from selling surplus emission credits continued increasing after 2014, it would exceed the expenditure of the livestock sector by USD 104 million in 2020 and USD 382 million in 2030. On the other hand, it appeared that if the agricultural sector implemented its reduction objective on its own without participating in ETS, it would not be able to sell surplus emission credits generated in the arable sector and agriculture-related industries but only have the burden of reduction in the livestock sector and therefore it would have to spend more for buying emission credits.

Concerning the change in income from selling emission credits and products both in the arable and livestock sectors, the income from selling emission credits in the arable sector appeared to be more than the expense of buying emission credits in the livestock sector by USD 17.7 million in 2013, resulting in the reduction of net income by USD 366 million, which was more than the decrease (USD 348 million) in the actual product sales. However, it was found that, as the income from selling emission credits in the arable sector after 2014 exceeded the expense of buying emission credits in the livestock sector, it would offset the decrease in the actual product sales.

2.2. Impacts of Carbon Tax

The impacts of imposing carbon tax on the agricultural energy (at a tax rate of 30%) on controlled horticulture, controlled floriculture and livestock were analyzed using partial equilibrium approach. When carbon tax was introduced for greenhouse gas reduction, it had a significant impact on the agricultural management cost depending on how much oil, electricity and coal used for agricultural machinery and heating accounted for. As the energy cost of producing chemical fertilizers and mixed feeds accounted for a considerable portion of the production cost as they are major inputs in the agricultural and livestock sector, carbon tax appeared to have a direct impact on the rise of agricultural management cost.

It appeared that when carbon tax was imposed on the fossil energy sector (assuming a carbon tax rate of 30%), the rates of agricultural management cost rise would be 18.9% for controlled citrus fruit cultivation, 11.2% for controlled rose cultivation, and 10.7% for controlled cucumber cultivation in the order of relative importance of their energy costs. As for the livestock sector, it was analyzed to be 6.7% for finishing pigs, 6.4% for layer chickens, 6.3% for breeder cows, 4.0% for milking cows, and 3.2% for beef cattle.

The analysis showed that the carbon tax imposed for emission reduction would put a considerable pressure in the short run on agricultural management cost in the controlled vegetable and floricultural sectors that are highly dependent on fossil energy.

It was analyzed that when emission reduction objective is imposed, the agricultural sector would be able to minimize the economic burden by actively participating in joint reduction efforts such as emission trading system involving the entire industries. Also, it appeared to be necessary to develop technologies to save fossil energy in the controlled agricultural sector and the livestock sector.

3. Analysis of Potentials of Emission Reduction Measures

3.1. Approach to Analysis of Emission Reduction Potentials

Greenhouse gas reduction potential (reduction capacity) is calculated by subtracting the annual emissions generated after reduction measures are taken from those generated without reduction measures. When there are emission reduction measures in force and more powerful measures can be put into force additionally, more emission is reduced and reduction potential increases more.

There is a difference between reduction potential and actual reduction, and the reduction potential varies with emission reduction standards. Technical potential refers to the potential of all measures that are technically feasible, while economic potential refers to the potential that can satisfy economic efficiency on top of the technical potential. In order to estimate the economic potential, economic evaluation of applicable technologies should be performed and the policy factors supporting the application of developed emission reduction technologies should be considered. Because the economic evaluation of each technology that is applied in real life requires considerable research, reduction potential in this paper was evaluated focusing on technical potential. In order to draw actual reduction closer to economic reduction level, investment risk factors and institutional obstacles that might act as reasons for market failure should be removed. In order to evaluate the potential of emission reduction technologies developed in the agricultural sector, three scenarios were developed depending on the baseline and conditions for technology application.

The first scenario, the one without any regulations or measures, was established as the baseline for comparison with other scenarios.

The second scenario sets the emission level at 5% below the 2000 emission level, representing cases where proper measures are taken to stabilize emission reduction.

The third scenario sets the emission level at less than 5% below the 2000 emission level.

3.2. Analysis of Effects of Each Greenhouse Gas Reduction Measure in Crop and Livestock Sector

Regardless of a variety of emission reduction measures suggested in the agricultural sector, the study in this report estimated emission potential based on emission targets with high feasibility or that had been evaluated to be achievable within the scope of existing research results.

3.2.1. Methane Reduction Potential of Direct Sowing of Rice on Dry Fields

An element that has the most significant impact on methane emission in rice farming is irrigation method. It appeared that direct sowing of rice on dry field could reduce methane emissions by 40~55% more than water sowing or transplanting cultivation (Jaegyu Lim et al., 2006). The total land area appropriate for direct sowing in Korea was 704,000 ha as of 1992, of which up to 42.7% (dry field 12.3% and dry field + watered field 29.4%) was estimated to be available for direct sowing on dry field. In this study, methane reduction potential was estimated assuming that 30% of total rice farming area would be available for direct sowing on dry field by 2020 as rice farming area showed a decreasing tendency. The estimation under this assumption showed that the methane reduction potential of direct sowing of rice would be 14.1%, a reduction of 809 × 10^3 tCO_2.

3.2.2. Nitrous Oxide Reduction Potential of Nitrogenous Fertilizer Control

The nitrous oxide (N_2O) emission from arable land is in proportion to the amount of nitrogenous fertilizers used. Owing to the increase of land adopting environment-friendly agriculture in Korea, the consumption of chemical fertilizers would be reduced by 40% in 2020. Based on the 40% reduction of chemical fertilizers, N_2O reduction potential was estimated, which would be about 791x 10^3 tCO_2 in 2020.

3.2.3. Emission Reduction Potential of Soil Organic Carbon in Arable Lands

The increase of soil organic carbon(SOC) has the effect of mitigating global warming by increasing the oxidation capacity of methane gas in soil. It was estimated that SOC storage had been lost by more than 30% since 1930 because of productivity-oriented intensive agricultural activities and loss of soil (Wongyo Jeong, 2007b).

To increase SOC storage, there are various methods such as reduction of soil tillage, restoration of crop residue to soil, prevention of soil erosion through mulched crop cultivation, conservation farming methods, and appropriate nourishment control. Though it is known to take time for the soil depleted of organic substances to recover its original condition, no research has been made on this matter. So, the objective was set to increase 3% of SOC by 2020, which was 1/10 level of the lost amount. In this case, the emission reduction through SOC sequestration by 2020 was estimated at 231 × 10^3 tCO_2.

3.2.4. Fossil Fuel Reduction Potential through Cultivation of Energy Crops (Rapes)

Energy crops such as rapes can replace fossil fuels. According to an analysis of the effects of cultivating rapes for bio-diesel, it was estimated that of 550,000 ha of potential rape fields which were abandoned during the winter season, about 319,000ha would be available for growing rapes (Sangho et al., 2005).

Based on this analysis result, the emission reduction potential of growing rapes on the area of about 300,000 ha by 2020 was estimated at 1,272 x 10^3 tCO_2.

3.2.5. Emission Reduction Potential of Improving Rumen Fermentation and manure Treatment Facilities in the Livestock Sector

Methane emission from rumen fermentation could be reduced by about 35% with direct or indirect methods such as good-quality roughage feeds, use of feed additives and improvement of livestock reproductivity. However, considering the increase in the number of head of cattle and the limit of using such methods, it was estimated that realistic potential would be at 7.8% in 2020. Greenhouse gas emission from livestock manure decomposition was also estimated to be around 12.9% when calculated in consideration of the time when reduction technologies would be used and the occupancy rate of each facility type. Therefore, the overall emission reduction potential of the livestock sector was estimated at 8.4% in 2020 (Taeyoung Thak et al., 1995).

Reflecting this estimation, the emission reduction capacity of the livestock sector in 2020 was estimated at 571 × 10^3 tCO_2.

3.2.6. Comprehensive Effects of Reduction Measures in Crop and Livestock Sector

The emission reduction capacity of greenhouse gas reduction measures in the arable and livestock sectors in 2020 is projected to be 3,675 × 10^3 tCO_2, about 25.3% of total emissions in the agricultural sector. It was expected that emissions after greenhouse gas reduction would be 10,828 × 10^3 tCO_2 in 2020,which would be about 31% less than 2000 level

(15,693 × 10^3 tCO_2).

When the 5% below baseline (2000) is decided as the allowable emission level in 2013 under the Kyoto Protocol, surplus emissions would exceed the emission cap by 44 × 10^3 tCO_2 when greenhouse gas reduction measures are not in force in 2013, and thus reduction objective would be imposed. However, it is estimated that if greenhouse gas reduction measures continue to be in force, surplus emissions of about 875 × 10^3 tCO_2 would be generated in 2020.

Table 4-2. Estimation of Reduction Capacity of GHG Reduction Measures and Emissions after Reduction

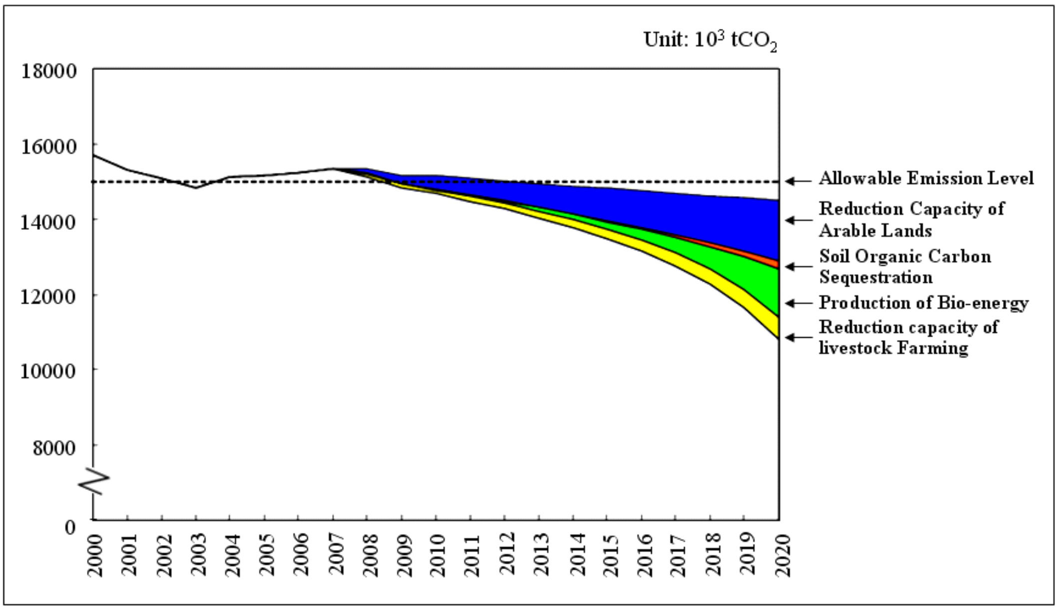
Unit: 10^3 tCO_2

Year	Emission before Reduction	Surplus Emission before Reduction1)	GHG Reduction Capacity						Emission after Reduction	Surplus Emission after Reduction
			CH_4 from Rice Paddy	N_2O from Arable Land	Soil Organic Carbon Sequestration	Bio-energy Production	GHG Reduction in Livestock	Total Reduction		
2013	14,953	-44	188	453	12	89	178	919	14,034	875
2015	14,823	86	302	562	27	190	248	1,329	13,494	1,415
2017	14,687	221	458	658	64	405	347	1,932	12,756	2,153
2020	14,503	406	809	791	231	1,272	571	3,675	10,828	4,081

Note: 1) Surplus emission refers to the amount that can be emitted additionally because of reduced emission in each year in comparison with 2000 emission level, and -surplus emission refers to the reduction objective.

