R613 | English Edition (2011.12)

Strategies for Promoting Green Growth in Agriculture and Rural Districts (The 1/2th Report)

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Responsibilities

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Jeong-Seop Kim	Fellow	Diagnosis and evaluation of green growth policies for rural districts
Myeong-Ki Lee	Fellow	Policy analysis and policy integration
Hak-Kyun Jeong	Fellow	MAC analysis, ecological efficiency analysis
Yoon-Hyung Kim	Fellow	Case study for green growth in major countries
Jeong-Kyung Jang	Researcher	Questionnaire survey analysis, local government's policies
Young-Dan Kim	Researcher	Development of indices for diagnosing green growth in rural districts
Tae-Hoon Kim	Researcher	Green productivity analysis

Preface

The Korean government has established the national administration paradigm of ‘low carbon green growth’ as a combination of preemptive measures against climate change and the energy crisis, and a green growth promotion policy throughout every sector.

The agricultural sector is no exception. It has implemented ‘low carbon green growth’ policies in order to cope with the environmental challenges faced in agriculture, such as the negative impacts of climate change, an increase in agricultural management costs due to the rising price of oil, and the degradation of the agricultural environment due to the excessive use of agricultural chemicals and the inappropriate treatment of livestock excrement. Examples of green growth policies in the agricultural sector include, but are not limited to, the development of biomass energy, the supply and national diffusion of green technology/equipment, and strengthening the sector’s capacity to cope with climate change. The effective promotion of green growth requires that systematic and efficient implementation strategies be established basd on an in-depth analysis of green growth.

This report is an English edition of the interim outcome of two-year study project on “Strategies for Promoting Green Growth in Agriculture and Rural Districts” which is to be carried out for the years 2010 and 2011 as a cooperative task of the National Research Council for Economics, Humanities and Social Sciences. It has carried out basic research to identify core tasks, based on a diagnosis of the current conditions of green growth in agriculture and rural districts, an evaluation of green growth policies, and empirical analysis. In addition, this report suggests that agricultural and rural district green growth policies be integrated after first evaluating whether the actual conditions on the ground will allow this. By all means, I wish this report to be a valuable reference in establishing practical green growth policies for the agricultural sector.

I would like to acknowledge the support and contributions by Professor Yoon-Woo Lee of Seoul National University, for suggesting a plan for furthering the use of supercritical fluid in the agricultural sector; Dr. Ik Jin of The Korea Insurance Research Institute, for suggesting a plan for utilizing green finance; Dr. Ji-Eun Seong of The Science and Technology Policy Institute, for analyzing theories for policy integration as well as overseas case studies; Professor Jeong-In Kim of Chung-Ang University, for research advice in connection with this study; and Deputy Director Woo-Shik Shin of the Ministry for Food, Agriculture, Forestry

and Fisheries, for designing policy instruments. In addition, I would like to thank Professor Ian Gordon of Chung-Ang University and Visiting Researcher James Banfill of KREI for their editorial comments of the English version of this report.

December 2011

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ABSTRACT

Strategies for Promoting Green Growth in the Agriculture and Rural Sectors

Green growth is the pursuit of economic growth, while preventing environmental degradation and unsustainable natural resource use. Korea imports about 97 percent of consumed gross energy and as a result is among the top 10 energy consuming countries. The challenge for Korea is to bring on line new sources of energy that will simultaneously permit coping with climate change and the exhaustion of fossil fuels. For as climate becomes ever warmer, international society will in an attempt to reduce greenhouse gas (GHG) emissions, further tighten environmental restrictions on energy use by means of international regulations within a framework of international cooperation.

Aware of the changing circumstances in Korea and other countries, the Korean government has presented 'low carbon green growth' as a preemptive measure for coping with climate change and the looming energy crisis. In this regard it is deemed necessary to present fruitful practical strategies for promoting green growth, arrived at by means of thorough in-depth analysis, in order to successfully implement a master plan for green growth.

This report details the first-year outcome of the 'Development of Strategy for Promoting Green Growth in Agriculture and Rural Districts' research project, carried out for the years 2010 and 2011 as a cooperative task under the Korea Council of Economic & Social Research Institutes. The purpose of research is to arrive at a systematic, step-by-step and fruitful strategy for promoting green growth in agriculture and rural districts by further examining the direction of discussion in Korea, and in other countries, concerning green growth.

The major findings of this study are summarized below:

First, GHG emissions for the agricultural sector amount to 2.9% of the gross national GHG emissions. The business as usual (BAU) figure for 2020 was estimated to reduce the figure by 0.5% from 2005 emission levels, in accordance with the IPCC guidelines for calculating the amount of GHG emissions. This exceeds the -4.0% which is a target figure for national GHG reduction and implies that it is necessary to take additional measures for reducing and absorbing GHG in the agricultural sector, e.g., technology for reducing emitted GHG from farmland, technology for storing organic carbon in soil, technology for improving enteric fermentation of ruminant livestock, etc .

Second, the assessment of green growth policy in the agricultural sector revealed that the means for pursuing green growth have been properly combined, but that it remains necessary to develop policy programs to ensure the achievement of fruitful green growth outcomes and to effectively supply the requisite green technology. The assessment of green growth in the agricultural sector, a prerequisite for the detailed tasks to be promoted in the sector, showed that it is necessary to include policy means to embody the tasks, policies and systems related to green growth in rural districts in their current state.

Third, survey data of farmers' and specialists' perception of green growth showed highly positive approval for the combined promotion of environmental conservation and economic growth. Respondents stated that 'furthering biomass energy' and 'spreading and supplying green technology' should be the highest priority policies. In addition, respondents evaluated as important 'the enhancement of preventive measure to cope with climate change' and 'driving the project of creating eco-friendly agriculture districts'.

Fourth, an analysis of the data, a combination of specialist investigations, policy integration theory and related data, showed that it is necessary to establish the basic direction of agriculture administration in which the economy and the environment are harmonized and balanced for integrating green growth related policies, and enhancing the policy promotion system for policy integration. Indications are that the budget system related to outcome management and mid- and long-term plans are not satisfactory, and that an assessment system for green growth contribution to a specific policy is needed.

Fifth, analysis of organic agriculture (the key green growth project) and of the eco-efficiency of geothermal heat pumps, to measure the level of green growth showed that organic agriculture was higher than conventional agriculture by 32.0 on the eco-efficiency index and the geothermal heat pump was higher than the petroleum heater by 5.1. Analysis of technical efficiency of organic rice farming, compared to conventional methods, on the eco-efficiency index showed that higher technical efficiency groups had higher eco-efficiency indices as well.

Sixth, analysis of green productivity in the agricultural sector by means of the carbon productivity index showed increasing carbon productivity. However, this increasing carbon productivity stems from a reduction in the area devoted to rice farming and consequently a corresponding reduction in the use of nitrogen fertilizer, coupled with a rise in GDP due to an increase in the prevalence of pig farming. This is not the type of green growth obtained from the application of green technology. However, it does suggest that green growth can also be achieved by simply reducing the amount of nitrogen fertilizer applied per cultivation area, and by technology which reduces GHG emissions from ruminant livestock, etc.

Seventh, a green growth potential index for rural districts was compiled with the methodology derived from the OECD index. It was shown that the green growth potential index generalizing the indices in four items of 'green growth', 'green consumption', 'green resource basis' and 'environmental living quality of residents' were found to be higher in relatively less urbanized areas, e.g., the mountainous districts in the provinces of Gangwondo and the Gyeongsangbukdo, and a part of plain fields in the provinces of Jeollanamdo and Jeollabukdo.

Eighth, the low carbon policy programs to be developed will need to include elements designed to increase farming sector incomes. These farming income increases would be related to green growth in the agricultural sector i.e. GHG reduction or absorption, and other feasible programs for reducing GHG emission, e.g., using a carbon trading system.

Exemplary green technology includes vertical farms for producing farm products (as produced in factories by means of a supercritical fluid system) that will allow the eco-efficient production of food, energy, raw chemicals and other products. Energy sources utilized would be either geothermal, LED and biogas plants or biomass resources, since all of these can reduce the associated energy costs and environmental loads, and would necessarily employ high-tech environmental controls and automation. Green technology should be accompanied by appropriate green finance support as this would reduce the risks involved. This is necessary as the deployment of green technology will require high levels of capital investment.

Ninth, it is important to establish a policy project to determine the policy targets for green growth in the agricultural sector. The policy targets should take into account local conditions, allow for the creation of a basis for promoting the green growth policy of local bodies in rural districts that will also enrich the regional area, to set up a green resource management system for efficiently managing various green resources, to foster green industry and create green employment, and to construct a basis for using renewable energy and reducing energy.

Lastly, in order to achieve the agriculture policy target, the achievement of balance and harmony between the economy and the environment, it is necessary to establish an environmental impact evaluation system for agriculture and rural districts. In other words, the policy promotion system should be reorganized. This would take the form of organizing a task force devoted to energy and environment related policies in connection with agriculture and rural districts. It would also require the establishment of a (provisional) green measures committee, whose purpose would be threefold: to enhance the connectivity between budgets and outcome management; to evaluate impact of individual policies on, and thus their contribution to green growth, and to reflect the result on budgets.

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TABLE OF CONTENTS

TABLE

FIGURE

Introduction

Chapter 1

1. Necessity of the Study

Recently scientific studies have implied that global warming will be a megatrend that will lead to dramatic changes in future society and that excessive use of fossil energy has put resources and the environment at risk. The increasing magnitude and frequencies of floods, heat waves, forest fires, and landslides has made it more convincing that global warming causes natural disasters. As the negative impacts of global warming have materialized, international cooperation and regulation to reduce greenhouse gases has become a necessity. Crises in resources and energy have become a real threat to humanity. Similarly, energy and environmental issues have become a key variable that decides the future of a national economy. Alongside global warming, the sudden increase in demand for energy and resources fuelled by rapid development in Brazil, Russia, India and China (the so-called BRIC nations) has made the economic "global imbalance" worse. Should this trend continue, fossil energy sources will be completely depleted; oil in 43 years and natural gas in 62 years

Given these circumstances, in which global warming and an energy/resource crisis continues, major advanced countries, such as the USA, Japan, Germany and the UK, have implemented practical strategies to promote green industry and green technology as the growth engine for national development for the past 20 years. Recently, they have focused their investments in the renewable energy sector and strengthened policies designed to cope with climate change. An example of this is Emission Trading System (ETS), which induces reductions in greenhouse gas emissions through market mechanisms.

For Korea, one of the top 10 energy consuming nations, and a nation that has to import 97% of its gross energy consumption, the task of finding and securing new energy sources to cope with climate change and fossil fuel depletion has become urgent. The existing “input-driven (i.e. high input – high output)” economic growth, dependent on continuous intensive use of energy resources has been criticized, not only as being undesirable from an environmental standpoint but also for having reached the limit of its effectiveness. Subsequent to recent price hikes in resources and energy, any economy which is dependent on massive inputs of resources and energy will lose competitiveness and become unable to grow. Additionally, the more global warming progresses, international cooperation will see ever stricter international environmental regulations will become, as a means of reducing greenhouse gas emissions.

Given such domestic and international circumstances, the Korean government put in place a preemptive measure to mitigate the effects of climate change and the energy crisis. This measure, ‘low carbon green growth’, was announced by the Korean government in 2008 as the national vision and paradigm for the coming 60 years. With this measure the Korean government plans to establish a virtuous cycle of mitigating greenhouse gas emissions while also minimizing resource use and the environmental pollution through green growth. Utilizing these achievements will be the driving force for economic growth. In order to establish an institutional framework to implement the national strategy of green growth, the Green Growth Committee was inaugurated in January, 2009, while the 5-year Plan for Green Growth (2009~2013), outlining the implementation strategies for green growth, was announced in July 2009. In April 2010, the Framework Act on Low Carbon Green Growth was enacted and enforced as an institutional foundation for promoting green growth (Enforced on April 14, 2010, See Attached Table 1).

Since the institutional and legal frameworks for green growth were put in place and the midterm plan for green growth announced, each and every government department has actively carried out discussion and research to achieve the policy objectives and has also established and implemented policy programs and investment plans. The agricultural sector and rural districts for their part have organized symposiums and seminars to promote green growth policies and to reach a consensus on green growth. However, systematic diagnosis of the current status of green growth in the agricultural sector and identification of tasks to be carried out in each field are still insufficient. In order to secure both sustained future growth for agriculture and the implementation of the national development strategies, it is urgent that viable strategies be developed for promoting green growth in agriculture and rural districts. In addition, as the demand for research in this field is expected to increase, both domestically and internationally, for a considerable period of time, it is necessary to carry out systematic cutting edge research.

2. Purpose and Scope of the Study

The purpose of this study is to present systematic, step-by-step, viable strategies for promoting green growth in agriculture and rural districts. This will be achieved by means of a discussion of the domestic and international green growth trends and an in-depth analysis of green growth in its industrial and spatial aspects.

In the first year, basic research was carried out. This was comprised of a diagnosis of the actual conditions on the ground for green growth in agriculture and rural districts and then followed by an evaluation of green growth policies that had been carried out. On the basis of this a direction for integrating the policies based on the diagnosis of the actual conditions for green growth was presented.

In the second year, detailed step-by-step practical strategies for green growth in agriculture and rural districts and their priorities will be presented, based on the diagnosis of the conditions for green growth in agriculture and rural district and the core tasks identified in the first year. Detailed implementation strategies to integrate green growth policies for agriculture and rural districts will also be discussed at this point.