Though the surplus emission before reduction in 2020 was 406 x 10^3 tCO_2, it increased 10 times to 4,081 x 10^3 tCO_2 when reduction measures were taken. Therefore, if the emission trading system is put in force among domestic industries, it would serve as an important opportunity for the agricultural sector.

Figure 4-2. Total Emissions and Reduction Estimation in the Agricultural Sector



Chapter 5. National Case Studies

1. Japan

1.1. Greenhouse Gas Emissions and Measures

Japan has an area of 37,790,000 ha (as of 2005), which mainly consists of forests of 25,320,000 ha (67%) and farmlands of 4,690,000 ha (12.4%). The country has recorded an annual economic growth rate of 1~2 %since 2000, thus increasing GHG emissions.

GHG emissions (as of 2005) total 1.361 billion tons of CO_2, of which greenhouse gas emissions in the agricultural sector reached 2.98 million tons of CO_2 (2.4%). Total GHG emissions increased 7.8% compared to 1990 (baseline of obligatory reductions as specified by Kyoto Protocol) but dropped 10.9% in the agricultural sector. The GHG emissions from the agricultural sector mostly consist of non-carbon dioxide: methane (69.5%) and nitrous oxide (57.2%).

According to Kyoto Protocol, Japan is obliged to reduce GHG emissions by 6 % during the first commitment period, compared to 1990 (baseline). However, GHG emissions increased 7.8% in 2005 from1990 and an actual reduction of 8.4% should be implemented during the period, thus making it not feasible to implement the 6% target. To cope with this situation, works are underway to reevaluate and modify a plan so that targets can be accomplished. The government organized “Headquarters for Preventive GHG Measures,” which consists of relevant departments for the implementation of reduction commitment, and has proceeded with policy related programs. From 2005 onward, the emission trading system has been performed by participating parties to carry out voluntary GHG reduction in Japan. In June 2007, ‘21st Century Strategies for Establishment of Eco-friendly Government’ was published as a national project against global warming and 'Comprehensive Strategies for Adaptation to Climate Changes' (2007) was announced by the Department of Agriculture & Fishery. The latter focused on promoting forest sinks, GHG emissions reduction in agriculture and livestock sectors, and adaptation to global warming and international cooperation.

1.2. Preventive Measures Against Global Warming in Agricultural Sector[3]

The major measures for agricultural GHG reductions include establishment of reduction targets, cyclic utilization of biomass resources directly related to reduction targets, and voluntary environmental campaigns in the food industry, etc. The sectors where reduction targets were not established have been performing voluntary reduction measures, including reduction of GHG emissions from cultivation facilities and farming machines and optimal reduction of manure resulting from eco-friendly farming. The department's comprehensive measures against global warming, which are categorized into the three divisions of reduction, adaptation, and international cooperation, are described below.

1.2.1. GHG Reductions in Agricultural Sector

A. Measures directly related to reduction commitment in agricultural sector

To implement the obligatory reduction required by the Kyoto Protocol, the government set up Kyoto Achievement Plan and mapped out specific details. In direct relation to the national GHG emissions reduction targets, the first measures are biomass utilization and voluntary practices that can be performed by the food industry. The cyclic utilization of biomass resources is a core portion of emissions reduction in agriculture because biomass has carbon neutral property, resulting in not increasing the

3 Japan's strategies to climate changes in agricultural sector are extracted from the text presented in 'The Ministry of Agriculture & Forestry's comprehensive strategies to climate changes (2007).' The comprehensive strategies are cited by Kim Chang-gil and three authors (2007).

level of carbon dioxide in the air.[4] The government supports the development of technologies which enable the efficient production of bio-ethanol through the cultivation of energy crops such as rice straws and woods, and it plans to establish local biomass towns in 300 areas by 2010. The local biomass towns use various biomass resources not existing in agricultural areas to achieve an estimated reduction of 1 million CO_2 tons. The second measure refers to voluntary environmental activities in food industry. The government encourages 16 food enterprises (14 food manufacturers, 1 food distributor and 1 food service industry) with higher energy consumption (base year 2006) to perform voluntary GHG reduction and estimates these sectors account for about 50% of GHG emissions. The GHG reduction is targeted at approximately 4.24 million CO_2 tons for 2010 through voluntary environmental activities in food industry. The government also actively promotes reutilization of food wastes for feeds or fertilizers while inhibiting large quantities of food wastes from food industry according to the Regulations of Promotion of Recyclable Food Resources (hereinafter referred to as the Act of Recyclable Foods, enacted in 2000 and effective in 2001).

B. Agricultural measures not associated with obligatory reduction

Voluntary reduction measures in agricultural sector, with less relation to GHG reduction specified by the Kyoto Protocol, include i) emissions reduction from cultivation facilities and farming machines, ii) optimal use of manure with eco-friendly farming, and iii) GHG emissions reduction in livestock sector. Reduction measures for emissions from cultivation facilities include promotional activities for energy saving and energy efficiency, introduction of energy saving facility models, distribution of energy saving and management manuals, and application of high efficiency heaters. Reduction measures for emissions from farming machines include provision of energy saving farming machines and utilization of bio-diesel machines, development and commercialization of farming machines that contribute to GHG emissions reduction. The reduction target is set at about 250,000 CO_2 for 2010. The following measures are recommended so that eco-friendly farmers can implement GHG emissions reduction: pop-

4 What biofuel is carbon neutral means is that carbon dioxide is not generated from biofuel burning. The carbon dioxide is absorbed in the air through photosynthesis during which biomass grows, and thus net emission is zero.

ularization of GAP (Good Agricultural Practices), soil cultivation through use of manure and technical guidance on reduction in the use of chemical fertilizers, recommended use for optimal amount of manure by area and product, and reduced use of chemical fertilizers through promotion of organic farming. Measures are actively being taken especially for simple irrigation for the reduction of methane emissions from arable lands, decomposition of straws, use of slow release fertilizers, and nitrous oxide reduction through improved fertilizing techniques. The reduction amount is targeted at about 167,000 CO_2 for 2010.

The reduction measures for GHG emissions from livestock sector include utilization of biogases from livestock manure and increasing the self-supporting rate of feeds. Seventy five plants using biogases from livestock manure are in operation from 2006. Extended use of straw as feeds and decreased straw burning contribute to reductions in nitrous oxide and methane emissions. The Japanese government establishes and performs systematic programs including the guidance on the provision of straws and the establishment of broad distribution networks to raise the self-supporting rate of feeds. Micro-hydro power plants using agricultural water are built in local areas and utilized as a power generating source for irrigation facilities, and the campaign, 'Local Production for Local Consumption' is on the increase so as to encourage residents to carry out eco-friendly living practices.

1.2.2. Adaptation to Climate Changes in Agricultural Sector

Adaptation to global warming in agricultural sector includes systematic measures such as cultivation of species and technology development for the stabilization of production based on climate change forecasts in the future. The government prepares the guidelines based on reports and process charts related to the adaptation to global warming and distributes them to cultivation fields. Agricultural water and irrigation facilities are expected to be largely affected by climate change, so adaptive measures for these are under deliberation. In particular, appropriate measures are taken into consideration based on short and long-term projections for global food demand and supply in the context that global warming directly affects crop harvest in relation to local food demand and supply, and the demands for both biofuels and source crops for biofuels are increasing around the world.

1.2.3. Technology Development Relating to Greenhouse Gases

The technologies in agricultural sector are divided into three categories: GHG emissions reduction, development of emission factors for reliable statistics, adaptation techniques to global warming. For GHG emissions reduction, research and development activities are underway in the following fields: livestock breeding (enteric fermentation), livestock manure treatment, and rice cultivation (management of organic matters and water sources). To explain the mechanism of sequestering organic carbon in soils, a carbon dioxide circulation model is being developed and techniques of reducing emissions and technologies of facilitating carbon sinks are developed. The government continues to promote studies on calculation of emission factors to identify GHG emissions. In addition, studies are being performed for livestock manure management, factor estimation of GHG emissions resulting from the use of organic fertilizers in arable lands, fertilization of food wastes and LCA relating to GHG emissions and evaluation of contribution.

2. United States

2.1. Status of GHG Emissions

The United States has an area of 919.20 million ha (as of 2005), of which farming lands account for 137.6 million ha (15%). The country has been posting an annual economic growth rate of 2 to 4 % since 2000, thus increasing GHG emissions.

In the U.S., GHG emissions total (as of 2005) 7.2604 billion CO_2 tons, of which GHG emissions from agricultural sector reach 536.3 million CO_2 tons (74%). A total of GHG emissions increased 16.3% in 2005 and emissions from agricultural sector 1.1 % compared to 1990. GHG emissions from agriculture include i) methane emissions that result from enteric fermentation and manure treatment (of livestock) and rice cultivation and burning of agricultural byproducts and ii) nitrous oxide that results from the use of fertilizers in farmlands and livestock manure treatment. GHG emissions from agriculture mostly consist of non carbon dioxide [methane (29%) and nitrous oxide (78%)].

2.2. GHG Emissions Reduction in Agriculture & Fishery Sectors[5]

The government advances programs focusing on carbon sequestration and biomass production for the reduction of GHG emissions from agriculture. The government pays higher interest in the strategies of reducing GHG emissions through carbon sequestration because it has a wide area of land. Exact evaluation of carbon sequestration in croplands should be based on the condition of reliable scientific analysis. Reducible GHG emissions from carbon sequestration are estimated to be approximately more than 10% of GHG emissions in total. Supposing that the Kyoto Protocol specifies the government to reduce about 14.55 billion tons of CO_2 out of GHG emissions, the possible amount of carbon sequestration would be about 720 million tons of CO_2, which would account for 50% of obligatory reduction. Carbon sequestration is usually possible through extensive farming, conservation tillage or no tillage or in case farmlands are converted into large grasslands or forests. Compensations and incentives should be appropriately granted to expedite carbon sequestration that entails a large amount of expenses. The government has huge human resources including agricultural producers and landowners, but it appears to have administrative difficulties in carrying out carbon sequestration programs.

Recently, the government has an eye on an environmental credit trading system that allows to trade GHG emissions owing to carbon sequestration. Through the system, allowable GHG emissions from agriculture can be purchased by a non-agricultural sector. In other words, the system gives a credit for the agricultural sector’s contribution to GHG emissions reduction. One example of group activities in relation to carbon sequestration is Climate Trust, a non-profit organization which engages in trad-

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5 The U.S.A.'s strategies to GHG emission reduction in agricultural sector is extracted from 'United States GHG emission reduction strategies in agricultural sector' authored by Kim Man-geun. The report of United States GHG emissions reduction strategies is cited by Kim Chang-gil and three authors (2007).

ing credits and carries out pilot projects for GHG emissions reduction.[6] The group collects joint funds from enterprises that have carbon emission rights and purchases or trade credits that it obtained for itself. It is responsible for selling credits obtained from the Chicago Climate Exchange. The carbon sequestration policies introduced by the agricultural sector include voluntary participation, controls and ordinances, taxes or subsidies, or contributions. In addition, what is important is whether more emphasis is placed on public ownerships or private property rights in carrying out policies. Two critical factors in the policy making are economic expenses and environmental effectiveness. The expenses for carbon sequestration can be referred to as carbon price per ton. A series of carbon sequestration related studies performed over the last 15 years estimated the carbon price per ton and the potential carbon sequestration capacity. The government should prepare specific subprojects including documentation, budgeting, research supports, and education & training for producers for the establishment of extensive infrastructure related to carbon sequestration policy. Policy makers should consider eco-friendliness, effectiveness, and legality at minimized costs that would be paid for carbon sequestration programs.

Biofuels or bioenergy using biomass as potential means of GHG emissions reduction attract more attention as they can replace fossil fuels. A recent trend is that more emphasis is put on biofuel production since energy expenses rapidly increase with increasing oil prices. The reason why biofuel is responsible for GHG emissions reduction is that the new energy source is carbon neutral, in other words, because it does not alter the level of carbon dioxide in the air. In reality, net GHG emissions will not be zero as GHG can be generated from nitrogen fertilizer used in the production of biomass, from farming machines or while biomass resources are delivered and transformed into biofuels. An economic model assumes that the efficiency of carbon cycle would be actually 80~90 %, which means that 80~90 % of carbon dioxide from burning biofuel might be reused. The key factors for successful utilization of biofuels are biomass production technology and biofuel conversion technology. It is expected that 30 % of total oil consumption may be replaced by biofuels if it is possible to produce biomass resources and convert them into energy at optimal expenses (Perlack et al,

6 The details of Climate Trust can be found at (http://www.climatetrust.org/).

2005). Biofuels play critical roles in diversifying energy sources as well as in making up strategy portfolios for UNFCCC and contributes to new sources of income in farm villages.

Currently, newly emerging biofuel sources are an ethanol group from corns or sugar canes. The production of ethanol rapidly increases with soaring oil prices and under the protection of Energy Policy Act of 2005 enacted by the government. The production costs largely depend on corn prices and reach approximately $1.20 per gallon including capital costs. It is predicted that ethanol has an advantage if oil prices continue to increase in the near and far distant future (USDOEEIA, 2005). Another source of biofuel is biodiesel, which is generally originated from soybean oil. The interest in biodiesel increased recently because the Department of Agriculture in the U.S. granted tax favors to soybean oil producers. However, biodiesel production capacity, unlike ethanol, is not expected to highly increase due to the competition with soybean oil in the market.

2.3. Step-by-step Approaches to Programs

Policy makers should prepare carbon sequestration programs that are cost-effective and feasible systematically, legally and politically. Commands and controls can be exercised by the government depending on policy means, and decision making may be freely made by landowners. Costs for carbon sequestration may be transferred to tax payers or businesses that are responsible for GHG emissions. For adaptation to climate changes, the following four stages are applicable so that policy means may be effectively exercised.

First, at the stage of governmental production, carbon sequestration policy can be carried out by the Department of Agriculture and related research centers. For carbon sequestration and GHG emissions reduction, ecologically concerned organizations can perform education, training and research, serving as information providers. NRCS, under the supervision of the MOA, US, provides training for landowners in soil and water resources protection areas and gives cyber education and information relating to carbon sequestration through websites.

Second, at the stage of command-and-control, the government obliges farmers and individual landowners to do specific carbon sequestration activities and charges the costs entailed accordingly.

Third, at the stage of practice-based incentives, the government gives financial incentives for carrying out carbon sequestration programs and encourages farmers or land proprietors to introduce the programs.

Fourth, at the stage of result-based incentives, private land proprietors are motivated to achieve carbon sequestration targets at minimal expenses. Participants in policies are given opportunities to individually cope with situations, depending on land properties and regional environments. The result-based incentive programs entail measurements, monitoring, and costs for verifying performances, while the practice-based incentive programs can be identified by voluntary reports or visual monitoring.

2.4. Voluntary Methane Program

The voluntary methane program is the program which the Office of Environment, U.S.A, initiates to reduce methane emissions in cooperation with industrial fields and state governments. AgSTAR program, in particular, induces users to utilize methane emissions from livestock manure treatment as a source for power generation by using the system of restoring biogas.

2.5. Financial Supports and Reduction Policy Portfolio

The United States Department of Agriculture has been operating a financial subsidy system for voluntary GHG emissions reduction since 2003. The Department induces farmers to adopt less intensive tillage or no tillage to increase the carbon sequestration capacity and decrease the chances of using farming machines or fertilizers, resulting in GHG emissions reduction.

Carbon credits can be considered to be a means of reducing GHG emissions from agriculture and forestry sectors, differently from credits obtained from direct reduction since carbon sequestration is characterized by continuity, supplementation, leakage, or uncertainty. It is therefore needed that targeted GHG emissions reduction from carbon sequestration should be lowered in price or quantity.

3. EU

3.1. Measures to Comply with Kyoto Protocol in EU

3.1.1. Implementation of Kyoto Protocol in EU

EU members signed the Kyoto Protocol in April, 1998 and announced its commitment to achieve an emissions reduction 8% lower than the base year 1990 during the first commitment period. For guaranteed implementation of GHG emissions reduction, 'Burden Sharing Agreement' was signed in June, 1998, and 15 EU members were individually allotted emission targets at that time. Each member should be obliged to implement its GHG emissions reduction target according to the agreement, and 10 new members of EU are not subject to the agreement but should implement individual targets specified by the Kyoto Protocol.

In 2000, the EU initiated the European Climate Change Program (ECCP) and presented eco-friendly and cost-effective specifics to be applied by industrial sectors for the implementation of GHG emissions reduction targets. The Community announced Emission Trading System (ETS) that would be utilized by manufacturers and energy enterprises (about 11,500 establishments in 27 EU members). The establishments, which are subject to EU ETS, are assigned allowable GHG emissions and if they have an excess of allowable GHG emissions, they should purchase trading rights from enterprises that have excess emission allowances in the market and should be subject to fines for emissions exceeding targets. The scheme was not successful at the initial stage but is expected to significantly contribute to further GHG emissions reduction. There were controversies about whether to include agricultural sector in EU ETS and consensus could not be reached among members due to uniqueness of agriculture sector and regional differences in emission sources and difficulties in monitoring (DEFRA, 2007). In relation to GHG emissions reduction, EU Common Agricultural Policy supports 45 euro per ha for production of energy crops in non-arable lands.

EU established 'Integrated Energy and Climate Package' in Jan., 2007, which specified prospective programs including 20% GHG emissions reduction for 2020, 20 % increase in energy efficiency, and 20% shares of recycle energy.

3.1.2. GHG Emissions and Measures in Agricultural Sector[7]

In 2005, GHG emissions from the agricultural sector recorded about 9% of total GHG emissions in 27 EU members, significantly higher than the portion which the agricultural sector accounts for in overall industry sectors.

The agricultural industry is considered to generate more GHG emissions second to the energy industry. According to CAP which weighed environmental aspects, the agricultural industry in EU has been on the decline with decreasing production capacity since 1990 and GHG emissions decreased about 11% (compared to 1990) due to the decreasing number of livestock and reduced uses of chemical fertilizers and are expected to further decrease in the future.

In relation to sustainable agricultural environmental policy, GHG emissions reduction measures against climate changes are propelled by feasible practices: improvement of fertilization efficiency, good farming practices, and bioenergy crops production. Major measures to reduce GHG emissions from the agricultural sector include bioenergy crop production, organic farming, utilization of Kyoto mechanism, soil organic carbon sequestration, and development of reduction technology. Bioenergy crops production can contribute to GHG emissions reduction by replacing fossil fuels with recyclable energy sources. Bioenergy crops grown in the EU include oilseed crops such as rapeseed, cottonseed, wild mustard, hemp, and sunflower. Agricultural programs are developed and applied for the promotion of straw utilization and the production of biogas from livestock manure as a bioenergy source in the agricultural sector. For GHG

7 EU's agricultural strategies to Kyoto Protocol are in large part extracted from "EU measures to comply with Kyoto Protocol in agricultural sector' authored by Dr. Anderson. The report of EU strategies to GHG emissions reduction is cited by Kim Chang-gil and three authors (2007).

emissions reduction, organic farming can be practiced. There are poor results of studies on whether organic farming can contribute to GHG emissions reduction. Obviously, organic farming practices reduce the use of mineral fertilizers such as nitrogen fertilizer that generate nitrous oxide emissions, and the use of organic fertilizers for the enhancement of soil fertility can contribute to GHG emissions reduction.