The scope of study of green growth in the agricultural sector includes the mitigation of greenhouse gas emissions as a response to climate change, adaptation to global warming, the eco-friendly management of agricultural resources, green technology and future growth. With regard to reduction of the greenhouse gas emissions and agricultural infrastructure adaptation, green growth invests considerable significance on low carbon. The agricultural sector in this instance covers both agriculture and livestock farming.

The scope of study related to rural districts encompasses the “green growth potential index for conservation and utilization” of green resources in rural districts, the maintenance of settlement space in rural districts in compliance with the green growth paradigm, and governance issues related to promoting the policies for developing green growth rural districts.

Policies to be integrated with regard to green growth agriculture include, but are not limited to, agricultural policies (expansion of production bases, agricultural mechanization, the improvement of production and distribution, technology development, manpower development, and income maintenance), and rural district policies (rural district development and the improvement of living conditions), environmental policies, and energy policies.

3. Review of Previous Studies

3.1. Discussion on the Concept of Green Growth

In Korea, serious research into green growth began in the latter half of 2008. In an article presented at the Green Growth Forum jointly held by The National Research Council for Economics, Humanities and Social Sciences and The Korea Development Institute, Jinhee Han and Jaehoon Kim (2008) presented a theoretical approach to the concept of green growth and its overall considerations related to the environment and the economy as a national strategy. They also suggested that the issue of uncertainty and the political-economic aspects and industrial-policy aspects of emission reduction policies be taken into consideration in implementing economic growth with a regard to the environment. The Presidential Council for Future & Vision (PCFV, 2009) presented the concept of green growth, the methods for its implementation, and outlined the core tasks for each field. The Presidential Committee on Green Growth (PCGG, 2009) synthesized various discussions on green growth from specialists in each field and government departments with skill competencies, in order to present a master plan for promoting green growth. This master plan covered both the concept and vision of green growth, the promotion strategies to be undertaken, and the implementation plans for each stage and field.

3.2. Critical Perspectives on Green Growth

Critical perspectives on green growth are from the conceptual aspect and the policy program content. Yun (2009) examined green growth by comparative analysis of the theories of ‘sustainable development’ and ‘ecological modernization.’ Yun concluded that the concept of green growth established on the basis of the government’s review of green growth was still growth-oriented in essence and thus unable to realize the value of sustainable development. Lee (2009) investigated the low carbon green growth strategy from the political economy perspectives, including the capitalistic nature-society relationship and the material-energy dimension of economic growth. Lee diagnosed that current green growth was still economic-growth oriented but was being promoted without clear financial plans, technical solutions or social consensus.

3.3. Discussions on Green Growth in the Agricultural Sector

Kim (2009) viewed green growth in the agricultural sector as “a concept more comprehensive than sustainable agriculture, being environmentally sound and economically profitable growth in consideration of the environmental capacity of the agricultural ecosystem.” Kim suggested that green growth in the agricultural sector was growth that could be achieved through the development of cultivation technologies, changes in farming methods, and environment-friendly low-carbon agriculture that give due consideration to the environmental capacity of each region and each water system. Lee *et al.* (2010) presented a direction, vision and strategies for promoting green growth in food, agriculture, forestry and fisheries, with the three master strategies being: low-input/high-efficiency green industrialization, sustainable utilization and management of natural resources, and promotion of public health and enhancement of national power. Action programs within these three master strategies included 50 projects for implementing low carbon green growth; and finance plans for 2009 ~ 2013 and their expected effects.

3.4. Discussions on Integrating Policies for Green Growth

Lee (1998) considered the integration of agricultural policies and environmental policies as a production condition on which agricultural policies related to the importance of natural preservation could be realized. He also suggested that dealing with environmental issues required a long-term perspective and long term approaches as a precondition. Lee emphasized the need to develop environmental taxes as tools for integrating agricultural and environmental policies on the principles of market economy, incentive policies for ecological protection, and research and technology development.

Sung and Song (2008) examined the background of policy integration theory, presented the importance of policy integration theory and outlined the difference between policy integration and policy coordination. They also detailed the policies to be integrated, the main issues concerning integration, and plans to materialize effective policy integration.

Sung (2009) analyzed a case in which Finland integrated innovation policies and environmental policies. Sung analyzed the environment-friendly innovation policies of Finland, in three stages: strategy formation, execution, and evaluation, from the perspectives of system switchover and policy integration and compared it with Korea's integration of environmental innovation policies, so as to present effective plans for policy integration.

Mickwitz and Kivimaa (2007) suggested that it was important for policy development to evaluate policy integration, including its outputs and outcomes. They presented as examples of policy integration the integration of environmental policies into technology policies and that of innovation policies into environmental policies.

3.5. Discussions on Green Growth in Rural Districts

Park and Song (1999) proposed a concept of 'environment-friendly rural villages' in order to apply the objectives of 'sustainable development' paradigm to the issue of rural district space maintenance as a more policy-oriented viable plan.

Choi (2008) proposed high-level strategies in relation to 10 master strategies for national land management that would bring about an era of green growth. These strategies included 'securing growth power through the recreation of local value, including local culture' and 'the formation of beautiful land through enhancing the value of the national landscape.' As for low-level strategies, Choi suggested the promotion of urban-rural exchanges and the maintenance of rural landscapes.

However, these low-level strategies did not reflect the current rural district development methodology and thus were considered mere declarations. Miryeong Song *et al.* (2008) estimated the degree of rural district development at the local government level using four area indices such as 'place of work,' 'place of living,' 'place of rest' and 'place of community.' The index related to 'place of rest' is related to the green growth evaluation index.

Lee (2009) examined the impact of climate change on the ecology of agriculture and rural districts and presented strategies and tasks for applying low carbon green growth policies and green technologies as countermeasures against climate change. Lee's proposals emphasized the Green Home project and the Energy-independent Village project as plans for promoting green growth in rural districts. Cho *et al.* (2009) investigated the feasibility of introducing into Korea the biomass town development project being promoted in Japan under the government leadership. The Japanese biomass town project focused mainly on technological issues concerning the introduction of facilities for converting biomass into energy in agricultural sector, forestry sector, and waste management sector, and proposed plans to implement the project.

3.6. Studies of Green Growth in Other Sectors

As for the study of green growth in the national land sector, Kim *et al.* (2009) presented six master policy tasks to be promoted for green growth in the national land sector based on three driving axes of green economy, green environment and green society.

For the science and technology sector, Bae *et al.* (2009) asserted that reasonable national strategies for technology development and growth were required for achieving low carbon green growth and suggested the need of efficient connection between green technology development and green growth strategies.

For the energy sector, Oh (2009) established the concept of green growth in relation to climate change and presented strategies for green growth in the energy and industry sector based on the analysis of means and effects of green growth.

With regard to local governments, Kim *et al.* (2009) identified the characteristics of green growth and analyzed the actual conditions of green growth in local governments, based on the conceptual understanding of green growth, and further presented main implementation strategies for local governments to achieve green growth.

3.7. Empirical Analysis of Green Growth

Kim and Chung (2009) analyzed the ecological efficiency of geothermal heat pumps by applying the concept and methodology of ecological efficiency, the core element of green growth, to the agricultural sector.

Pyo *et al.* (2009) established a green growth model based on green growth accounting theory and calculated the green productivity for each industrial sector through estimation of gross element productivity using the hybrid industrial relation table.

McKinsey & Company (2009) analyzed the cost-efficiency of the means of greenhouse gas mitigation for each sector, using the marginal mitigation cost curve, and calculated the potential marginal mitigation cost for eleven means of greenhouse gas mitigation in the agricultural sector in preparation for BAU in 2030.

3.8. Application of New Green Technologies to Agricultural Sector

Kang (2009) presented the need for introducing plant factories that could produce all-weather agricultural products whilst also minimizing greenhouse gas emissions in response to climate change. He also presented domestic and international cases of such plant factories, their cost structures, and the plans to introduce them. Kim (2009) and Kim and Chang (2009) presented the transition to, and latest trends of, plant factories as well as plans to promote pilot projects and to develop a ubiquitous building-farm model. In addition, they reviewed the conditions for commercializing the plant factory and its economic feasibility before proposing the prospects for, and tasks of, such plant factories.

3.9. Differences between Previous Studies and This Study

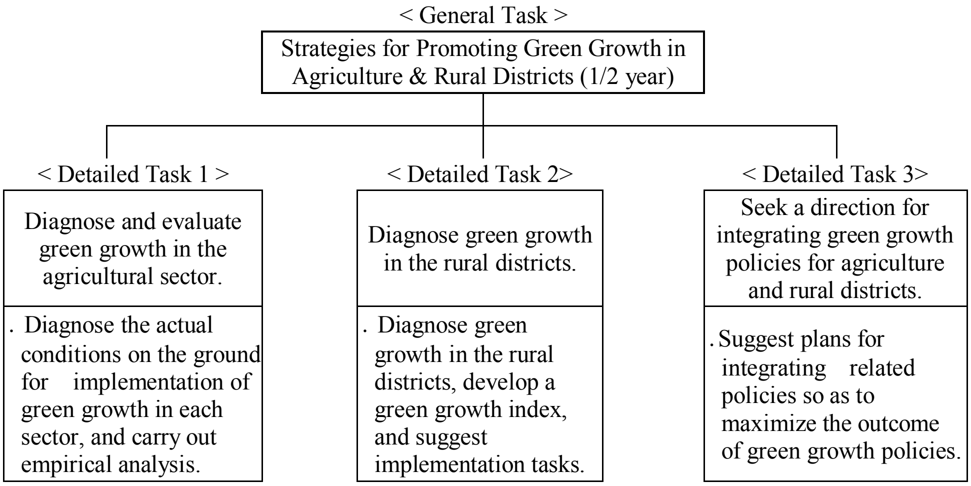
KREI previously conducted four studies directly related to green growth in the agricultural sector green growth. The first in 2003 and 2004 was the transition to environment-friendly agriculture. The second in 2006 and 2007 was the formation of strategies for mitigation of greenhouse gases in response to the climate change convention. The third, again in 2006 and 2007, researched strategies for promoting the use of biomass in the agricultural sector. The fourth and most recent study, in 2008 and 2009, researched the formation of strategies for adaptation to climate change. This study of green growth was undertaken to synthesize the series of previous studies so as to present practical implementation strategies for each sector and stage. These strategies would necessarily be based on the systematic diagnosis and empirical analysis of actual conditions of green growth in the agriculture and rural districts. This study was intended to maximize the outcome of study by making the most of cooperative research (detailed tasks and outsourcing for articles) in conjunction with domestic and international specialists in green growth in rural districts.

A forum for green growth in agriculture and rural district green growth, ‘The KREI Climate Change Forum’ established in 2009 during a period when work was being undertaken to prepare for climate change, expanded interdisciplinary research and information exchange among related fields in order and to present fruitful strategies. This forum was later reorganized into “The KREI Green Growth Forum for Agriculture and Rural Districts”. The KREI Green Growth Forum has met six times since April 2010.

4. Organization of Study Tasks and Flow Chart

To ensure effective research activities for developing strategies for promoting green growth in agriculture and rural district green growth, three major tasks were carried out: “Diagnose and evaluate green growth in the agricultural sector”; Diagnose green growth in the rural districts”; and “Seek a direction for integrating green growth policies for agriculture and rural districts (Figure 1-1).

Figure 1-1. Flow Chart for Research Tasks for Establishing Green Growth Strategies for Agriculture and Rural Districts

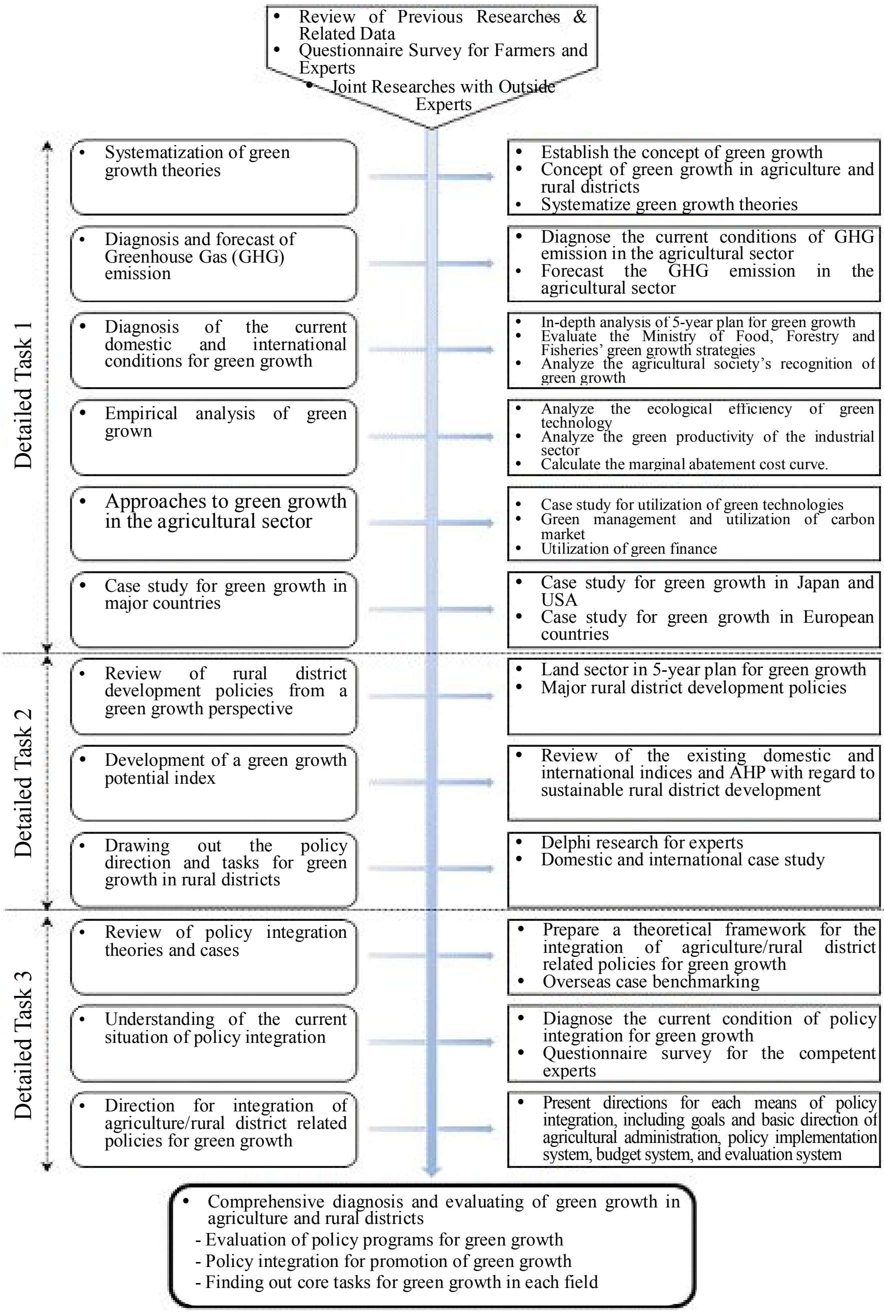


Detailed Task 1: “Diagnose and analyze green growth in the agricultural sector” includes the systematization of green growth theories, an empirical analysis of green growth following the application of green productivity and ecological efficiency , and additionally an analysis of green growth cases in major countries.