For the utilization of the Kyoto mechanism in the agricultural sector, CDM projects may be promoted for the reduction of enteric fermentation, improved livestock manure management, management of agricultural resources such as fertilizers and chemicals, improved rice cultivation, and biogas production plants. Yet, the project is not in full swing. CDM methodologies approved by UNFCCC are presented for GHG emissions reduction through improved livestock (hog) manure treatment system. Standardized methodologies are under study for the application of CDM projects and CDM methodologies (ACM0010) in agriculture and livestock sectors. Currently, there are approximately 2,551 CDM based projects in the EU, among which 177 projects (66%) are related to the agriculture sector. For CDM projects in the agricultural sector, 94 projects initiated by 10 approved buyers are on the right track. Soil carbon sequestration is one example of measures for reducing GHG emissions from agriculture. For the utilization of lands and forests, carbon sinks are considered GHG absorption sources as specified by the Kyoto Protocol. There are debates about the applicability of carbon credit trading in LULUCF in relation to non-arable lands, fallow lands and forests. Unfortunately, less effective incentives are still available for soil carbon sequestration as means of GHG emissions reduction. Concerning recent measures to cope with the Kyoto Protocol, uncertainty of soil carbon sequestration and leadership in UNFCCC are under heated discussions. It is therefore required that the rate of organic carbon accumulation in farmland, sustainability and measurement of carbon sinks, and interaction with natural elements should be analytically studied in relation to LULUCF.

3.2. Denmark

3.2.1. GHG Emissions from Agricultural Sector

Denmark has an area of 4.3 million ha (as of 2003), which mainly consists of forests of 470,000ha (11%) and farmlands of 2.65 million ha (62%). The country has recorded an annual economic growth rate of 2~3% since 2000, thus increasing GHG emissions. GHG emissions reached a total of 7.4 million CO_2 tons in 2003, of which GHG emissions from the agricultural sector account for approximately 17 %, (12.5 million CO_2 tons) consisting of both methane and nitrous dioxide (about 80% in total) and carbon dioxide (20%) (Danish Department of the Environment, 2005). The majority of methane emissions, in particular, come from the agricultural sector, reaching 176,000 tons in 2003 (equivalent to 3.7 million CO_2 tons). Methane emissions generally come from dairy cattle breeding (from enteric fermentation and manure in livestock). Nitrous oxide from the agricultural sector reached 26,000 tons, of which about 20,000 tons (equivalent of 6.2 million CO_2 tons) are estimated to have come from livestock manure and leached nitrogenous fertilizer.

For the implementation of the Kyoto Protocol, the government commits an average of 21 % GHG emissions reductions per year (base year 1990) during the first commitment period according to the EU Burden Sharing Agreement.

3.2.2. GHG Emissions Reduction in Agricultural Sector

For GHG emissions reduction, the government has been carrying out policy programs under the 'Action Plans for the Aquatic Environment,' a core eco-friendly farming program. The government has been exercising them under the Act of Environmental Preservation published in 1989, which prohibits the burning of agricultural byproducts in order not to produce methane and nitrous dioxide emissions. The government has been performing specific programs for the management of aquatic environment since the late 1980s.

The Action Plan for Aquatic Environment I, published in 1987, is intended to prevent the aquatic environment from worsening in Denmark and specifies total emission targets of nitrogen and phosphorous. The plan provides for that a livestock manure slurry tank with at least 9-month capacity be installed for the improvement of water quality and fertilizers be appropriately spread in farmlands.

Nitrogen emissions reduction was not largely performed in 1991 despite the ‘Action Plan for Aquatic Environment,’ and a sustainable farming action plan was established. The plan, which was performed step by step since 1994, stated that chemical fertilizers and livestock manure should be limited per unit area based on a nitrogen quota system that specified crops' nitrogen needs and reflected nitrogen contents in livestock manure. The ‘Action Plan for Aquatic Environment II’ was published in 1998, and it has promoted programs that included compliance with nitrogen contents in crops 10 % lower than economically optimal amount, intensified requirements for using nitrogen in livestock manure, fertilization of manure in organic farming, and increased utilization of biogas.

The ‘Action Plan for Aquatic Environment III,’ unveiled in 2004, was intended to effectively manage the agricultural ecosystem. The plan presented criteria of nitrogen & phosphorous emissions and objectives of farmland management and specified projects to be carried out during a 10-year period (2005 ~ 2015), along with guidelines on the management of water resources and habitats in the EU. The plan projected at least about 13 % nitrogen reduction by 2015 (base year 2003) and outlined strong supports for this, such as the designation of 300m-long buffer zones around vulnerable habitats. In addition, environment tax is applied for the promotion of organic produce in the market. It is estimated that about 200,000 CO_2 ton emissions will be reduced between 2008~2012 with the spread of organic farming.

For nitrous oxide emissions reduction, the Ammonia Action Plan was established in 2001 and related projects have been carried out concerning optimal livestock manure treatment, intensified solid and liquid fertilizer storage, soil confinement after scattering livestock manure, livestock manure confinement and obligation to use slurry container covers, and straw treatment with ammonia. It is estimated that nitrous oxide emissions equivalent to 34,000 CO_2 tons will be reduced by 2010. The mitigation measures for GHG emissions reduction using bioenergy include projects that support biogas plants using livestock manure, and agricultural cooperatives are responsible for the construction, delivery and distribution of storages. In Denmark, about 60 centralized biogas plants and farm-size biogas plants have been built since the late 1980s under the 'Action Plan for Aquatic Environment.' The biogas plants generate biogas using organic wastes such as hog manure, which is decomposed and then delivered to farms for use in farmlands.

3.3. Germany

3.3.1. GHG Emissions from Agricultural Sector

Germany has approximately an area of 3,208 ha (as of 2004), of which farmlands account for 53% (17 million ha), including arable lands (11.9 million ha). Organic farming lands account for 5% of overall farmlands. GHG emissions from the agricultural sector reach about 6% of total GHG emissions and methane and nitrous dioxide emissions significantly comefrom chemical fertilizer and livestock. It is shown that dairy cattle generate 94% methane emissions from the agricultural sector. GHG emissions from agriculture and forestry dropped 16.6% between 1990 and 2003 due to decreases in livestock breeding and use of fertilizers. During the period, methane emissions fell 27% and nitrous oxide emissions 16%.

The government set GHG emissions reduction target at 21% until 2012 (based year 1990) as specified by the Burden Sharing Agreement according to the Kyoto Protocol. At the end of 2003, 18.5% GHG emissions reduction target was already achieved and the government raised the target to 30% for GHG emissions reduction by 2012. It is estimated that the agricultural sector would significantly contribute to GHG emissions reduction.

3.3.2. GHG Emissions Reduction Measures in Agricultural Sector

The government emphasized successful non-carbon dioxide emissions reduction in the National Climate Change Program in 2005, which would be probably expected to continue in the future. GHG emissions reduction measures include ecological land management, soil management, agricultural investment supports, organic farming practices and bioenergy related policies. For ecological land management and organic farming promotion, a federal ecological land management project was initiated in 2002, which was especially intended for about 700,000 ha farmlands. Land management regulations require farmers to comply with good farming practices according to the ‘Federal Land Preservation Act.’ The 'Federal Nature Conservation Act' specifies that cultivation in grasslands should be especially managed for soil carbon sequestration.

Cross compliance direct payments are granted under eco-friendly practices over a 5-year period of contract. Environmental cross compliance programs include supports for perennial crops in arable lands, conversion of croplands as grasslands, organic farming practice, and permanent fallow lands management, and they are carried out by areas, which reach 4.3 million ha, with the budgetary aid of the federal government and the EU CAP. The AFP prepares for financial supports which are provided for control of GHG emissions (for example, biogas facilities, storage and utilization of organic fertilizer, and change in heating system). In order to increase energy production in the agricultural industry, more emphasis is put on the production and extension of recycle energy using biomass resources. The ‘Biofuel Quota Act’ was introduced in 2006 to stimulate bioenergy production with the production quota of recycle energy established.

3.4. United Kingdom

3.4.1. GHG Emissions from Agricultural Sector

The United Kingdom has an area of 24.25 million ha (base year 2004), which mainly consists of grasslands of 12.36 million ha (51%), farmlands of 4.6 million ha (19%), and forests of 2.91 million ha (12%). The country recorded an annual economic growth rate of 2~3% since 2000 and GHG emissions, which totaled 209.5 million CO_2 tons in 1990, fell by about 14.6% to 179 million CO_2 tons in 2004 (base year). GHG emissions from the agricultural sector, which accounts for 77% of total emissions, also dropped by 15.3% from 1990 to 13.8 million CO_2 tons in 2004 (DEFRA, 2006). GHG emissions consist of methane (46%), nitrous oxide (66%), and nitrous dioxide (17%). GHG emissions decreased because popularized eco-friendly farming and decreasing use of chemical fertilizer reduced methane emissions (13%) and nitrous oxide emissions (17%). The government expects that GHG emissions from agriculture will have reduced approximately 32% by 2010 (base year 1990). The government established 20% reduction target (compared to baseline) and presented 60% GHG emissions reduction by 2050 and announced in Jan., 2007 that GHG emissions had decreased 15.6% in 2005 (compared to baseline).

3.4.2. GHG Emissions Reduction in Agricultural Sector

The government established the first climate change program for GHG emissions reduction in 1994 and since then has been carrying out the program. Overall measures to national climate changes are under the supervision of the Department for Environment, Food, and Rural Affairs (DEFRA) and opinions are collected from departments, research centers, industrial circles and NGOs in establishing the project ‘Sustainable Agricultural Produce and Food Strategies.’

For the reduction of GHG emissions from agriculture, ‘2002 Strategy for Sustainable Farming and Food’ was published. The government actively promotes the policy program that raises farmers' and citizen's perception of global environmental issues. As part of it, the government set up several forums including the Rural Climate Change Forum so that farmers, administrators and the parties concerned are inspired to share the awareness of global warming. The forums present practical GHG emissions reduction measures, development of communication strategies and effective delivery of climate change programs. EU CAP includes detachment of direct payment from production and 680, 000 ton emissions reduction per year by 2010 from decreasing number of livestock. The government follows cross compliance to facilitate soil carbon sequestration.

For the reduction of nitrous oxide and methane emissions, ‘Catchment Sensitive Farming (CSF) Program supports irrigation projects in the EU and is carried out especially for the management of nitrate sensitive areas. Livestock manure and fertilizers are advised to be limitedly used within special restricted areas to reduce nitrous oxide emissions. The U.K.IPCC specifies that poultry and pig breeding farmers manage barns in eco-friendly ways and treat livestock manure appropriately for the reduction of ammonia emissions and that the dairy industry promote methane emissions reduction.

For optimal land management, soil management programs are carried out to solve soil related problems including soil carbon loss and soil resources conservation. The government persuades farmers to suspend decreasing organic matters in soils until 2025 and carries out a cross compliance program to prevent soil from erosion and keep organic matters in soils. The government acknowledges organic farming can contribute to GHG emissions reduction and promotes it. It is however necessary that scientific studies should be conducted on how much organic farming may contribute to GHG emissions reduction.

To spur the use of bioenergy, 'Strategy for Non-Food Crops and Uses' was established in Nov., 2004, and since 2007 'Strategy for Bioresources' has been applied to help expand the use of recyclable energy and promote the sustainable development of farming. Core projects include establishment of bioenergy infrastructure, subsidization for bioenergy producers over 5 years, and strategic development of biofuel technology. Single direct payments are delivered for cultivation of energy crops in non-arable lands. Non-food crop farms reached 5,120, about 20% up, from about 4,286 in 2003 and non-food croplands increased about 75% in area.

In addition, the government supports R&D activities including improvement of farming management techniques and utilization of soil carbon sinks and performs strategic studies to explore a feasible mechanism in the market that enables the operation of an emission trading system and feasible alternatives.

3.5. Implications of National Case Studies

The national cases above described are of 'Annex I Signatories' in the Kyoto Protocol, and the countries are obliged to implement GHG emissions reduction from 2008 on. The reduction targets are set at 6% for Japan, 7% for the U.S, 8% for Denmark, Germany and U.K. However, the United States rejected to ratify the agreement and is not obliged to reduce GHG emissions.

GHG emissions from agriculture post less than 7%, except for Denmark (17%) [Japan (2.4%), United States (6.9%), Germany (6%), United Kingdom (7%)]. Although there are some differences among countries, emissions of non-carbon dioxide such as methane and nitrous oxide appeared to account for a significant portion of GHG emissions from the agricultural sector.

For GHG emissions reduction stipulated by the Kyoto Protocol, such signatories as Japan, Denmark, Germany and the United Kingdom agreed to voluntarily reduce GHG emissions from the agricultural sector. Japan sees GHG emissions decreasing (compared to base year) with production capacity falling in the agricultural sector and is committed to voluntary reduction. The government is geared to reduce emissions through energy saving campaigns that agriculture related institutions carry out to reduce electricity consumption. The United Sates sees growing trends that appear to increase GHG emissions in the agricultural sector (base year 1990), and apparently bears the burden of reducing GHG emissions from the agricultural sector. EU members such as Denmark, Germany and the United Kingdom record less production activities in the agricultural sector, which in turn results in accomplishing reduction targets earlier than specified by the Kyoto Protocol, and voluntarily take part in reducing GHG emissions.

As described above, all of the countries face burdensome emissions reduction obligations amid continuing economic growths. They seem to be utilizing national strategic measures including carbon sinks because GHG emissions from agriculture pose a relatively small portion of total emissions but are easy to reduce with decreasing production capacity and technology development. In the agricultural sector, GHG emissions reduction measures include economic or regulatory means, voluntary agreements, R&D activities, and adaptation to climate changes. Measures are commonly implemented in most of the countries: funding of eco-friendly agricultural facilities, promotion of organic farming, bioenergy utilization, R&D activities, and adaptation to climate changes. For economic means, direct payments are a part of cross-compliance programs and include compensating payments for eco-friendly farming and direct payments for GHG emissions reduction, and they are adopted by countries including Denmark, Germany, the U.K and the U.S.

Carbon tax comes into effect in Denmark and the United States and the emission trading system is in full swing in EU countries. Regulatory measures require minimum obligation to meet environmental criteria: regulations on farmers' emissions adopted by Denmark and the Netherlands, obligations to use chemical fertilizer per unit area governed by Denmark, France, Germany, and the Netherlands. Voluntary agreement is closely related to farmers' participation in good farming practices adopted by Denmark, Germany, the U.K and Japan. Bio-town or farmhouses' recyclable resources management is adopted by Denmark, Germany and Japan.

Chapter 6. Measures to comply with GHG Reduction Commitment in Agricultural Sector

1. Basic Policy in Strategy Formulation

The strategy formulation is intended to establish and comprehensively accomplish an emissions reduction target that should be implemented nationwide by the agricultural sector according to the Kyoto Protocol. For GHG emissions reduction, agricultural strategies could significantly contribute to sustainable farming and national economic growth through an eco-friendly low carbon-farming system including voluntary reduction measures and utilization of carbon sinks.

To establish agricultural strategies relating to the implementation of the Kyoto Protocol, a new paradigm of perceptions should be formed between agricultural activities and GHG emissions. The following basic policies may be established in the context that the GHG emissions reduction commitment can be an opportunity to establish an eco-friendly low-carbon farming system.

First, agricultural policies for GHG emissions reduction should be appropriately associated or detached with other policies.

Second, the administrators should actively cope with inter and intra-national negotiations in relation to GHG emissions reduction.

Third, for GHG emissions reduction in the agricultural sector, possible carbon sinks and reduction potentiality should be estimated on the basis of scientific analyses that relevant parties can have trust in.

Fourth, feasible programs should be developed and carried out in related fields to cope with climate changes during short or long terms of period.

2. Approaches to Practical Strategies

It is necessary that feasible programs should be developed and listed to establish agricultural strategies to comply with the Kyoto Protocol, taking into consideration the details described in Chapter 3 and GHG emissions reduction along with practical programs that can be induced from national case studies. Priorities should be put on feasible programs while applying evaluation criteria since it is impractical that policy programs should be carried out at one time under a certain condition as budgets, human resources, organizations and systems vary. For policy program evaluation, consideration was given to four parameters: urgency, effectiveness, enforceability and political acceptability.

The urgency is one parameter that evaluates which policy should be preferentially weighted in term of time to cope with GHG emissions reduction and climate changes. The effectiveness is for evaluating to what extent a policy is carried out to reduce GHG emissions, whereas efficiency refers to the ratio of economic input (expense) to output (advantage). The enforceability represents whether a certain program justifies policy goals or not. The political acceptability means to what extent a feasible program obtains political support.

An evaluation of emissions reduction programs in terms of economic measures shows that the subsidy for GHG emissions reduction facilities is evaluated low in terms of efficiency but high in other aspects and may be representatively adopted. As part of the Kyoto Protocol, the CDM project and emission trading system are highly evaluated in all aspects. Carbon tax is not yet established and lowly evaluated in terms of political acceptability but may be introduced as one of key projects.

For regulatory measures, chemical fertilizer uses per unit area are neither well monitored nor enforced and thus lowly evaluated in terms of enforceability. Limitation to the number of livestock may be a powerful measure for reducing GHG emissions from livestock but scarcely acceptable or enforceable politically.

Cross compliance programs include direct payments that are granted for cultivating bioenergy crops such as rape and astragalus, eco-friendly farming that reduces the use of chemical fertilizer and practices directly related to GHG emissions reduction, and may be a core one that is highly evaluated.

R&D programs are core ones but they may be less effective in terms of capital input but applicable in Korea and other countries. The effectiveness or urgency varies in the field of technology development.

Technology development and training programs are highly evaluated and should be significantly handled in strategy formulation. A program of establishing statistics and GHG database is important in establishing GHG related policies and negotiations. It shows low results in terms of efficiency but should be significantly managed.

The adaptation sector is directly related to R&D activities and thus should be strategically managed in preparation for future climate changes, rather than for short-term performances of policy.

It would take a long time to establish an eco-friendly low-carbon farming system by 2030 and strategies were set up by stage: initial stage (for building up a framework), interim stage (for a big leap), and final stage (for establishment) <Figure 6-1>.

First, at the initial stage, projects should be carried out: promotion of eco-friendly farming policies, establishment of recyclable energy production facilities, and pilot projects utilizing the Kyoto mechanism. In the GHG sinks sector, organic carbon' role in soils should be identified and organic carbon accumulation in farmlands should be estimated. In the adaptation sector, crops productivity and flora should be forecasted and adaptive species to climate changes should be developed.

Second, the interim stage includes setting up a GHG emissions D/B, distributing GHG reduction technologies, extending the Kyoto mechanism, and applying incentives for the improvement of carbon sinks.

Third, the final stage includes setting up a low-carbon farming system, reducing GHG emissions, applying carbon sinks and adaptation to climate changes in association with policies. In relation to a low-carbon farming system, infrastructure should be built up to prevent GHG emissions and apply adaptations to climate changes (Fig. 6-1). For GHG emissions reduction, a national GHG inventory should be prepared and national emission factors developed, and a GHG emission sources consumption statistic system should be set up. For carbon sinks, an analysis model should be established to clarify why GHG emissions are generated or absorbed and carbons balance. For the adaptation to climate changes, a system should be set up for crop production, flora prospects, and vulnerability analysis.

Figure 6-1. Measures to cope with Kyoto Protocol

Establishment of Eco-friendly Low Carbon Production System

GHG emissions reduction	Carbon sinks	Adaptation to climate changes
Spread GHG emission reduction technology. GHG emissions reduction incentive. Foster sound organic farming. Set up a foundation of utilizing Kyoto Mechanism.	Develop and popularize carbon sequestration techniques. Encourage farmers to grow bioenergy crops. Commercialize biogas from livestock manure Identify carbon sinks and sequestration in farmlands.	Establish Eco monitoring system. Ser up climate info system. Develop adaptive species to climate changes and do R&D.

Ser up anti global warming and adaptive system to climate changes

- ○ Establish national GHG emissions inventory and develop emissions factor and prepare consumption pattern statistics.
- ○ Identify GHG emissions and sinks mechanism and establish carbon balance model.
- ○ In case of climate changes, estimate crop production quantity and predict agricultural flora and clarify disadvantages and set up adaptive system.