Detailed Task 2: “Diagnose green growth in the rural districts” addresses the green growth policies for rural districts, developed the green growth potential index, and sought for political tasks for green growth in rural districts based on in-depth research by specialists.

Detailed Task 3: “Seek a direction for integrating green growth policies for agriculture and rural districts” proposed plans for integrating policies to maximize the outcome of green growth policies. This report is a general report summing up the core contents of the outcome of the first year research for each detailed task. The main contents and results of the research for each detailed task are summarized in Figure 1-2.

Figure 1-2. Flow Chart for 1st year Study of Green Growth in Agriculture and Rural Districts



5. Study Methods

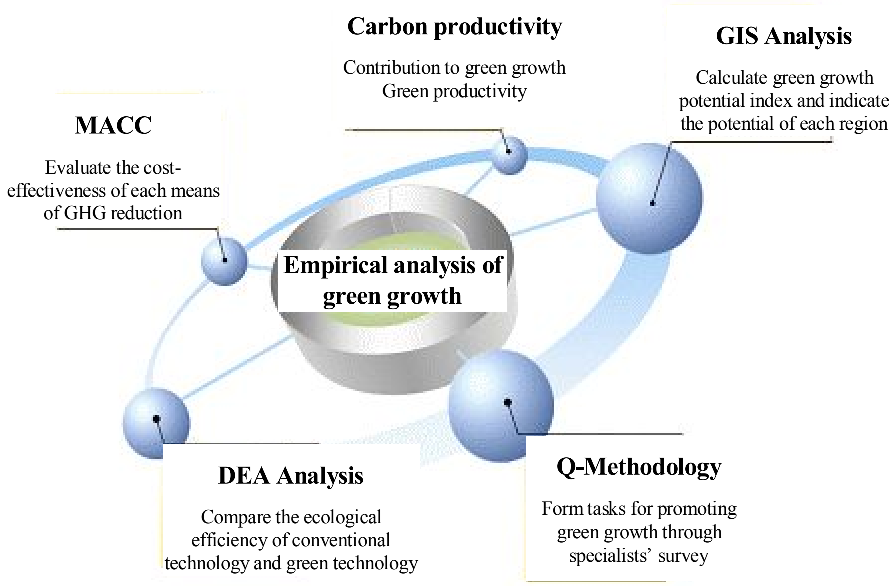
5.1. Literature Study

With regards to the domestic literature, numerous government policy papers and research reports related to green growth were studied. These were primarily green growth related documents and research papers issued by The Ministry for Food, Agriculture, Forestry and Fisheries, The Rural Development Administration, The National Academy of Agricultural Science, The Ministry of Environment, The Presidential Committee on Green Growth, The National Research Council for Economics, Humanities and Social Sciences, The Korea Environment Institute and The Korea Energy Economics Institute. In addition, foreign literature such as government documents and other related research materials from the USA, the UK, Australia and Japan were reviewed. Furthermore, green growth related documents and research results issued by international organizations such as the OECD, the FAO and UNESCAP with relation to the agricultural sector were referred to.

5.2. Empirical Analysis of Current Conditions of Green Growth

Empirical analysis for evaluating the current conditions of green growth was carried out using various quantitative and qualitative methodologies Figure 1-3. Frequency analysis and cross tabulation were performed on the results of surveying the agricultural sector's perception of green growth. For empirical analysis of green growth in the agricultural sector, Data Envelopment Analysis (DEA) based on ecological efficiency, was performed to compare the outcomes of organic agriculture and conventional agriculture, by using ecological efficiency base. Furthermore, to evaluate the cost-effectiveness of each means of greenhouse gas reduction in the agricultural sector, an attempt was made to draw a Marginal Abatement Cost Curve (MACC). For a comparison of green productivity between the agricultural sector and the non-agricultural sectors, a regression analysis to identify carbon productivity and the factors contributing to the carbon productivity was performed. For the rural districts, the green growth potential index of each region was calculated and then visualized using GIS. Also, specialists, local government workers, and rural district residents were surveyed using Q-methodology as a prerequisite to the formation of tasks to promote green growth in rural districts.[1]

Figure 1–3. Methodology applied for Diagnosis and Evaluation of Green Growth



5.3. Surveys for Domestic and International Specialists and Competent Organizations

In order to evaluate perceptions of green growth and the responses to government policies a survey of farmers and experts, including those in charge of implementing policies, was undertaken. In order to identify the tasks necessary for implementing green growth policies in rural districts, a panel of experts was organized, interviewed and additional meetings with the panel arranged. Also, to

1 Q-methodology is a type of factor analysis, which statistically classifies various opinions about a certain issue into several groups of similar degree of consensus (Stephenson, 1953; Honggyu Kim, 2008).

diagnose the current status of policy integration within green growth policies, competent experts were interviewed by e-mail.

National research institutes in Korea in charge of research into green growth, as well as other related institutes, were visited for the purpose of collecting data, exchanging information and establish expert networks. Visits were also undertaken outside of Korea to the UK and Japan, where active research was ongoing and green growth policies had been implemented. During these visits qualified researchers and the staff in charge of green growth policies were interviewed to gather information and data. This information and data was then analyzed and used as benchmarking data.[2]

5.4. Holding Seminars and Conferences

In order to collect opinions about green growth in agriculture and seed fruitful discussion, a total of five seminars and conferences with domestic and international specialists were held. In addition the 'KREI Green Growth Forum for the Agricultural Sector' was held six times. An international seminar with the topic of "Diagnosis and Tasks for Green Growth in Agriculture" was also held. This seminar revealed the outcomes of the first year study on the development of strategies for promoting green growth in agriculture and rural districts and allowed an opportunity the free exchange of expert opinion from both domestic and international specialists.[3] This international seminar on green growth mostly consisted of a theme presentation by specialists from the USA, Australia, Japan and Korea followed by comprehensive discussions. These proceedings were published in 2010 (Kim C.G., 2010b).

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[2] The international survey of the green growth in agriculture took researchers to Japan (May 12 ~ 16, 2010) and the UK (September 12~18, 2010) . In Japan, The Ministry of Agriculture, Forestry and Fisheries, The Institute for Agriculture and Trade Policy, and The Institute for Agricultural Technology and Policy were contacted. In the UK, The Department for Environment, Food and Rural Affairs, The Scottish Agricultural College and the EU Institute of Environmental Policy were contacted.

[3] An international seminar was held on November 19, 2010 in order to diagnose green growth in the agricultural sector and share information on green growth policies with major countries. The findings and material presented in the seminar (five theses presented) and the contents of the ensuing comprehensive discussion has been issued as a proceedings.

5.5. Current Situation of Cooperative Researches

To ensure the effective implementation of the first-year research tasks for diagnosing green growth in agriculture and rural districts and identifying future tasks, research into areas that required the specialized knowledge of researchers in other disciplines was outsourced (for articles solicited refer to Table 1-1).

The outsourced research produced within Korea consisted of articles such as "The Utilization of Rice-based Supercritical Fluid as a New Green Technology for the Agricultural Sector" (Prof. Yoonwoo Lee, Seoul National University), "Plans to Utilize Green Finance in the Agricultural Sector" (Dr. Ik Jin, Korea Insurance Research Institute), "The Systematization of Green Growth Theories for Rural Districts" (Dr. Hoeseong Jung, Korea Environmental Policy and Administration Society) and "Policy Integration Theories and Overseas Cases of Policy Integration" (Dr. Jieun Seong, Korea Institute of Science & Technology Evaluation and Planning).[4] Research tasks outsourced to overseas specialists involved the diagnosis and evaluation of green growth in US agriculture, including an empirical analysis of green productivity and detailed strategies for green growth (Prof. Susan Capalbo, USA Oregon State University).

Table 1-1. Domestic and Overseas Contract for Researches

	Researcher in Charge	Main Contents
Domestic Joint Research	Prof. Yoon-Woo Lee (Biochemical Engineering Dept., Seoul National Univ.)	◦ Analysis of technologies for applying supercritical fluid in the agricultural sector ◦ Plans to establish a rice biorefinery system
	Dr. Ik Jin Korea Insurance Research Institute)	◦ Concept of green finance and current conditions for its application ◦ Plans to utilize green finance for green growth in the agricultural sector
	Dr. Hoe-Seong Jung (Korea Environmental Policy and Administration Society)	◦ Systematization of green growth theories from the perspective of rural district development ◦ Methodology for the development of a rural district green index
	Dr. Ji-Eun Seong (Science and Technology Policy Institute)	◦ Theoretical review of policy integration ◦ Overseas cases of policy integration and their implications

[4] In order to facilitate the utilization of outsourced research outcomes from the first year study for green growth, the results of this research was published as a research journal.

	Researcher in Charge	Main Contents
International Joint Research	Prof. Susan Capalbo (Applied Economics Dept. Oregon State Univ. USA)	◦ Empirical analysis of green productivity in the USA agricultural sector ◦ USA strategies for green growth in the agricultural sector ◦ USA design of green growth policy for the agricultural sector and review of its applicability to Korea
Total of 5 tasks (4 domestic and 1 overseas)		

Concept of Green Growth and the Related Theories

Chapter 2

The concepts and theories of green growth have not been established systematically but have been actively discussed. Chapter two describes the concept of green growth, as compared with sustainable growth, based on the literature published so far in these related fields, and sets forth the concept of green growth as presented by the Framework Act on Green Growth. Chapter two continues with the theoretical background of green growth (based on the Environmental Kuznets Hypothesis) and examines the prerequisites for achieving the goal of green growth. In addition, it presents the concept of green growth in relation to the agricultural sector and the policy measures for achieving green growth.

1. Concept of Green Growth

Sustainable development, which means to achieve continuous economic growth while maintaining a balance between environmental conservation and economic development, was the basis of UN's 1992 "Rio Declaration on Environment and Development" with the particular tasks to be implemented listed in "Agenda 21". The concept itself was defined by the World Commission on Environment and Development (WCED) in 1987 following its mention in the UN's declaration on environment in Stockholm in 1972.

The concept of sustainable development originated from critical reflection on the perspective of mainstream economics, a perspective that prioritizes the economic growth paradigm over environmental issues (i.e. "growth first, clean up later"). The WCED defines "sustainable development" as "development that meets the needs of future generations while satisfying the needs of the present generation based on equity between generations." (Changgil Kim & Jeongho Kim, 2002, pp.7-9)

Green growth is a concept derived to complement the conceptual abstractness and enormous breadth of sustainable growth (economic, environmental and social); which itself signifies an environmentally sustainable economic growth. In other words, green growth is a "qualitative growth" seeking to raise the quality of life by securing both a sound ecology and a sound economy. While the existing economic growth paradigm places the economy and the environment in conflict, from a green growth perspective they are seen as complementary (Table 2-1).

The Korean government defines green growth as "economic growth that creates new growth power and job opportunities while minimizing environmental pollution and greenhouse gases (GHGs)" (The Presidential Committee on Green Growth, 2009). As can be seen from the descriptions above, green growth encompasses different definitions and perspectives and thus it should be understood as an open-ended concept that can accommodate new cultures and paradigm shifts. In this context, the concept of green growth will continue to evolve through the course of many discussions.[5] The Framework Act on Low Carbon Green Growth (Article 2) sets forth green growth as being "growth that ensures harmony between the economy and the environment by reducing climate change and environmental deterioration by means of the efficient use of energy and resources, whilst securing new growth power through research into, and the development of, clean energy and green technology and by doing so creating new job opportunities."

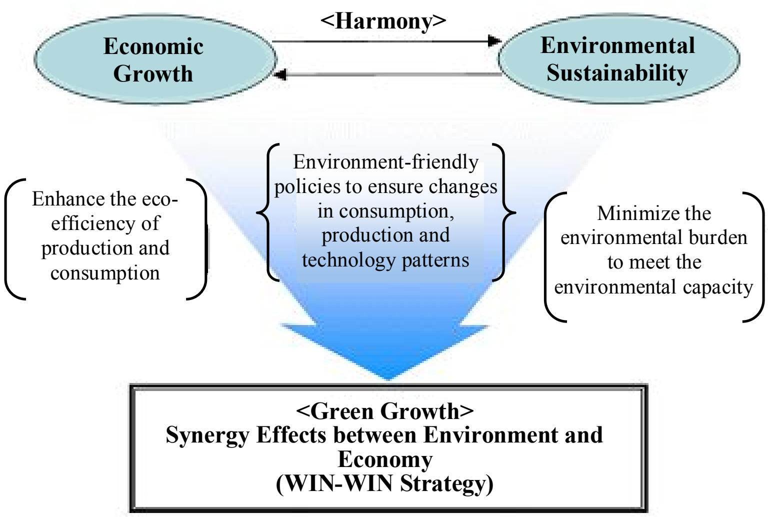
Table 2-1. Comparison between the Existing Growth Paradigm and Green Growth Paradigm

Category	Existing Economic Growth Paradigm	Green Growth Paradigm
Growth Method	Input-driven	Optimum input in consideration of environment
Core Value	Quantitative growth	Qualitative growth
Relation between Environment & Economy	Contradictory	Complementary
Growth Power	Energy consuming businesses	Green industry & green technology
Social Structure	Energy waste, Environmental pollution	Low carbon recycling society

[5] The term "green growth" was first coined in *The Economist* (January 27, 2000) and thus is a term from a journal rather than from an academic paper. Subsequently, the 2005 UNESCAP Ministerial Conference on Environment and Development conducted in-depth discussions on green growth whereupon the the term "green growth" started to be widely used, for example at the Davos Forum.

Though the definition of green growth can depend on one's position and perspective, the basic principle is established as the conversion of a vicious cycle between the environment and economic growth into a virtuous cycle through changes in growth patterns and the economic paradigm. To bring about this conversion, green growth endeavors to reduce environmental pollution by investing in green capital, green technology and green knowledge; and continuously enhancing productivity by expanding the natural capital (energy, environmental resources). When green growth is realized, eco-efficiency is improved to the point where demand meets environmental capacity. This is achieved through changes in production, technology and consumption patterns and through environment-friendly policies. This is only possible when economic-efficiency and environmental-efficiency are considered at the same time in both production and consumption aspects. Therefore, green growth can be adopted as a national development strategy that will establish a virtuous cycle between the environment and the economy and so maximize the synergy effects. It is a win-win strategy that enables economic growth to contribute to environmental improvement and for the environment in turn to serve as a new growth power (Figure 2-1).

Figure 2-1. Green growth system where environment and economy grow in harmony



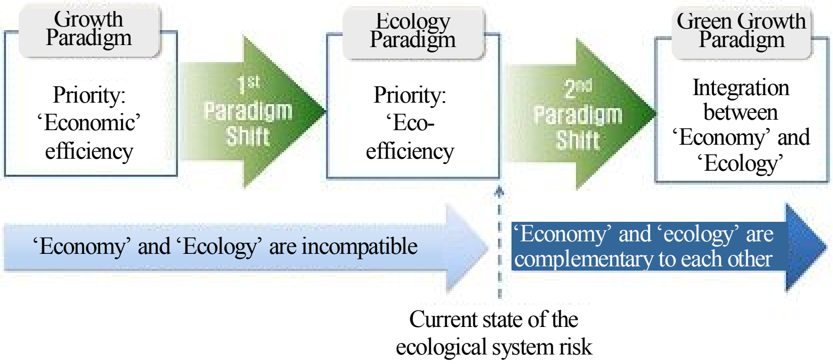
In reality, green growth can be realized when environmental sustainability and environmental performance are combined. While the existing environmental approaches focus on improving environmental performance through regulations, environmental sustainability requires the shifting of social systems related to production and consumption.

Green growth suggests that combination of a policy statement and aligned social values are needed to realize sustainable economic growth through the promotion of low carbon green industry. Green growth involves considerable economic cost and effort, and requires turning away from the present convenience-oriented lifestyle. Therefore, achieving the goal of green growth will require economic incentives, the development and popularization of green technologies, increased understanding and cooperation between related parties, a paradigm shift, and prompt action. All these requirements are urgently needed.

2. Theoretic Background of Green Growth and Its Prerequisites

Green growth has at its theoretical basis ecological modernization theory. Ecological modernization holds that economic growth and environment protection, a relationship previously believed to mutually contradictory, can be integrated within a framework of industrial modernization and that they form a WIN-WIN relation in which both sides of the equation can benefit the other (Figure 2-2). Given that it is seen as possible to achieve environmental improvement and economic growth simultaneously by firstly, considering environments within the capitalistic economic structure and secondly, internalizing environmentally external effects, ecological modernization theory considers economic growth and environment protection to be compatible. Green growth suggests that combination of a policy statement and aligned social values are needed to realize sustainable economic growth through the promotion of low carbon green industry.

Figure 2-2. Shift to Green Growth Paradigm



A fundamental difference of the green growth model from the traditional economic growth model is that the green growth model sees environment protection not as an obstacle to economic growth but rather one of its drivers (Table 2-2). Therefore, formulating green growth plans should ideally place more emphasis on long-term prospects rather than short or mid-term ones and require structural changes in green technologies and management techniques to facilitate the role of a political mediator at the time of market failure.

Diagnosis of green growth requires a green productivity and ecological-efficiency index be added to GDP and productivity index. Such an index should encompass the qualitative aspects and the environmental issues of growth. In addition, the environmental index in the green growth model should be capable of measuring the relationship between, one the one hand the supply of environmental goods and services and on the other economic activities as well. This should be in addition to simply measuring the use of resources and the emission of pollutants used in the traditional economic growth model.

Table 2-2. Comparison between Traditional Economic Growth Model and Green Growth Model

	Traditional Economic Growth Model	Green Growth Model
Relation between economy and environment	Environmental protection and economic growth are incompatible.	Environmental protection is an economic growth driver.
Perspective of planning	Short-/mid-term prospects	Long-term prospects

	Traditional Economic Growth Model	Green Growth Model
Political perspective	Government policies perform a role of mediator at the time of market failure.	Government policies promote the development of green technologies and management techniques and the structural changes, to provide solutions and mediation at the time of market failure.
Environmental responsibility	Both government agencies and private sector are responsible for environment-friendly management.	All government agencies, enterprises, and social structures are responsible for the environment.
Environmental-political intervention	To improve all patterns of production and consumption	To change the pattern of economic activities to have less of an environmental burden
Econo-political intervention	Taxes and levies on environmental externalities and effects	Supports and financial incentives for green renovation, businesses and jobs
Economical index	Measures economic growth rate and extent (e.g. GDP and productivity).	Measures the extent of well-being including the qualitative aspects of growth and the environment
Environmental index	Measures the use of resources and pollution	Measures the relationship between economic activities and the supply of environmental goods and services
Political index	Overall level of production effect and support for the level of change in political supports	Change in components of production, environmental effects, and political supports, in relation to the level of change in components of political supports

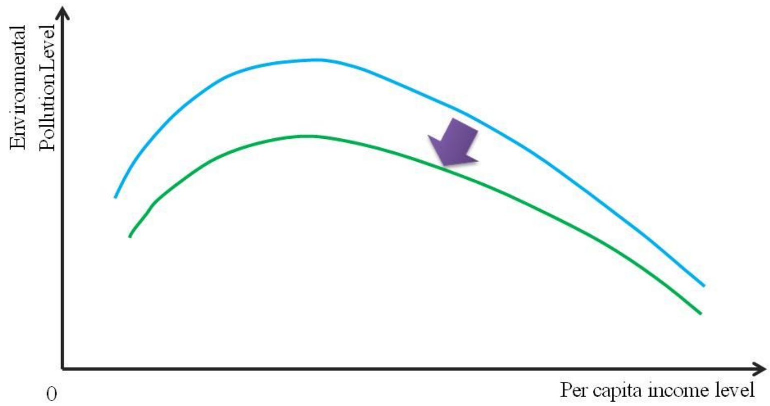
Source: OECD (2010c).

Theoretically, green growth can be explained using the Environmental Kuznets Hypothesis that empirically explains the relationship between the environment and income level (UN ESCAP, 2008).[6] The hypothesis considers that the same tendency exists between environmental pollution and economic growth as between distribution and growth. The Environmental Kuznets Curve (EKC) refers to a reversed U-shape curve that shows the increase of environment pollution as the economy grows in its initial stages followed by a decrease in environmental pollution as the income increases

[6] The Environmental Kuznets Hypothesis (EKH) is a theory proposed by Simon Kuznets, a winner of Nobel Prize in economics, in which income inequality becomes worse in early states of economic growth but income distribution improves as the national income reaches a certain level and beyond. With regard to the relation between environment and income level, the environment is deteriorated as the income level increases but improves when the income level reaches a certain point. Environment Kuznets Curve (EKC) signifies that economic growth is a cause of environmental issues but at the same time can be its cure.

in the later stages of growth beyond a certain level (Figure 2-3). Economic growth requires the improvement of environmental performance. However, an increase in income does not necessarily lead to a decrease in environmental pollution. Rising incomes may worsen environmental pollution until economic growth reaches a certain turning point. Therefore, growth-oriented countries need to improve their environmental performance by switching over to green growth paradigm so as to flatten the EKC curve and shorten the time needed to reach the curve's peak.

Figure 2–3. Improvement of Environmental Performance through Green Growth – Downward Movement on EKC



Domestic and overseas cases have shown that when economic growth reaches a certain level, policies designed to reduce environmental pollution become increasingly prioritized, with environmental policies being given more manpower and increased budgets for their execution. High levels of income and education help communities strengthen environmental standards. The claim that environmental pollution will start to decrease once the national income reaches about $8,000 ~ 10,000 is also gaining support. Though the issues of GHG emission are not easy to improve, it appears that the GHG increase rate has slowed down in those countries that have achieved high economic growth.

The EKC cannot be accomplished automatically without regard to the role of government and/or the private sector. As the economic level improves and environmental pollution worsens, the government and private enterprises increase their interest in, and investment in, technology development and environment-friendly industry so as to conserve the environment. Also, the government implements policies to strengthen environmental regulations. Without such complementary roles between private enterprise and the government, it is difficult for a virtuous cycle of growth to be established. On the other hand, the EKH shows the possibility that environment can be improved along with economic growth. At the same time, however, it also highlights a fundamental unfairness between developed and developing countries since, according to the EKC, developing countries cannot improve environmental issues until their economy reaches a certain level. However, current climate change conventions require their participation nonetheless.[7]

With regard to climate change and energy issues, developing countries can pursue economic growth while minimizing environmental damages when they can adopt advanced technologies and knowledge from the developed countries. In other words these nations accommodate green growth instead of trying to copy the development path of developed countries. Let's assume that the developing countries are now in between points A and B while the developed countries are at point C (Figure 2-4). From the current economic growth point of view, the developed countries are already in a risk range with regard to environmental issues. However, when they implement low carbon, green growth policies in compliance with the climate change convention, they will move from C to E. In this case, what policies do the developing and the underdeveloped countries have to use? Do they have to stop their economic growth? At this time, the hypothesis of sustainomics suggests that there will be another way to be opened for the developing countries in B. In other words, they can enjoy the tunnel effect, in which they follow a path below the environmental danger threshold by borrowing green technology and knowledge from developed countries. Therefore, while the developed countries move from C to E, the developing countries can jump from B to D and then E rather than following the same developmental path as that of the developed countries. Such a tunnel is only made possible only when there is international cooperation between the developed and the developing countries.[8]

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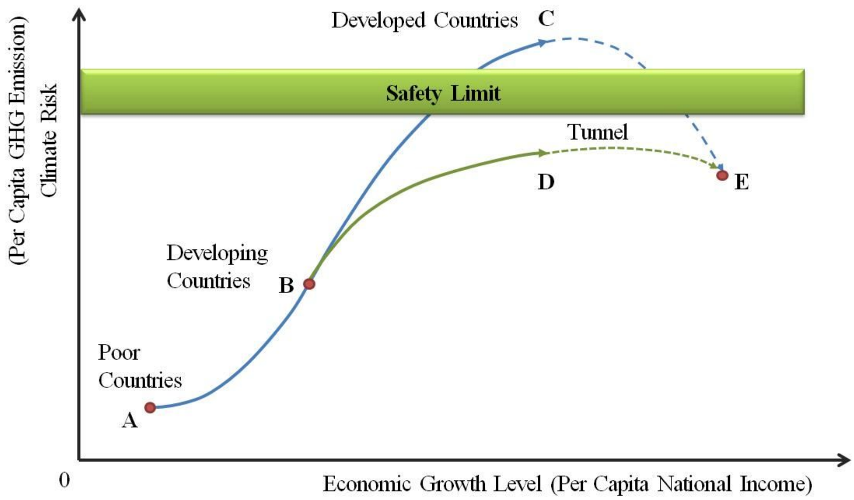
[7] In response to this situation, Munasinghe, who was a co-winner of 2007 Nobel Prize in Peace as a vice chairman of IPCC, proposed a hypothesis of economy (sustainomics)'. The hypothesis modifies the traditional EKC to incorporate a new variable of international cooperation (Munasinghe, 2010).