<Measures by stage>

	Initial stage(2008～2012)	Interim stage (2013～2018)	Final stage (2019～2030)
GHG emissions reduction	Provide subsidy & supports Extend energy saving campaigns in agricultural sector. Develop and spread GHG emissions reduction. Increase to grow bioenergy crops. Execute emission trading system and pilot CDM project.	Set up GHG emissions D/B. Develop and make public technology fit for regions. Establish bioenergy production system. Establish emission trading system.	Supplement GHG emission reduction programs. Set up low carbon farming system. Establish GHG reduction BMP. Build water power plants using agricultural water.
GHC Sinks	Clarify organic carbon's role in soils. Estimate accumulated organic carbon and set up a system of using it.	Apply incentives and programs for carbon sinks. Make pubic the methods of using sink sources.	Utilize GHG sinks. Set up maximized carbon sink farming system.
Adaptation to climate change	Establish the model for productivity forecast and flora evaluation. Set up eco agricultural monitoring system. Map out adaptive croplands and crop distribution. Develop adaptive species to climate changes.	Prepare and distribute anti-global warming manuals. Set up weather info & alert system. Make public adaptive species to climate changes. Set up adaptation to climate changes & training system.	Distribute adaptation manuals. Set up adaptation system in farming. Adopt farming system using adaptation to climate changes. Set up crop transformation evaluation system.

For GHG emissions roadmap (reduction-absorption-adaptation), feasible programs should be established and carried out by sector and stage. For GHG emissions reduction, the followings should be performed at the initial stage: subsidies and supports for GHG reduction technology, extending energy-saving campaigns, increasing the cultivation of bioenergy crops, utilization of an emission trading system and pilot CDM projects. The following should be done at the interim stage: setting up GHG emissions, technology development and distribution, establishing a bioenergy production system and an emission trading system. At the final stage, the followings should be done: supplementing GHG emissions reduction programs, setting up a low-carbon farming system, managing optimal GHG emissions reduction, constructing water power plants by using agricultural water. In the carbon sink sector, the system should be set up to identify organic carbon's role in soils and to estimate and utilize organic carbon accumulation at the initial stage. The following measures should be carried out at the interim stage: direct payment for promoting carbon sinks and granting incentives, and educational program for enhancing perceptions of utilizing emission sources. At the final stage, a maximized farming system should be set up for carbon sinks.

For adaptation to climate changes, the following measures should be taken at the initial stage: forecasting produce productivity, establishing a flora evaluation model, setting up a monitoring system for eco agricultural shifts, mapping out croplands and crop distribution, and developing adaptive species. The interim stage includes such measures as preparing a manual of adaptation to climate changes, setting up an alert system using weather info, spreading adaptive species, providing adaptation info, and establishing an education system.

3. Future Projects for Practicing Strategies

3.1. Core Projects

3.1.1. The 4th Comprehensive Projects to Climate Changes

The 4th comprehensive projects to climate changes are national projects that last from 2008 to 2012 in preparation for GHG emissions reduction since 2013, and include 5 divisions: responses to negotiations, GHG emissions statistics, GHG emissions reduction, climate change prospects/effects/adaptation, and R&D activities. The agricultural sector includes 10 core projects: 3 GHG emissions statistics projects, 4 GHG emissions reduction projects, 1 prospective climate changes project, and 3 R&D projects. The projects should be implemented in compliance with the Kyoto Protocol.[8]

The GHG emission statistics projects include three divisions: 'national emissions factor development for GHG emissions from agricultural sector,' 'Agricultural Inventory Establishment', which will contribute to establishing GHG D/B, and 'GHG emission consumption statistics establishment' that is related to how to apply methodologies and targets.

The projects should be appropriately managed and carried out after an in-depth review.

For GHG emissions reduction, 'Methane Emissions Reduction Projects in Livestock Industry' includes a subproject that is related to providing and extending good quality feeds and utilizing livestock manure resources. 'Supports of Cultivating Rapeseed for Biodiesel' is related to production and distribution of new recyclable energy, which is to be carried out jointly with departments and should be in linewith programs that include incentives and technical transfer to farmhouses.

8 National projects to cope with climate changes were determined on a basis of evaluation that scored the criteria of reduction effectiveness, possible quantification, urgency, and relationship with other sectors.

Table 6-1. The 4th comprehensive measures to FCCC in agriculture & forestry sectors

Division	Project Name	Major Contents	Remark
GHG statistics (3)	National Inventory Establishment -Agricultural Inventory Establishment	• Set up an annual emissions estimation standard. • Get agricultural GHG emissions statistics.	RDA (joint works)
	National GHG emission Factor Development & Management -Nation's Agricultural Emissions Factor Development.	• Extend measurement networks for establishing a nitrous oxide emission factor. • Estimate methane emission by species and crop in the fields. • Evaluate GHG emission statistics uncertainty. • Estimate the GHG emission factor depending on liquid fertilization.	RDA (joint works)
	GHG Consumption Statistics Establishment -Agricultural GHG Demand Info System Establishment.	• Examine FCCC's effects on agriculture. • Categorize & examine GHG emission sources from consumption. • Identify GHG emissions from horticulture. • Examine GHG emission sources from livestock industry.	RDA (joint works)
GHGs reduction (3)	Nitrous Fertilizer Reduction	• Support organic fertilization and wild field management projects.	MAFF
	Livestock Methane Emissions Reduction.	• Extend to install liquid storages and to build joint recycling facilities.	MAFF
	Recyclable Energy Production & Distribution -Rapeseed production for biodiesel	• Pilot rapeseed cultivation project • Review whether to extend projects after evaluating pilot projects.	RDA (joint works)
Climate Change prospects adaptation (1)	Nationwide Comprehensive Effects Evaluation & Measures Establishment -Prospective harvest and good croplands from climate changes -Evaluation of the effects of climate changes on agricultural flora	• Examine the effects of climate changes on grains, fruits, feed crops. -Forecast shifts in crop productivity and optimal arable lands. • Examine insects and weeds distribution in croplands. • Identify the effects of climate changes on beans, fruits, and feed crops. • Set up a monitoring system of long-term shifts in an eco-agricultural system. • Examine the effects of climate changes on beans, vegetables, and feed crops. • Prepare a vulnerable flora distribution chart.	RDA (joint works)
R&D (3)	Adaptive Bioenergy Crops Production Study	• Select a source crop fit for bioethanol production. • Develop the system of evaluating bioenergy source crops.	RDA
	Study of Alternative Energy Using Biomass Resources	• Obtain statistics of GHG emissions from eco-friendly alternative energy production. • Examine potential GHG emissions using a bioenergy utilization system. • Examine a possible relationship to a bionenergy CDM project.	RDA
	Agricultural Carbon Accumulations Analysis and Carbon Balance Study	• Estimate biomass production in farmlands and CO_2sink capacity. Clarify shifts in carbon accumulation from climate changes. • Estimate carbon dioxide flux in croplands. • Develop a model to estimate carbon emissions and accumulation in farmlands.	RDA

Sources: Core projects are extracted from papers documented by Kim, Kim Lee (2007, pp.94-148).

「The Nitrous Fertilizer Reduction Project」 is initiated by the Ministry of Agriculture & Forestry in relation to the comprehensive projects on climate changes. The project, which includes promoting eco-friendly farming programs such as establishing wide eco-friendly farming complexes, organic fertilizer supports, and wild field management campaigns, should be effectively carried out in connection with GHG emissions reduction and supplemented by relevant policy programs.

Concerning the climate change prospects/effects/adaptation, ‘Comprehensive Evaluation of Nationwide Effects and Measures’ will be jointly carried out by relevant departments. ‘Evaluation of the Effects of Climate Changes on Flora’ is a long-lasting work which should be systematically and continually performed. To share information on shifts in flora, the system should be established in collaboration with international institutions.

In the R&D division, 「Study of Production of Bioenergy Source Crop」 is a new project that selects and cultivates bio-crop species, whereas 「Study of Development of Bioenergy Using Agricultural Byproducts in Preparation for Climate Changes」 is an existing project that is related to the development of alternative energy using biomass. The bio-industry plays a key role as a national strategic industry and should be appropriately managed so that it can more or less contribute to the agricultural sector that is related to raw material production. The project 「Development of Technique of Carbon Sinks/Emission Balance and Carbon Sequestration in Farmlands」, which is related to biomass production and carbon balance, should be carried out jointly with international organizations.

3.1.2. Introduction of Kyoto Mechanism Programs

A. CDM Pilot Projects in the Agricultural Sector

Though CDM in the agricultural sector of Korea is in its very early stages, it could make great contributions to greenhouse gas reduction and sustainable development of agriculture based on the case study of overseas CDM projects and the evaluation of domestic agricultural sector’s potential for greenhouse gas reduction.

CDM projects that generate power using bio-mass residues as fuels and those that recover methane from the livestock manure treatment facilities and use it for energy production are making active progress around the world, so it is very likely for Korea to have such successful cases even though not many efforts have been made to explore such project opportunities

These CDM projects can also be implemented in the agriculture sector of Korea. If these projects are implemented, methane, the greenhouse effect of which is 21 times greater than that of CO_2, could be reduced, and electricity or heat could be produced additionally, achieving a significant emission reduction effect. Therefore, it is shown that the potential of these CDM projects for emission reduction is very high.

To promote CDM projects in the domestic agricultural sector, an executive program should be established to validate the greenhouse gas reduction potentials of livestock manure treatment facilities, bio-mass generation and bio-fuel utilization. For validation, the greenhouse gas emission from each project unit should be calculated and applicable conditions of baselines and monitoring methodologies currently in use for CDM projects should be reviewed in depth.

For step-by-step implementation of CDM pilot projects in the domestic agricultural sector, a clear understanding of how to calculate the amount of greenhouse gas emissions from each source in the agricultural sector should precede. Above all, as regional characteristics and production methods have significant impacts on the emission potential in the agricultural sector, proper emission calculation methods should be devised in consideration of locational conditions. Then, accumulated knowledge of and experiences in technologies to reduce greenhouse gases from their sources should be provided. For CDM projects to succeed, risk factors in project implementation should be removed in advance by applying technologies proven to be appropriate in the past technology development process or those that have already been in use in developed countries. Feasible project items should be chosen and necessary infrastructure should be established such as basic emission level calculation methods, database required for evaluating the leakage and calculating the amount of reduction, and institutional supplementation including project permission, which will enable CDM projects.

Additionality, one of the most important factors for CDM projects, should also be verified. In other words, it should be evaluated whether the project can be generally implemented and whether there is any difficulty in spreading the project because of economic or technical obstacles. It is necessary to choose projects of proper scales, and solutions for environmental problems or civil petitions against the projects should be prepared. Proper role division among related bodies should also be made.