[8] The international cooperation described requires developed countries to share green technologies they have developed and used with economically developing countries and to support those developing countries with their GHG reduction efforts. It is a key problem as to whether such cooperation is possible in an international society where each country attaches importance to its own interest. The hypothesis of sustainomics assumes that the issue of climate change requires global cooperation and if it fails, that all perish together.

Figure 2-4. Green Growth Paths of the Developed and the Developing Countries

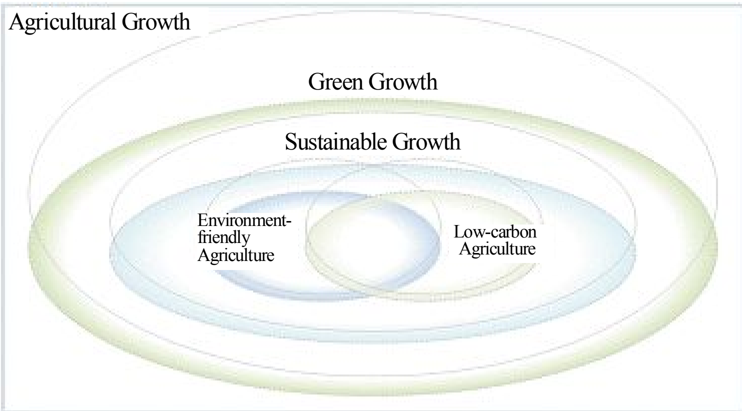


Source: Munasinghe (2010)

3. Concept of Green Growth of the Agricultural Sector

Differences between sustainable growth and green growth have been examined in the previous section. Green growth of the agricultural sector is a more comprehensive concept than sustainable agriculture and can be understood as environmentally sound and economically profitable growth which considers the environmental capacity of the agricultural ecosystem. In reality, green growth of the agricultural sector means growth achieved through the conversion of cultivation technology, farming methods and the conversion to environment-friendly low-carbon agriculture, taking into consideration the environmental capacity of each region and water system. To achieve green growth, it is necessary for the agricultural sector to switch over to a sustainable agricultural system by promoting environment-friendly agriculture and low carbon agriculture and by doing so maintain the foundations for environment-friendly agriculture and rural districts. (Figure 2-5)[9]

Figure 2–5. Conceptual Place of Green Growth of the Agricultural Sector



Farming that pursues green growth of the agricultural sector can be defined as green agriculture but it is not an officially used term. Though many terms are used in the agricultural sector with regard to green, it should be noted that they are not always directly related to green growth. For example, China uses a term “green food” to convey the meaning of environment-friendliness to consumers. Another example is the agricultural sector’s use of the terms “green revolution” and “the second green revolution,” the first one referring to an epoch-making increase in productivity through development of a high-yielding varieties (for example the new variety IR667, a class of *Tongil* rice) and the second one referring to cultivation of forage crops in fallows during the winter, both of which are not deemed to be directly related to green growth.

The green growth of the agricultural sector is a concept in which economic efficiency and environmental efficiency are integrated, which can be approached from the 3P viewpoint: People, Planet and Profit. First of all, “people” refers to the

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9 Environment-friendly agriculture refers to agriculture that produces safe agricultural products and livestock products while maintaining and conserving agricultural ecosystem and environment by not using, or by minimizing the use of, chemical materials including pesticides, chemical fertilizers and antibiotics whilst recycling agricultural and livestock byproducts. Low carbon agriculture refers to the environment-friendly farming methods that uses less chemical materials like nitrogenous fertilizers and pesticides. It also implies agriculture that emits less GHG like carbon dioxide through, for example, direct-sowing in dry paddy, improved irrigation control, no-till, bio-crop farming, biogas plants, and use of feed additives that promote enteric fermentation.

establishment of proper role division and a cooperation system among such people closely related to the materialization of green growth of the agricultural sector, such as producers, consumers, policy-makers, researchers and other related organizations. "Planet" signifies continuous management and maintenance of environmental components of the agricultural ecosystem such as soil, water and air within the range of environmental capacity. Lastly, "profit" refers to enhancing competitiveness and maintaining profitability, in order for agriculture to be maintained and managed as a bio-industry, through improved green management power, green technology innovation and policy support.

Green agriculture restructuring means to convert the nation's agriculture, in its entirety, into low-carbon agriculture by enhancing its energy efficiency and utilizing convergence technologies. The green value chain requires a green growth foundation for agriculture to be established through conversion of the entire value chain from 'production–distribution-processing–consumption - recycling' into an environment-friendly chain. Also, for green value chain, green conversion should be promoted using a green technology certification system and such convergence technologies such as Information Technology (IT), Nano-technology (NT) and Biotechnology (BT). Restructuring is required to protect green technology for the agricultural sector and improve environmental competitiveness in response to climate change. This can be achieved through domestic standardization of resource recycling and energy efficiency improvement and the preemption of international standards related to them. Restructuring is also needed to promote green industry related to agriculture, for example by improving energy efficiency and solving environmental issues using green IT. Restructuring is also need to establish the conversion of the entire supply chain into green by means of the conversion of agricultural production, distribution, export, marketing and consumption. The foundations for green growth should be established through green agriculture restructuring and establishing an environment-friendly agricultural materials industry (including organic agriculture and food industry using LED or geothermal energy). All these should be fostered as key green industries.

4. Policy Measures for Green Growth

In reality, it is almost impossible to find the best means of accurately measuring the external effects of global warming and environmental issues. This in turn means it also virtually impossible to accurately levy the economic expenses on the parties responsible for GHG emissions (or environmental pollution). Green growth policies that can balance the environment and the economy, even taking into consideration this realistic limitation, include, but are not limited to, the following: economic measures such as tax reform (e.g., a carbon tax) and a carbon emission trading system; direct regulations like an emission cap as well as regulations on nitrogenous fertilizer application and stocking density; voluntary conventions like proper farming standards; research, development and spread of technologies; and information provision and public awareness programs including GHG monitoring and support for project implementation (Table 2-3).

Table 2-3. Classification of Policy Measures for Green Growth

Classification	Detailed Measures
Economic measures	Levies, carbon tax (or GHG tax), emission trading system, grants
Direct regulation	Emission caps, regulations on nitrogenous fertilizer application, regulations on manure application, regulations on stocking density
Voluntary convention	Proper farming standards, formation of resource recycling villages
Research, development & spread	Research programs, technology development programs, demonstration projects
Information provision and public awareness programs	GHG monitoring, and support for project implementation

Source: Perman *et al* (2003); OECD (2010a)

Policy measures for promoting green growth of the agricultural sector are: climate policy measures for both GHG reduction and adaptation to climate change; energy policy measures for efficient energy use, promoting the use of renewable energy, and the development of new energy sources; environment and resource management policy measures including the formation of green spaces and resource management; green industry policy measures for establishing environment-friendly agriculture (including organic agriculture) creating green foods, green finance, bio-industry and new job opportunities; and green technology policy measures including the establishment of a certification system, a green technology integration project team, a green technology standards system, and a DB (Refer to Attached Table 2 that lists the inventory of green growth policies for the agricultural sector).

Diagnosis of Domestic and International Conditions for Green Growth of Agriculture and Rural Districts

Chapter 3

To develop tasks for green growth of agriculture and rural districts, it is necessary to correctly understand the present status of green growth. Chapter three diagnoses the changes in conditions for green growth, focusing on the present status and the prospect of GHG emissions and its management measures. This is necessary in order to identify the present condition of green growth of agriculture and rural districts. It also suggests the current conditions of green growth policy programs for the agricultural sector and evaluates those policy programs as well. It then describes the results of surveys of both farmers' and experts' (including those in charge of the policies) recognition of green growth. Finally the chapter ends with a review of the present condition of policy integration for green growth of agriculture and rural districts.

1. Changes in Conditions for Green Growth of the Agricultural Sector

1.1. Present Conditions and Prospect of GHG Emissions from the Agricultural Sector

Gross national GHG emission (as of 2007) amounts to about 620 million CO_2 tons, which was a recorded 2.9% increase from the previous year. The year by year variation in each industrial sector shows a 3.9% increase in the energy sector and a 5.3% increase in the agricultural sector but a 4.4% decrease in the industrial process sector and a 2.2% decrease in the wastes sector.

The GHG emissions from the Korean agricultural sector (as of 2007) are about 18.4 million CO_2 tons, an amount equal to 2.9% of gross national GHG emissions.

The trend for the sector points to increasing emissions due to an increase in stocking density and the use of chemical fertilizers. This represents a reverse of what was until 2006 a decreasing trend. Sixty-five point four percent of the sector's GHG emissions come from crop farming including rice farming, farmland soil and residue incineration with the remaining 34.6% coming from livestock farming including enteric fermentation and livestock wastes treatment.

An estimate of GHG emissions from the agricultural sector in 2020 is calculated in several ways. For comparison with the national forecast of GHG emissions, it is possible to estimate GHG emissions from the agricultural sector without any reduction measures being taken (Business as Usual or BAU). As for the details of the scenario itself, they include the suspension of rice tariffs and the enforcement of FTAs with major countries from 2011 and reflected change factors in the international conditions. For domestic change factors, a straw input rate of 20%, an intermittent irrigation rate of 50% and a mid-/late-ripening variety rate of 89% are applied (Table 3-1).

Table 3–1. Estimates of GHG Emissions from the Agricultural Sector

Unit: Thousand Tons

Year	Crop Farming			Livestock Farming			Total (for each gas type)		
	CH_4	N_2O	CO_2 converted	CH4	N_2O	CO_2 converted	CH_4	N_2O	CO_2 converted
2005	312	19	12,553	213	4	5,811	524	24	18,363
2008	297	18	11,971	238	5	6,614	535	24	18,585
2010	289	21	12,736	258	6	7,207	547	27	19,943
2015	279	21	12,341	243	5	6,775	522	26	19,116
2020	270	20	11,905	228	5	6,367	498	25	18,271

Source: Changgil Kim *et al.* (2010).

Under this scenario methane emission from crop farming amounting to 312 thousand tons in 2005, are estimated to decrease by 7.2% in 2010, an additional 10.4% in 2015, and finally by another 13.5% in 2020 (270 thousand tons).

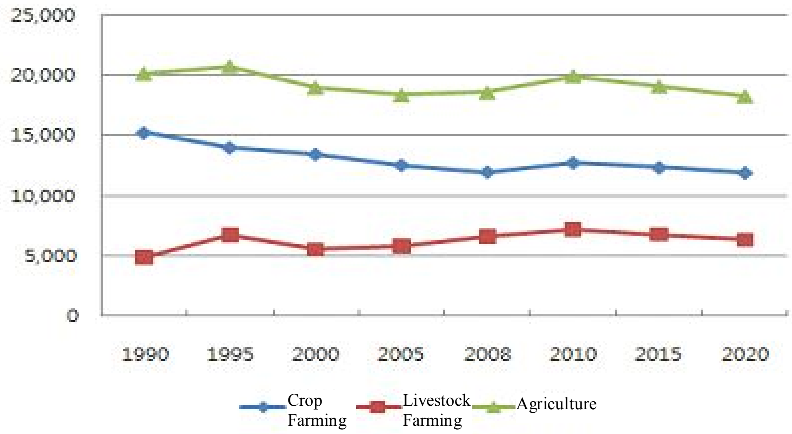
Conversely, nitrous oxide emissions from crop farming amounting to 19,000 tons in 2005 is estimated to increase by 10.9% in 2010 and then increase by another 7.8% in 2015, and by 3.9% by 2020 (20,000 tons).

On the other hand, methane emission from livestock farming amounting to an estimated 213 thousand tons is predicted to increase by 21.3% in 2010, by another 14.1% by 2015, and by 7.3% by 2020.

Nitrous oxide emissions from livestock farming amounting to an estimated 4,000 tons in 2005 are also estimated to increase by 33.2% in 2010, by an additional 25.1% in 2015, and a further 17.2% in 2020. BAU for the agricultural sector in 2020 is estimated to be 18.27 million CO_2 tons, recording a 0.5% decrease from 18.36 million CO_2 tons in the reference year of 2005 (Figure 3-1).

Figure 3–1. GHG Emissions from the Agricultural Sector, converted into CO_2

Unit: Thousand CO_2 tons



Source: Changgil Kim *et al.* (2010).

1.2. Measures for Managing GHG Emissions from the Agricultural Sector

In order to facilitate greater GHG reduction and absorption in the agricultural sector a wide variety of technologies for reducing GHG emissions from farmlands have been developed and put into practical operation. These technologies include soil organic carbon sequestration, improving the enteric fermentation of ruminants, improving livestock waste treatment plants, utilizing biomass, and reducing the use of fossil fuels (Table 3-2). The various GHG reduction technologies can be largely divided into four classifications: emission reduction technology, organic crop farming and livestock farming technology, soil organic carbon sequestration technology, and bio-energy utilization technology.

The first of these, emissions reduction technology, is a clean technology that reduces methane and nitrous oxide emissions. It does this by applying crop cultivation technologies such as improved fertilizer and water management, livestock farming technologies such as feeding improvement and the use of fermentation accelerating additives. Reduction technologies applicable to rice farming includes reductions in fertilizer usage, the expansion of organics usage, conversion to an intermittent irrigation method, and changing the method of cultivation method to direct-sowing on dry paddy. Methods applicable to dry paddy farming include reductions in chemical fertilizer usage and the practice of environment-friendly agriculture. Emission reduction technologies applicable to livestock farming include improvement of the energy content and the digestion efficiency of animal feed, livestock breed improvement, the use of high-quality

Table 3-2. List of GHG Reduction Technologies for the Agricultural Sector

Applicable Field	Reduction Technology
Reduction of methane and nitrous oxide emissions from farmlands	Expansion of organic farming methods and environment-friendly farming methods
	Reduction of fossil fuel usage through improvement of farming methods
Formation of vegetation in fallow lands	Formation of forests and/or vegetation in fallow lands
	Cultivation of cover crops in fallow lands
Soil organic carbon sequestration	Conservation tillage (single till, no till), crop rotation
	Substitution of chemical fertilizers with organics (crop residues, sludge)
	Soil cover, irrigation method improvement (water management method improvement)
Improvement of ruminants' enteric fermentation	Improvement of energy content and digestion efficiency of feeds
	Livestock breed improvement, High-quality roughage feeding
	Administering a rumen fermentation regulating agent (feed additives, microbes)
Improvement of livestock wastes treatment facilities	Expansion of facilities for aerobic treatment of slurry and installation of covers to those facilities
	Methane capture and recycling
Biomass utilization and reduction of fossil fuel usage	Substitution of fossil fuel with bio-energy crops
	Expansion of technologies for recycling biogas and biomass resources
	Power generation using rice bran

roughage, and improvements in the enteric fermentation of ruminants through the addition of rumen fermentation regulating agents (feed additives or microbes). The technology for improving livestock waste treatment facilities is also included in emission reductions such as expanding the facility for aerobic treatment during the slurry storage period and installing covers on livestock waste storage tanks.

Second, organic crop and livestock farming technology is a type of GHG reduction technology for reducing CO_2 and nitrous oxide emissions. Organic agriculture manages the soil by rotating crops or applying byproduct fertilizers or organic fertilizers and so do not use any chemical fertilizer or pesticide. The essence of organic agriculture is to manage soil fertility through promotion of soil microbial activities, biological nitrogen fixation, legume crops and crop rotation, replacing external inputs with the organic relationship between crop farming and livestock farming, as well as ensuring an agriculture that recycles everything. It is suggested that such recycling organic crop and livestock farming technology is contributing to reductions in CO_2 and nitrous oxide emissions. According to an International Federation of Organic Agriculture Movements (IFOAM) report, the organic crop and livestock farming technology contributes considerably to direct and indirect reductions of GHG emissions. The report argues that this is achieved by behavior changes to green consumers as well as the environment-friendly use and management of farmlands, the recycling of livestock wastes, environment-friendly livestock management, and resource-cycling nutrient management (Kotschi and Muller-Samann, 2004). In actuality, the practice of organic farming methods can reduce CO_2 emissions when the input of external agricultural materials (including formulated feed) is minimized through soil and nutrient management, which in turn allows for fossil fuel energy inputs to be reduced.

Third, soil organic carbon is a substance in the process of decomposition, from the carbon previously stored in the plant by photosynthesis, once it enters the soil in the form of plant residue.[10] Present in the soil for an extended period, while being slowly decomposed in the soil, soil organic carbon plays an important role in regulating the relationship between soil carbon sequestration on the earth's surface and atmospheric CO_2. As soil organic carbon accumulates in the soil this soil organic carbon sequestration has the effect of offsetting the carbon emitted as a result of fossil fuel

[10] Soil organic carbon is the source of nutrients for crop growth and an important means to maintain the agricultural productivity. When soil organic carbon is considerably lost, the soil quality is deteriorated and the biomass production decreases.

combustion. Soil organic carbon sequestration technology includes soil management, cover crop cultivation, conservation tillage, comprehensive nutrient management, no-till farming, and optimal crop cultivation, all of which take into account the environment.

Fourth, bio-energy refers to the energy produced from biomass. Biomass, in turn, refers to those organisms, including plant and bacterial material, which are generated by the photosynthesis of plants as well other microorganisms that take in solar energy. In addition, it also includes the animal bodies that feed on them. Biomass resources have various properties, being composed of starchy resources, including grains and potatoes; cellulose resources, including herbs, trees, shrubs, straws and chaff, glucosidic resources, including sugar cane and sugar beet, and protein resources including livestock wastes, carcasses, microorganisms and bacteria. Therefore, bio-energy production technology refers to the chemical, biological and combustion engineering applied to converting these organisms and resources into various forms of gas, liquid or solid fuels or alternatively the production of heat, vapor or electricity by combusting those fuels. Depending on the type of biomass, bio-energy from the agricultural sector can be divided into biogas that uses livestock wastes and food wastes, biodiesel that use rapes and oil crops, ethanol that use starch from corn, sugar cane, potato and/or sweet potato, and methane that uses chaff and sawdust. Representative technologies for making bio-energy for practical use include technology for producing biodiesel from oilseed rape and other oil crops and biogas plant technology that uses fermentation from livestock wastes and methane.

Biogas plants using livestock waste have been actively promoted at home and abroad.[11] Two types include German-type biogas plants for individual farms and Danish type biogas plants for joint treatment. The German-type biogas plant anaerobically digests the livestock wastes in each farm to supply methane gas, which is then piped to a generator to produce electricity. It uses treated livestock wastes as manure. The joint treatment type gas plant is a technology which has emerged due to the increasing demand for the treatment of organic wastes such as livestock waste and food waste (Sooncheol Park, 2006). Livestock waste biogas plant are of benefit in the following ways; renewable energy production, the treatment of otherwise noxious livestock wastes, and GHG reduction.

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[11] Biogas plant is a generation system that generates electricity and heat by combusting biogas in a combined heat and power generator foruse within the plant or to sell for profit.

2. Diagnosis of Green Growth Policies for the Agricultural Sector

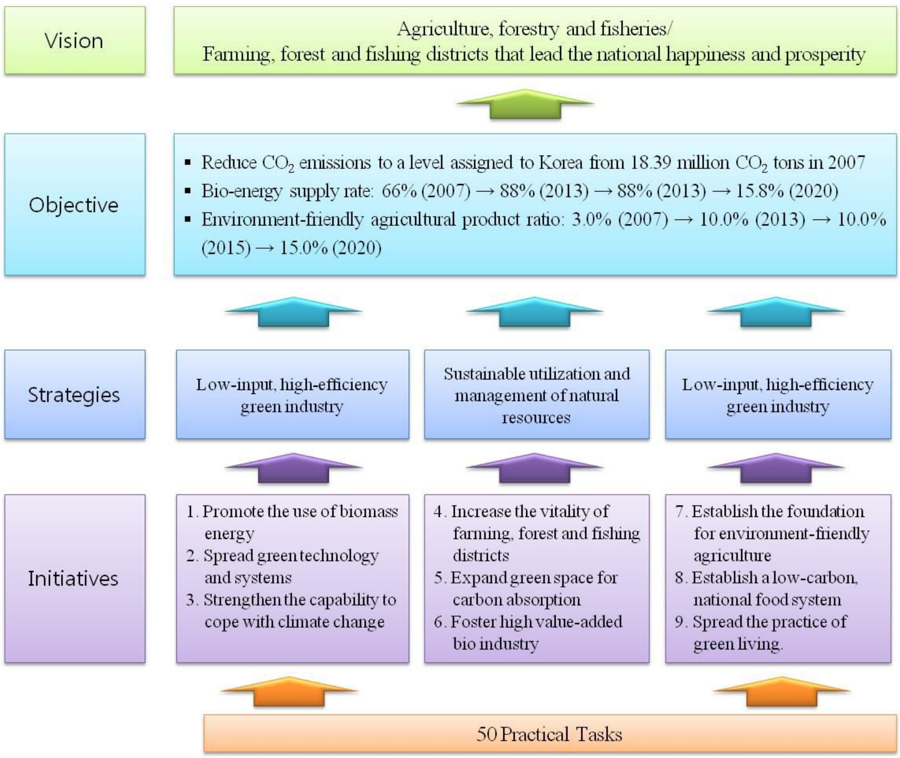
2.1. Policies for Promoting Green Growth of the Agricultural Sector

Since "low carbon, green growth" was announced as the future national growth paradigm in August 2008, MIFAFF has been working to prepare green growth measures based on the low carbon, green growth policies proposed by each bureau and department within the ministry.[12] In December 2008, the MIFAFF created "The Council for Green Growth in Food, Agriculture, Forestry and Fisheries" (chaired by the Minister of MIFAFF) and established "strategies for promoting low carbon, green growth" in the fields of food, agriculture, forestry and fisheries in November 2009 and through three council meetings between January and October 2009.

For a comprehensive and systematic promotion of green growth in the agro-food sector, a green growth policy officer was instated in April 2009 and "Green Future Strategy Department" was created to supervise green growth affairs. The Department administrates the tasks related to the agro-food sector from among the 50 major implementation tasks listed in the "Five-year Plan for Green Growth (2009 ~ 2013)" issued by the Presidential Committee on Green Growth. (Attached Table 3) The plan established "agriculture, forestry and fisheries and rural, forest and fishing districts that will lead to national happiness and prosperity" as its vision to promote green growth in the agro-food sector. The Committee has formulated and implemented three strategies (low-input, high-efficiency green industry; sustainable utilization and management of natural resources; and improvement of public health and enhancement of national quality), nine initiatives and 50 practical tasks(Figure 3-2, Attached Table 4).

[12] With regard to promotion of green growth in the agricultural sector, The Korea Rural Economic Institute presented the "Concept of and Initiatives for Green Growth of the Agricultural Sector" in an official meeting among related agencies presided over by the Minister, at the MIFAFF conference room on October 7, 2008.

Figure 3-2. Organization of Green Growth and Initiatives for Agriculture and Rural Districts



The basic direction for promoting green growth policies for the agricultural sector has been established as "to focus capabilities on producing substantial outcomes and to maximize those outcomes by means of step-by-step, strategic policy approaches." (MIFAFF 2010b). As for the principles for promoting green growth policies, a set of principles entitled 3-G&Ss have been proposed. The first G represents a preemptive voluntary response which is referred to as green spontaneity. The second G represents a systematized policy promotion which is referred to as green system). The third G represents the spread of the outcomes of green growth and is referred to as green spread).

"Green Spontaneity" refers to the search for tasks that can produce concrete outcomes and fit within the new policy environment so as to initiate and accelerate green growth.

"Green System" refers to efforts to strengthen the systematized policy promotion system, including strengthening cooperation between related agencies in order to produce visible outcomes from the established policy tasks.

"Green Spread" refers to the efforts to prepare various public relation plans that will disseminate the outcomes and enhance public accessibility to green growth in the agro-food sector.

As policy objectives for green growth the following were presented: spreading through seeking and promoting green policies applicable to daily life, establishing a foundation for low carbon, green energy policies to take root in, and the realization of green global leadership of the Korean food, agriculture, forestry and fisheries sectors.

There are six initiatives and two major management tasks to maximize the outcomes.

The six initiatives are:

① To put green growth in practice in people's everyday life, ② to promote the utilization of biomass energy and enhance energy efficiency in the green energy field, ③ to firmly establish low-carbon food, agricultural, forestry and fishery policies in the low carbon policy field, ④ to expand investment in green R&D and foster a foundation for an environment-friendly agricultural industry in the green industry field, ⑤ to protect the ocean and forest ecosystems in the sustainable resource management field, and ⑥ to strengthen the green global partnership in the international cooperation field.

The two management tasks are ① to check the results of implementing the 50 practical tasks and strengthen their feedback and ② to disseminate the outcomes through the promotion of the agro-food sector.

In order to check the results of implementing the 50 practical tasks and to strengthen their feedback by means of the two management tasks, a self-assessment team, composed of experts in related fields, will review the results of each task and encourage the further implementation or improvement of tasks for which the results are deemed unsatisfactory. Also, successful cases will be collected and collated into a case-study book. This case-study book will be published and distributed so as to disseminate the positive outcomes of green growth in the agro-food sector and so promote green growth policies in the agricultural sector.

In parallel with the central government's green growth policies for the agricultural sector, each province has established and promoted its own green growth policies (Table 3-3).

Table 3-3. Specialized Green Growth Policies of Local Governments for the Agricultural Sector

Local Government	Description	
Gangwondo	Climate	. Establish a comprehensive plan to reduce flood damages, carry insurance against flood damages (for 18 cities and counties). . Develop and foster strategic crops for each region, and develop alternative crops and technologies for ensuring the stable production of highland vegetables. . Develop technologies for the utilization of the oceanic climate resources of the East Coast.
	Green industry	. Expand international cooperation for elastic food supply and demand (operate 'Gangwon Agriculture Town' in Mongolia) . Foster an environment-friendly agro-food industry (designate and operate an ecological green bio zone). . Foster high value-added food industry (good ginseng fields, brand-name herbs, and specialized crop items)
Gyeonggido	Climate	. Foster management professionals specialized in rice farming under the motto of 'Farming is also professional management!' . Development of new formula chemical fertilizers to reduce GHG emissions.
	Green industry	. Disseminate organic agriculture related industry by successfully holding the 2011 World Organic Agriculture Conference.
Gyeongsangbukdo	Environment/resource management	. Increase the water reservoir of the Nakdong River water system.
	Green industry	. Form a Green Agriculture Town (green energy horticulture complex). . Develop local foods.
	Green technology	. Form a industrial complex centering around a plant factory. . Form a renewable energy horticulture complex.
Gyeongsangnamdo	Climate	. Promote natural disaster insurance.
	Environment/resource management	. Supply clean water for agriculture (to enhance crop quality and productivity)
	Green industry	. Foster bio-environment agriculture (Goseong County)
	Green technology	. Disseminate the circulatory water-membrane system for horticulture facilities (Agricultural Research Institute)
Jeollabukdo	Climate	. Promote crop disaster insurance to minimize damage from natural disasters.