Among the CDM projects that have been recognized by the CDM Executive Committee, none has been developed with regard to the domestic agricultural sector in spite of its increasing interest in CDM projects. Though not directly related to the agricultural sector, the bio-mass generation project of Jecheon, Chungcheongbuk-Do Province can be a good example of reducing greenhouse gas emissions by building a bio-mass power plant using forestry wastes. The Jecheon Biomass Power Generation project is to generate power by using forestry waste bio-mass as fuel, which is expected to reduce about 4,752 tCO_2 a year. As an example of bio-energy utilization in the livestock sector, a farmhouse-type bio-gas plant was installed at Yeoyang Farm in Cheongyang, Chungcheongnam-Do Province, to generate power.

B. Utilization of Emission Trading System in the Agricultural Sector

Emission Trading System (ETS) is a major economic measure to comply with the Kyoto Protocol, which is being actively promoted in EU, UK, Canada, Denmark, USA and Japan as a full-scale project or a pilot project. Under ETS, every country assigns emission units to firms and sectors in it to meet the reduction target assigned to it, and the firms that do not meet the assigned reduction targets are induced to trade off certified emission reductions from firms of other countries.

To study an example of ETS, it is necessary to review the environmental credit system of the US for the introduction and implementation of ETS in the agricultural sector. The environmental credit system allows firms under regulation to meet their reduction targets through emission reduction service credits trading. Though the agriculture does not come under most of environmental regulations, farmers could participate in the credit trading program by producing emission reduction credits and selling them to the firms under regulation. When the cost of producing emission reduction credits is lower than the price of the credits, farmers could make profits, allowing them to actively participate in the ETS.

When a credit trading market is formed regarding greenhouse gas reduction, the price of environmental credit would be determined by the market in the same way as product trading as long as there are enough numbers of buyers and sellers. Even when the price is determined by the administrator as there are not enough numbers of buyers and sellers, the cost of compliance with the environmental regulation would be efficiently distributed among the program participants and thus they still could make profits. It is necessary to develop a program to encourage farmers to participate in the environmental credit market under new market-oriented policies, which requires developing a methodology to calculate environmental credits that farmers can produce. It is also necessary to find cases where farmers can generate income by participating in an environmental credit trading program and make them known to farmers. When an institutional foundation on which environmental credit trading could be operated is formed, it might be used as an influential urban-rural exchange program by being linked to One Firm-One Village (or One Firm -Multiple Villages) program that substantially helps both firms and farming villages. In this program, the other party to farming villages would be firms that have to buy emission credits for greenhouse gas reduction. If mandatory greenhouse gas reduction is put in force, firms that rely on fossil fuels such as oil and coal would be considerably interested in the purchase of emission credits, and the exchange of environmental credits with farming villages will be greatly stimulated.

3.1.3. Introduction of Environmental Inter-compliance Program such as Menu-mode Direct Payment System

When the agricultural sector reduces greenhouse gases voluntarily, proper incentives should be paid to encourage farmers to participate in the reduction efforts more actively. The present environment-friendly agriculture direct payment system applies only to the agricultural products certified to be environment-friendly, such as organic crops and pesticide-free crops. Menu-mode direct payment system is to give proper direct payments to farmers when they put program menus prepared for each reduction measure into practice as suggested in the menus. Especially to induce voluntary participation of the agricultural sector in emission reduction known to the nation and the world, the menu-mode direct payment system should be utilized as an influential policy measure to reduce greenhouse gases in early stages in compliance with the Kyoto Protocol.

As reviewed so far, such emission reduction technologies as direct sowing of rice onto dry fields, nitrogenous fertilization control, soil organic carbon sequestration by arable lands, energy crop cultivation, improvement of rumen fermentation, and improvement of livestock manure treatment facilities have been developed to be applicable in the agricultural sector and they have been evaluated to have a significant potential for greenhouse gas reduction. Specifically, direct sowing of rice onto dry fields, labor-saving rice cultivation through simplified irrigation, and improvement of rumen fermentation by applying Ionophore, a fermentation accelerant, could be utilized as menu-mode direct payment project menus for greenhouse gas control in the agricultural sector. The unit payment cost of the menu-mode direct payment system should be arranged by putting together the characteristics of each project, additionally invested economic cost, and social conveniences achieved by emission reduction all together.

3.1.4. Promotion of Sound Organic Farming

It has been suggested that organic farming that does not use chemical fertilizers and pesticides could make a great contribution to greenhouse gas reduction and, therefore, it is necessary to prepare a program to promote sound organic farming. Plans to form organic farming complexes in the areas where organic farming has already been in practice and the areas of which regional conditions are favorable for organic farming need to be positively reviewed. It is necessary to review plans to verify the agricultural materials invested in the organic farming complexes, recognize the greenhouse gas reduction in comparison with the conventional agriculture, and support them in addition to the current direct payment system.

If organic farming uses excessive organic fertilizers or environment-friendly agricultural materials in place of chemical agricultural materials, its contribution to greenhouse gas reduction might be lower than expected. Therefore, education and public relations on the practices of organic farming methods are needed. As of now, the environment-friendly direct payment system temporarily paid to organic farm households for 3 years is the only organic farming promotion program in force. Therefore, various programs that could encourage more farm households to participate in organic farming, such as technical support, education and training, and support for finding markets, should be developed and implemented.

3.1.5. Expansion of Support for Bio-Energy Production

As suggested in the examples of major countries for reduction measures in the agricultural sector, all countries reviewed have been executing positive support policies for bio-energy production activities such as energy crop cultivation and bio-gas generation from livestock manure treatment. As suggested in the projects for the agricultural sector in the 4th comprehensive measures to comply with the UNFCCC, research and development projects for the bio-energy field such as cultivation of bio-energy crops and development of alternative energies using bio-mass were selected as major tasks. A bio-energy production support program under way is the rape cultivation pilot project being developed on a 1,500ha complex over a 3-year periodfrom 2007 for the purpose of producing raw materials for bio-diesel (Changyong Kang et al., 2006, pp.82-84).

Rapes have higher oil content than other crops, therefore many examples of cultivating rapes to supply raw materials for bio-diesel are found in major countries of Japan, USA and Europe and the cultivation area keeps expanding. It has been analyzed that rape cultivation in Korea is not cost-effective. Therefore, a menu-mode direct payment system and other proper measures to support rape cultivation should be provided. Also, in the mid/long run, it should be positively reviewed from technical and policy perspectives to cultivate energy crops on arable land, such as Saemangeum Reclaimed Land, to be newly secured.

Production of bio-gas from livestock manure treatment in the livestock sector has been suggested as an important menu of CDM projects. Since the technology to produce bio-gas from livestock manure has already reached the application stage, the manure treating farm household bio-gas plants in Germany and Denmark could also be widely used in Korea if proper support measures are taken. Excessive initial investment in bio-plant facilities and absence of institutional devices to promote the use of alternative energies are causing a bottleneck in the bio-gas project. It is shown that if there is a plan to promote bio-gas plants using livestock manure in connection with

CDM projects, the bio-energy projects in the livestock sector could gain momentum. When an accurate diagnosis and evaluation is completed concerning bio-gas production facilities using livestock manure (as in the cases of Cheongyang Yeyeong Farm, Sunghwan Livestock Experiment Station and Hongseong Pig Farm in Chuncheongnam-Do Province), it would be possible to prepare proper measures to solve problems.

3.1.6. Continuous Efforts in the Adaptation Sector

Though adaptation is not directly related to mandatory greenhouse gas reduction, impacts of global warming on agricultural production are unavoidable and considerable; therefore, the agricultural sector should make efforts to find solutions for adaptation on its own. Otherwise, negative impacts of global warming would increase as it gets intensified. Implementation programs in the adaptation sector should involve scientific analyses of the impacts of global warming on the agricultural sector and of its vulnerability. Based on the climate change forecast and related meteorological information, effects of global warming on the agricultural sector should be monitored, an early-alert system be established, and a vulnerability map be drawn for each field of the agricultural sector.

With regard to adaptation, the agricultural sector needs to establish new cultivation methods to cope with global warming (through fertilizer ingredient control, improvement of irrigation method, etc.) and develop new varieties suitable for the changed climate. Also, it should consider organizing “Special Research Group for Reorganizing Chief Producing Districts (tentative name)” to prepare proper measures to cope with changes in the chief producing districts due to climate change in each area.

3.2. Major Implementation Tasks

3.2.1. Positive Participation in Domestic and International Negotiations regarding the UNFCCC

In order to effectively cope with international negotiations at the Conference of the Parties (COP7) to the UNFCCC and the Annex Conferences, the agricultural sector should establish an expert pool to facilitate efficient review of agenda.

The government should actively participate in the international negotiations to reflect the circumstances of the Korean agriculture in the greenhouse gas emission unit. For the purpose of statistics on greenhouse gas emissions, each country is required to apply an emission coefficient unique to the country (Tier 2). However, Korea calculates the amount of greenhouse gas emission from the agriculture and livestock sector using the random emission coefficient of the IPCC (Tier 1). On the other hand, Japan uses an emission unit drawn in Japan for calculating the amount of N_2O emission, contributing to the calculation of the assigned reduction amount of greenhouse gas emissions. Other developed countries like the USA and Canada have developed and applied their unique national emission coefficients, and recently they are focusing on researches to minimize uncertainty in emission reduction measures, which also contributes to the reduction of greenhouse gas emissions in the agricultural sector.

When using the random emission coefficient of the IPCC, it is impossible to properly reflect the circumstances of the Korean agriculture and livestock farming and thus the uncertainty of statistical data on greenhouse gas emissions becomes larger. Therefore, it is necessary to develop a unique national emission coefficient that can correctly reflect greenhouse gas emissions in the agricultural and livestock sector, do research to enable precise statistical calculation when reduction measures are applied, and actively participate in the IPCC technical conferences to ensure the circumstances and opinions of Korea to be reflected in its decision making.

In response to the UNFCCC, the government has established and operated a pan-government organization named the Committee on Climate Change which is chaired by the Prime Minister. As a participant to this Committee, the Ministry of Agriculture and Forestry needs to facilitate the agricultural sector to make contributions to the domestic greenhouse gas reduction known to the government and draw plans to compensate the agricultural sector for the cost proportionate to its contributions to the industrial sectors that have to reduce greenhouse gases. It seems that when the mandatory greenhouse gas reduction is put in force in compliance with the Kyoto Protocol, there would be a lot of discussions on the amount of reduction allocated to each sector and the selection of reduction measures. The domestic greenhouse gas emission increased by 90.2% in 2004 from the1990 level. Therefore, when the mandatory emission reduction is put in force, it would bring significant economic impacts on the industrial sectors that rely on fossil fuels. As suggested in the analysis of impacts of mandatory emission reduction on the agricultural sector in Chapter 4, the agricultural sector would be able to secure allowable emissions rather than being allocated a reduction target against baseline. That is why the Korean government has to involve in positive negotiations.