Local Government	Description	
	Environment/resource management	. Extend the agricultural reservoirs around 4 major rivers (Keum River and Seomjin River). . Develop multi-purpose water sources for rural districts.
	Green industry	. Pilot projects for carbon-circulating seawater farms . Seed valley formation project . Project to develop an environment-friendly brand-name salt . Foster the environment-friendly herb industry . Foster green business professionals (agriculture CEOs). . Green internships for creating green job opportunities
Jeollanamdo	Green industry	. Promote urban agriculture. . Form a global agro-food complex. . Globalize and make Namdo food industry a brand-name for (establish an agro-business for Namdo food industry) . Foster the seed industry. . Foster the environment-friendly food industry. . Make sea salt a global brand-name.
Chungcheongbukdo	Climate	. Development general nutrient management technology in response to climate change.
	Green industry	. Form an oriental medicine bio-industry cluster along Taebaek Mountains. . Foster the herb industry cluster in Jecheon.
Chungcheongnamdo	Environment/resource management	. Strengthen the international exchange for agricultural development.
	Green industry	. Form a high value-added agricultural and livestock-farming complex using waste heat from generation plants.
	Green technology	. Form an agricultural and livestock-farming bio R&D cluster in Seosan and Hongseong.
Jejudo	Environment/resource management	. Foster the water industry (develop resources to substitute for water supply to rural districts)
	Green technology	. Materialize low-carbon energy reduction in horticulture facilities (using underground air heat, geothermal heat pumps).

For programs related to climate change mitigation, each province has been promoting a carbon cash-back point system, a carbon labeling system and a greenhouse gases target management system in connection with the central government programs. However, as far as the agricultural sector is concerned it is difficult to find any programs to reduce GHG emissions that run parallel with central government programs. Indeed Gwangyeong city’s environment-friendly agriculture complex formation project can be considered to be the only program being promoted in connection with central government. At present, many local governments are actively promoting specialized green growth policies according to their regional circumstances. The province of Gangwondo is focusing on adaptation to climate change and the fostering of green industry; Gyeonggido attaches importance to GHG reduction, and the promotion of organic agriculture as part of its preparations for The World Organic Agriculture Conference; Gyeongsangbukdo is making efforts in the areas of environmental resource management, the formation of a green agriculture town, and the fostering of an industrial complex for plant factories; Gyeongsangnamdo is focusing on adaptation to climate change and water resource management. Jeollabukdo and Jeollanamdo are promoting green growth, attaching considerable importance to adaptation to climate change and the fostering of green industry, while Chungcheongbukdo, Chungcheongnamdo and Jejudo are endeavoring to form industrial complexes centered around the use of new green technologies.

2.2. Evaluation of Green Growth Policies for the Agricultural Sector

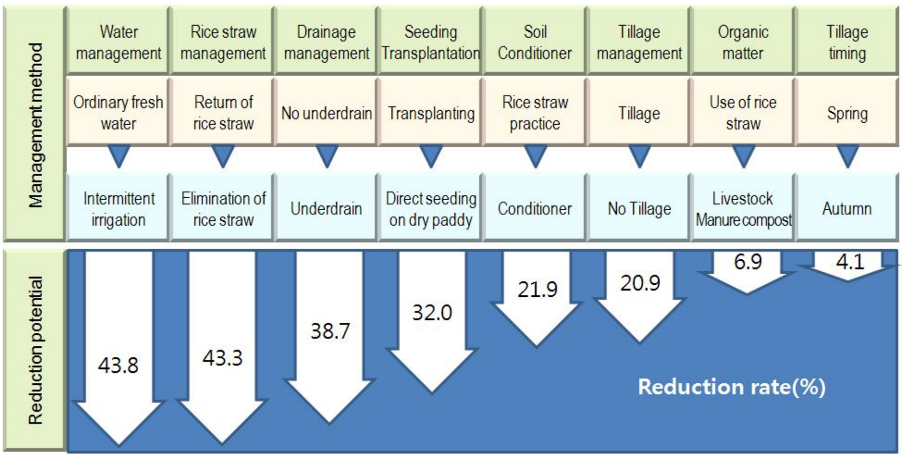
The vision and basic direction for materializing green growth in the agricultural sector is now considered to be established practically and persuasively. The principles governing policy implementation and policy objectives are also considered to have been systematically and adequately formulated.

Of the 50 practical tasks set forth for green growth, a total of 34 policy programs are for the agro-food sector, which appears to have green growth measures properly combined. However, the expected outcomes and effects of green growth policies for the agricultural sector, such as the amount of GHG reduction, are not clearly outlined. Assuming that the proposed 34 policy programs are all successfully implemented, a reduction of around 1.27 million CO_2 tons of GHG are expected, which amounts to a 6.7% reduction in the GHG emissions of the agricultural sector (about 19 million tons) (Attached Table 5).

As the core green industry for green growth of the agricultural sector, the organic agro-food industry was selected in the policy document “A Plan for Fostering Organic Agro-food Industry” (MIFAFF, 2010a). The master plan for fostering the organic agro-food industry has been formulated according to this policy document. This policy document covers the formation of production bases, the fostering of the processing and agricultural material industry, the continued promotion of distribution and consumption, and the establishment of a coherent management system. In order to maximize the outcomes of this organic agro-food fostering policy, it is deemed necessary to prepare a budget plan and consistently promote the detailed implementation plans for each field.

In order to raise public awareness recognition of green growth in the agricultural sector and increase their participation in the policy programs, it is necessary to develop policy programs that can produce visible outcomes of green growth in agriculture and rural districts. Low carbon farming methods for the agricultural sector should be closely reviewed to find out the methods that can be easily applied on the ground. Along with this, it is necessary to monitor and quantitatively evaluate those methods employed and select the successful cases, so as to build an outcome management system that will disseminate the positive outcomes. GHG reduction technology appropriate for the domestic agricultural conditions has been developed for each agricultural subsector. For rice farming in the crop farming sector, direct seeding on dry paddy, intermittent irrigation and reduction of nitrogenous fertilizer usage (Figure 3-3) have been suggested as low carbon technologies that can considerably reduce GHG emissions; while for the livestock farming sector, the selected technologies are the improvement of enteric fermentation and use of feed additive (National Academy of Agricultural Science, 2009).

Figure 3-3. The Effects of GHG Reduction Measures in Rice Farming



Source: National Academy of Agricultural Science (2009).

Given this, it is necessary to develop policy programs to ensure the effective dissemination of the green technologies developed. With regards to the crop farming sector, if around 30% of the total rice farming area is converted to direct seeding on dry paddy, an estimate of the resulting methane reduction would amount to 800 thousand CO_2 tons a year (Chang-Gil Kim *et al.*, 2007). To achieve this reduction, the introduction of a direct payment for low carbon practice should be positively considered so as to induce rice farming households to practice direct seeding on dry paddy and intermittent irrigation. With regards to the livestock farming sector, a GHG reduction can be achieved through improvements in both ruminants' enteric fermentation and livestock productivity. These improvements would be obtained by using high-quality roughage and feed additives. Therefore, to the development of policy programs to disseminate these technologies is urgently needed. For the 34 policy programs designed to promote the green growth of the agricultural sector, it is necessary to strengthen the feedback mechanisms in policy complementation and coordination. This could be achieved through the examination and evaluation (self evaluation and evaluation by external experts) of the implementation results.[13]

3. Diagnosis and Evaluation of Green Growth Policies for Rural Districts

3.1. Present Conditions of Policy Programs for Rural Districts in the 5-year National Plan for Green Growth

The Framework Act on Low Carbon Green Growth comprehensively establishes the basic principles for promoting green growth and the responsibilities of the national government, local governments, firms and people.

The following four major tasks assigned to rural districts for implementation are as follows: (1) to formulate a green growth plan for local government; (2) to promote

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[13] The Policy Analysis and Evaluation Office under the Prime Minister's Office organizes a green growth evaluation team, with experts from related fields, to evaluate each central administrative agency's implementation efforts and performance for the efficient and systematic achievement of low carbon, green growth. The evaluation rates performance into four levels: Excellent, Good, Satisfactory and Needs Improvement, with feedback being given to the corresponding agency.

environment-friendly agriculture, forestry and fisheries and expand carbon sinks; (3) to promote eco-tourism; and (4) to spread a production and consumption culture for green growth. Examining only what is prescribed in this Act, it is difficult to review the green growth policy programs being promoted specifically from the perspective of ‘rural districts.’ To understand the green growth policies for rural districts, it is necessary to examine “The Five-year Plan for Green Growth” formulated by the Presidential Committee on Green Growth.

The Five-year Plan for Green Growth suggests three major strategic directions, ten policy directions, 50 practical tasks and detailed subtasks for each practical task. The Plan does not classify policy tasks spatially into urban and rural districts but the policy tasks to be approached with regard to rural districts are listed separately below in Table 3-4.

Table 3-4. List of tasks related to rural district policies in the Five-year Plan for Green Growth

Strategy Direction	Policy Direction	Practical Tasks	Detailed Tasks	Implementation Time		Supervising Dept. Cooperating Dept.
				Start	Completion	
Develop new growth drivers	Make industry green and foster green industry	Convert industries into green industries and spread green renovation	Foster the environment-friendly agro-food industry	2009	2016	MIFAFF (RDA)
	Form the foundation for green economy	Promote creating green job opportunities	Create job opportunities by promoting green new deal projects	2009	2013	11 Depts.
			Positively promote green social enterprises	2009	2013	ML & each Dept.
			Build a comprehensive information network for green job opportunities	2010	2013	ML & each Dept.
Improve the quality of living & raise the national status	Form green land and transportation	Form green land and cities	Actively conserve forests, urban forests, farmlands, water resources and oceans that are highly valuable as carbon sinks	2010	2012	MLTM, MIFAFF, Forest Service
		Extend eco-space	Extend the multi-functional eco-space	2010	2013	ME, ML, MIFAFF

Strategy Direction	Policy Direction	Practical Tasks	Detailed Tasks	Implementation Time		Supervising Dept. Cooperating Dept.
				Start	Completion	
			within cities, for plant habitation, flood reduction and water resources			
			Form low carbon green forests through public participation and expand urban parks, to extend green living space	2009	2013	Min. of Environment, Forest Service, MIFAFF
		Expand green buildings	Develop and spread green home models, environment-friendly energy-efficient houses	2009	2013	MKE, MLTM, (MIFAFF)
	Green revolution of living	Promote green consumption	Spread the culture of green consumption into people's life style	2009	2013	ME, MKE, MIFAFF,(KFDA)
			Expand the green distribution network for it to be easily accessible by consumers	2009	2013	ME, (MIFAFF)
		Develop green town movement	Develop and spread government-led low carbon green towns	2010	2013	ME, MOPAS, MIFAFF, Forest Service
			Develop the green town movement	2010	2013	ME,(MOPAS) (MIFAFF), (KFDA)

Source: The Presidential Committee on Green Growth (2009).

Excepting those closely related to agricultural policies, there are 12 detailed tasks to be implemented for rural districts. However, this list of detailed tasks still lacks the following: First, the policy measures required to materialize the detailed tasks for green growth policies are not specified. Depending on the type of policy measure to be taken, the government agency that will implement the task may choose different response strategies and direction at their own discretion. Therefore, it is a very important matter. Second, current policies or institutions that are clearly involved in the green growth of rural districts are missing from the Five-year Plan for Green Growth. "The Promotion of eco-tourism" mentioned in the Framework Act on Green Growth is also omitted from the policy task list of the plan.

3.2. Review of Rural District Development Policies related to Green Growth

3.2.1. Perspective of Policy Review

Regarding the green growth paradigm, two approaches are possible: One is to accept it as a regulatory or normative value and the other is to accept it as a realistic possibility. There is a considerable disparity between these two approaches and thus if policies are developed without a strict distinction between them, it might lead to validity or effectiveness issues. On the other hand, when discussing certain policy programs, making an assertive conclusion that green growth of rural districts is ‘possible’ or ‘impossible’ should be avoided. Discussions on “rural district amenities” that took place within the context of the OECD for several years in the 1990s offer important suggestions (OECD, 1999). Through these discussions, it was revealed that the relationship between environmental conservation and economic growth of rural districts could not only be defined as being either ‘compatible’ or ‘incompatible.’ In other words, there could be various relations between economic growth and the environmental conservation of rural districts (Table 3-5).

Table 3-5. Relation between economic growth and environmental conservation of rural districts

	Environmental Conservation	Environmental Destruction
Economic Growth	**Synergy** - The environment of rural districts is used as a tourism resource, while being adequately protected (Regional Nature Parks in France)	**Hostile Relation** - Rural districts where excessive tourism leads to overdevelopment
Economic Recession	**Hostile Relation** - Regulations for environmental protection are so strict that they hinder economic activities (Aska Village in Japan)	**Interdependent Relation** - Mountainous areas where the environment and landscapes are not properly management as economic activities are slowed down and population dwindles

Strictly speaking, the concept of green growth conforms to the ‘synergy’ relation among four types of relations suggested in Table 3-5. However, it is still difficult to specify that green growth policy for rural districts must be put in to areas where synergy could be created. Instead, it is necessary to have a wider perspective to find policy measures that can convert other types of relation into a ‘synergy’ relation. This is needed to implement various policies, depending on the kind of relations between economic growth and environmental protection in various circumstances present in rural districts as well as the characteristics and scope of resources that the public sector can mobilize. Green growth policies to be implemented for rural districts can be classified, based on their operation mechanisms, into ‘incentive,’ ‘regulation,’ ‘market facilitation’ and ‘promotion of collective public action’.