Regarding the implementation of emission trading system (ETS), proper strategies need to be developed to ensure that ETS can be implemented for the entire industrial sectors including agriculture.

3.2.2. Systematic Research and Technology Development

Systematic research and technology development should be promoted in the three fields of global warming prevention measures, impacts of global warming, and adaptation to global warming.

First of all, the research on global warming prevention measures should deal with reduction of greenhouse gas emissions, enhancement of greenhouse gas capture, and development of an LCA model to identify emission and capture mechanisms. The LCA is a methodology to quantify the amount of greenhouse gas emissions in each process of production, processing and consumption of agricultural products by scientifically evaluating the environmental load in each process.

In the research of impact assessment, crop cultivation, ecologic and socioeconomic impacts, and policy effects should be analyzed and quantitative estimation models should be developed while in the research of adaptation, heat injury mechanism and genetic factors should be identified and new varieties should be developed.

For these researches, a road map should be drawn for each field of research (on prevention measures, on impact assessment and on adaptation) in each stage of foundation establishment, application and settlement to establish a systematic execution and evaluation system. In these researches, strategic research projects should be picked out and promoted so that they can turn the compliance with the Kyoto Protocol into opportunities that can realize sustainable development of agriculture.

Researches on strategies to compensate the agricultural fields with emission credits for greenhouse gas reduction based on scientific analyses should also be carried out. In order to put the farming methods that can reduce greenhouse gases into practice, a menu-mode environment-friendly direct payment system should be developed and fertilization control and water control technologies to reduce methane and nitrous oxide emissions from arable lands should be developed and popularized. Above all, policy programs to popularize farming techniques that can reduce greenhouse gas emissions through astragalus cultivation, sound organic farming, and bio-energy crop cultivation should also be developed.

The greenhouse gas emission mechanism related to methane and nitrous oxide emissions from ruminants should be identified, and the effectiveness of developed emission inhibitors (garlic, etc.) should be verified. Detailed programs such as livestock manure recycling and rape cultivation to promote CDM pilot projects in the agricultural sector should be developed.

3.2.3. Establishment of an Integrated Management System for Greenhouse Gases in the Agricultural Sector

In preparation for the future implementation of mandatory emission reduction, it is necessary to establish an integrated institutional system that will control and operate emission reduction and capture measures in the agricultural and livestock sectors. Above all, the Agri-Environmental Integrated Management System should be established to build a database for emission reduction technologies, managing newly developed technologies, monitoring and publicizing developed technologies, and developing improvement plans. In the mid/long-run, it is necessary to review plans to install and operate “Agricultural Climate Change Information Center” (tentative name) which will take mandatory emission reduction as an opportunity for the agricultural sector and generally manage efforts to effectively adapt to global warming. This center could be organized with teams in charge of policy development, impact assessment, technology development, survey and statistics, public relations, and international cooperation. The policy development team takes charge of developing emission reduction and adaptation policies in the agricultural sector, establishing reduction targets for each sector, and developing policies for greenhouse gas sink utilization. The impact assessment team is in charge of assessing the impacts of climate change on agricultural production and the agricultural ecosystem. In addition, the team takes charge of analyzing the impacts of bio-energy crop cultivation on agricultural product prices and farming household income. The technology development team takes charge of developing technologies for reducing emissions in the arable and livestock sectors and increasing greenhouse gas sinks in the arable lands, varieties adaptable to global warming, and energy crop cultivation technologies. The survey and statistics team is in charge of preparing a greenhouse gas inventory in the agricultural sector and developing techniques to estimate greenhouse gas emissions in the agricultural sector. It is also responsible for the general evaluation of achievement of greenhouse gas reduction targets and implementation of adaptation policies. The PR team deals with public relations and education on technologies for reducing greenhouse gas emissions and expanding greenhouse gas sinks in the agricultural sector. It also takes charge of encouraging the agricultural field to participate in national measures to comply with climate change and publicizing the value of contribution to greenhouse gas reduction. The international cooperation team is in charge of establishing negotiation strategies to comply with the UNFCCC and the Kyoto Protocol in the agricultural sector, participating in related international conferences, identifying international trends in the utilization of the Kyoto mechanisms such as CDM and ETS, collecting international information to cope with the UNFCCC, and carrying out international cooperation regarding climate change.

3.2.4. Manpower in Exclusive Charge of Complying with the UNFCCC in the Agricultural Sector

The manpower that will take exclusive charge of administrative affairs and research to comply with the UNFCCC in the agricultural sector should be secured. Currently in Korea, the administrative affairs to comply with the UNFCCC in the agricultural sector, together with other policy issues related with environment-friendly agriculture, are managed by the planning section under the Agricultural Policy Bureau at the Ministry of Agriculture and Forestry (1 Administrator, 1 Chief Official). On the other hand, the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan established the Environmental Policy Division as an organization under the direct supervision of the Ministerial Secretariat in 2003 to actively cope with the problems of global warming. It is responsible for establishing and coordinating agriculture-related environmental policies. The Environmental Policy Division is organized with General Affairs Team, Planning Team, Environmental Technology Team, Natural Environment Team, Global Environment Team, and International Coordination Team. In 2007, the Division changed its name to 'Environment and Bio-mass Policy Division'and expanded its organization and affairs by adding the Bio-mass Planning Team and the Regional Environment Team. As of the end of September 2007, the Environment and Bio-mass Policy Division has 36 persons in charge of related affairs.

The technology research to comply with the UNFCCC in the agriculture and livestock sector is handled by the National Institute of Agricultural Science and Technology, the National Institute of Animal Science, Yeongnam Agricultural Research Institute, Honam Agricultural Research Institute and the National Institute of Subtropical Agriculture under the Rural Development Administration. However, since the research manpower in each institute in exclusive charge of overseeing the compliance with the UNFCCC and the Kyoto Protocol is very small, manpower competent for the related fields should be secured. Also, a joint research and information exchange network in which experts in climate change related researches participate should be established.

Chapter 7. Summary and Conclusion

Summing up the changes in domestic and international circumstances regarding the post-2012 Kyoto Protocol, Korea is likely to participate in the emission reduction commitment from the second commitment period. When the mandatory greenhouse gas reduction is imposed, the agricultural sector may be able to take it as an opportunity depending on how it complies with it as the greenhouse gas emission from the agricultural sector is in a decreasing tendency and the sector has sink functions. The present study, which was carried out as a follow-up study on the analysis of impacts of the UNFCCC on the agricultural sector presented effective step-by-step measures to comply with the Kyoto Protocol in the agricultural sector.

It was analyzed that when the agricultural sector participated in the emission trading system as a means of greenhouse gas reduction, it would increase the profits of the agricultural sector and make contributions to the national economy. When carbon tax was imposed, high pressure would be applied in the short run due to a rise of agricultural production cost in the controlled vegetable and floricultural sectors that had high reliance on fossil energy. So, proper countermeasures need to be devised.

With regard to the greenhouse gas emission reduction in compliance with the Kyoto Protocol, examples of Annex-I countries (Japan, USA, Denmark, Germany and UK) were analyzed. In these countries except Denmark, the agricultural sector accounted for less than 7% of total greenhouse gas emissions except methane and nitrous oxide that took a considerable portion in the overall emissions. It was shown that they let the agricultural sector manage and control greenhouse gases voluntarily rather than including them in the mandatory reduction sector. Such emission reduction measures in the agricultural sector as facilities support, promotion of organic farming, utilization of bio-energy, research and development, and adaptation are adopted by Japan, USA and EU countries, which Korea could use as a benchmark in establishing its own reduction measures.

According to the result of an evaluation of reduction potentials of core greenhouse gas prevention technologies such as methane reduction through direct sowing of rice on dry fields, reduction of nitrous oxide through nitrogenous fertilization control, utilization of soil organic carbon in the arable lands, cultivation of bio-energy crops, and improvement of rumen fermentation and livestock manure treatment facilities, which were based on researches that have been made in Korea so far, it was shown that they could make significant contributions to greenhouse gas reduction.

As for basic policies for establishing measures to comply with the Kyoto Protocol in the agricultural sector, it is suggested in this report that the government should take this opportunity for establishing a sustainable agricultural system, combining and consolidating agricultural policies and greenhouse gas policies, positively and actively coping with the domestic and international negotiations, scientifically analyzing the amounts of greenhouse gas emission and capture, and adapting to global warming. The implementation strategy for the agricultural sector was approached in 3 stages with 2030 as the target year: Foundation Establishment Stage (2008~2012), Take-off Stage (2013~2018) and Settlement Stage (2019~2030).

A stage-by-stage road map was also presented to establish an environment-friendly low-carbon agricultural production system through program implementation in each sector of greenhouse gas reduction, capture and adaptation.

As for implementation strategies, key tasks were suggested as follows: active promotion of the 4th comprehensive measures to comply with the climate change, development of programs to make the best use of the Kyoto mechanisms, promotion of sound organic agriculture, and continuous efforts in the adaptation sector. In addition, as major tasks to properly cope with the recent circumstantial changes of the UNFCCC, the following were suggested: active participation in the domestic and international negotiations regarding the UNFCCC, continuous effort in the adaptation sector, systematic research and technology development, and establishment of an integrated greenhouse gas management system.

At this point of time when the global warming issues are highlighted at home and abroad, the agricultural sector should make effort to make the public recognize effective greenhouse gas management as a key industry. For this, manpower and organizations in exclusive charge of participating in the discussions of national projects for establishing measures against climate change should be strengthened, proper role division among the related organizations should be made, and the right experts should be employed at right places.

In the case of the agricultural industry, in particular, the acceleration of global warming due to increased greenhouse gas emissions has direct impacts on the agricultural ecosystem and agricultural products. Therefore, greenhouse gas management programs should be established and implemented strategically together with proper adaptation measures.

Calculation of the marginal cost of each emission reduction measure in the agricultural sector and priority analysis of each policy measure were not made in this study. Therefore, further studies should deal with these matters in depth. Furthermore, empirical research on the estimation of the amount of substantial reduction should be carried out based on the evaluation of cost effectiveness between reduction amount and cost of each reduction measure by applying an economic engineering methodology to each reduction measure.

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