Policies that provide direct economic incentive to the activities are the most common policy measures put in place to contribute to the green growth of rural districts. Like direct payments, it is possible to support green growth measures by decoupling them from production activities or by providing grants to those measures that recover or protect ecosystem or green resources in the form of investment. In the meantime, the regulatory policies seek to restrict economic activities on resources present at certain locations, and so they might be considered to be irrelevant to, or even hinder, ‘economic growth.’ However, regulatory policies for green growth can function as a very important measure that permits the conservation of ‘green resources as a growth driver’ over an extended period. Such regulatory policies can be enforced in several ways. The first way is to designate certain locations as protected areas and restrict land use or other economic activities in those areas. The second way is to designate land for each use according to land use planning, and then restrict certain activities or certain types of land use to those designated areas.

Policy measures for facilitating the formation of a ‘green product market’ are typical of the types of ‘public intervention to promote the internalization of external effects of the environment’ asserted by the ecological modernization theory. This type of policy measures can also be implemented in various forms. The first one is the ‘access right market promotion policy’ that restricts access to green resources in rural districts (e.g., amenities including landscape) and charges fees for access to them. For example, many developed countries have established a system in which people who want to have access to a river for leisure activities have to buy a the fishing permit from a club that manages the fish stocks of the river. The second policy measure could be product differentiation through ‘green product’ certification. By providing a standard quality certification or guarantee system, the public sector can persuade consumers to buy goods or services certified as being produced through economic activities that contribute to ‘green growth.’ The third policy measure is to support enterprises working towards green growth in rural districts. It is possible to provide various support policies for enterprises that make a certain level of profit while contributing to the environmental protection for rural districts; such support policies include infrastructure, education and training, information and consulting and also tax relief. Support for a social enterprise that recycles food wastes and/or livestock wastes would be one example.

Policies that could be considered last are ones that promote the collective actions of related parties' that maintain economic activities at a proper level while also protecting the environment of rural districts. The most representative example is to encourage those involved in economic activities, i.e. suppliers, to self-regulate their economic activities which are directly related to the management of the environmental resources of rural districts. For example, if a certain area contains important environmental values in need of protection, farmers voluntarily observe environment-friendly farming practices and consumers are persuaded to preferentially buy the agricultural products produced by means of those environment-friendly farming practices. Such types of collective action can be promoted through various policy measures such as the 'institutional framework for promoting communication in the process of regional development' and 'direct support for collective actions.' Many development activities in rural districts proceed based on specific plans. In particular, regional planning directly related to land use rural districts is a stage where important decisions are made with regards to green growth. It is important to prepare an institutional framework through which all the related parties can have a proper communication channel for exchanging their information and their vision about rural districts and so participate in the planning process while maintaining an equal partnership.

3.2.2. Implications of the Policy Review

Of the policy tasks suggested in the Framework Act on Green Growth, the Five-year Plan for Green Growth and the policy programs implemented by MIFAFF and other government departments, only those related to the green growth of rural districts are reorganized into the list in Table 3-6. The list outlines the results of reviewing the applicable types of policy measures and the basic direction for changing the policy programs being promoted into a form that could contribute to green growth. The content of this table will be a valuable reference for the 'development of strategies for promoting green growth' to be carried out in the second year. The details of any concrete implementation plan will vary with types of policy measures to be applied. For example, if a regulatory policy is to be applied, it would be important to enact or revise various regulations. Whereas if an incentive policy is to be applied what is needed is to secure the necessary funds. Details of a green market facilitation policy depend on the level of implementation sought at the national dimension. For policies promoting collective action, communication with the community and governance are the important issues.

Table 3-6. Summary of the results of reviewing main policy programs and tasks for green growth of rural districts

	Policy Program	Type of Applicable Policy Measure				Remark
		Market Facilitation	Promotion of Collective Action	Regulatory	Incentive	
The Framework Act on Green Growth/ The 5-year Plan for Green Growth	Create job opportunities in green new deal projects	-	-	-	○	-
	Foster green social enterprises	-	-	-	○	-
	Conserve forests, farmlands and water resources that are highly valuable as carbon sinks	-	○	○	○	-
	Expand green space by forming low carbon green forests	-	○	○	○	-
	Develop and spread environment-friendly low-energy house models	○	○	-	○	-
	Spread the green consumption culture	-	○	-	○	-
	Expand the green distribution network	○	-	-	○	-
	Form and expand low carbon green towns	-	○	-	○	-
	Promote eco-tourism	○	○	-	○	-
Programs in 'Quality of Life Plan', not led by MIFAFF	[ML] Promote social enterprises for rural districts	○	-	-	○	Support those companies fit for green growth
	[MCST] Turn Slow City into a green tourism resource	○	-	-	○	-

	Policy Program	Type of Applicable Policy Measure				Remark
		Market Facilitation	Promotion of Collective Action	Regulatory	Incentive	
	[MEST] Expand the elementary/middle school students' opportunities for experiencing and exchanging with farming/fishing villages	-	○	-	-	Encourage field study activities highlighting the themes of 'ecology' and 'environment'
	[ME] Install a comprehensive waste treatment plants for farming/fishing districts.	-	-	-	○	-
Programs in 'Quality of Life Plan', not led by MIFAFF	[ME] Recycle livestock wastes and turn them into energy	-	-	-	○	-
	[NEMA] Maintain rivers and streams	-	-	○	-	-
MIFAFF Program Guideline and MIFAFF Programs in 'Quality of Life Plan (incl. RDA & Forest Service)	Direct payment for landscape conservation	-	○	-	○	-
	Develop tour/leisure resources in rural/fishing districts	○	-	-	-	Focus on 'eco-tourism' in some program locations
	Develop new farming/fishing towns	-	○	-	○	Introduce environment-friendly energy-saving facilities to houses
	Foster community companies for rural/fishing districts	○	-	-	○	Support the companies that pursuit profit and 'green growth'
	Develop new villages and redevelop existing villages	-	○	-	○	Introduce environment-friendly energy-saving facilities to houses and community buildings
	Comprehensive maintenance of small living zones	-	-	○	○	Introduce environment-friendly energy-saving facilities to infrastructure, including houses

	Policy Program	Type of Applicable Policy Measure				Remark
		Market Facilitation	Promotion of Collective Action	Regulatory	Incentive	
	Build scenic villages	-	○	○	○	Establish an integrated regional planning model reflecting 'green growth'
	Improve the living environment of rural districts	-	-	-	○	Introduce energy-efficient houses; passively heated houses
	Support regional cooperation programs	-	○	-	-	Support cooperative development projects by multiple local governments who adopt 'green growth'
	Form forest recreation spaces	○	-	-	-	-
	Build indigenous botanical gardens and eco-forests	-	-	-	○	-
	Build an institutional basis for conserving the landscape of rural districts	-	○	○	-	Use regional planning for green growth as an institutional basis
	Support the promotion of field study activities in rural districts	○	○	-	-	Encourage field study activities in rural districts, especially those focusing on 'ecology' and 'environment.'
	Spread the use of wood pallet	○	-	-	-	-
	[SAPRD] General rural district development programs	-	-	-	-	-
	[SAPRD] Rural district resource development support programs	-	-	-	-	-

4. Results of Survey on Agriculture People's Recognition of Green Growth

4.1. Questionnaire Survey of Farmers

4.1.1. Overview of the Questionnaire Survey

A questionnaire survey was carried out to evaluate the farmers' awareness of green growth in the agricultural sector and of related policies. The questionnaire consisted of four questions about green growth in general, seven about green growth policies, and five about participation in green growth policy programs. The survey was carried out (by mail) during the period of August to September 2010 for 786 local correspondents of The Korea Rural Economic Institute. The subjects of the survey were regionally distributed as follows: Gyeongsang Zone (31.7%), Jeolla Zone (26.1%), Chungcheong Zone (20.4%), Gangwon Zone (9.3%), Gyeonggi Zone (8.9%) and Jeju Zone (1.7%) (Table 3-7).

Demographically, 85.8% (674) of the respondents were male while 12.8% were female (101) (11 respondents did not specify their gender). 56.2% of respondents were aged 61 or over, 29.3% were aged between 51~60, and 14.5% were younger than 50. In total 85.5% of all respondents were older than 50. With regards educational qualifications, 62.1% were high school graduates or higher with 37.2% being middle school graduates or lower. Data on farming experience revealed that 70.2% had more than 30 years of experience. Crops cultivated by respondents broke down as follows: rice and/or barley (44.5%), fruits (13.7%), vegetables (6.6%), fruit-bearing vegetables (4.3%) and others (10.9%).

The survey data was statistically analyzed using SPSS 12.0 with frequency and cross tabulation, and the statistical significance was obtained using χ^2 verification.

Table 3-7. Socio-economic characteristics of the respondents

Items		No. of Responses	Percentage (%)
Gender	Male	674	85.8
	Female	101	12.8
	No response	11	1.4
Age	40 and younger	17	2.2
	Between 41-50	97	12.2
	Between 51-60	230	29.3
	Between 61-70	202	25.7
	71 and older	240	30.5
Education	Elementary school or lower	64	8.1
	Middle school	229	29.1
	High school	370	47.1
	University or higher	118	15.0
Experience	20 years or less	96	12.2
	Between 21-30	124	15.8
	Between 31-40	227	28.9
	Between 41-50	173	22.0
	51 years or more	152	19.3
Main Crop	Rice and/or barley	350	44.5
	Vegetables	52	6.6
	Fruits	108	13.7
	Fruit-bearing vegetables	34	4.3
	Others	86	10.9
	Missing value	156	19.8
Total		786	100.0

4.1.2. Level of Recognition of Green Growth

To a question asking whether they know about green growth being promoted by the government, 45.8% answered ‘have heard of it’, 43.3% ‘know a little, 6.0% ‘know well’, and 3.7% ‘no idea,’ showing that about 89% of the farmers were aware of green growth.

To a question asking whether they knew about sustainable growth, 55.1% answered ‘have heard of it’, 28.1% ‘know a little and 3.6% ‘know well,’ which showed that green growth was more recognized than sustainable growth.

Regarding the relation between green growth and sustainable growth, 45.9% chose ‘green growth and sustainable growth have something in common’; 22.9%

'sustainable growth is a larger concept that includes green growth'; 18.2% 'green growth is a larger concept that includes sustainable growth'; and 6.0% 'green growth and sustainable growth are separate concepts'.

To a question asking whether it is likely to achieve environmental conservation and economic growth at the same time, 56.7% answered 'likely.' If 'very likely' is also included, 61.3% of the farmers expressed positive opinions about co-achievement of environmental conservation and economic growth. Conversely, only 9.2% expressed negative opinions.

4.1.3. Green Growth Policies for the Agricultural Sector

To the question asking them to state the importance of the 33 green growth policy programs related to agriculture (from among 50 detailed tasks of MIFAFF), the percentage of respondents choosing "important" appeared to be high overall. Among the green growth policy measures, those which more than 70% of the respondents declared important were: 'promote the use of biomass energy'; 'develop and spread green technologies'; 'strengthen preventive measures against climate change'; 'build low-carbon green towns and supply environment-friendly houses'; 'foster the environment-friendly agricultural material industry'; 'expand the globalization of Korean food'; 'develop adaptation technologies and technology to cope with meteorological disasters'; and 'create new job opportunities.' Conversely, the following tasks were deemed 'important' by less than 50% of the respondents: 'build Saemangeum area into an outpost for green growth'; 'spread green space for carbon absorption'; and 'form food clusters in an environment-friendly way' (Table 3-8).

The results suggests that the farmers evaluate policies that could be practical in terms of coping with climate change plus those that could enhance energy independence, to be important among the green growth policies for the agricultural sector. Conversely, farmers viewed policies which would have difficulty producing visible outcomes in a short period of time to be less important.

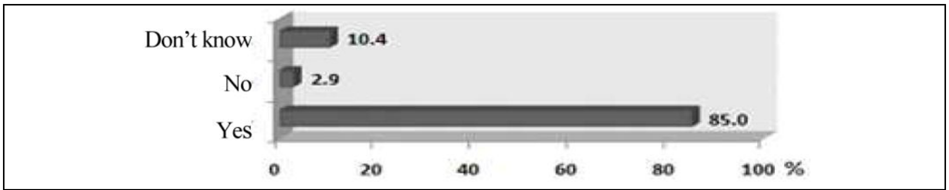
Table 3-8. Importance of MIFAFF' green growth policy programs

Unit: %

Task	Details	Not important ①	②	③	④	Important ⑤
Promote the use of biomass Energy	• Expand the facilities to recycle livestock wastes and turn them into energy. Develop bio energy technology using crops.	3.8	6.2	13.2	31.7	42.2
Develop and spread green technologies	• Improve the thermal insulation of horticulture facilities. Develop and use energy saving devices, and utilize geothermal heat pumps and LEDs in place of fossil fuels.	3.2	6.0	15.8	35.4	35.6
Supply the equipment for utilizing green technology	• Produce and supply electrical energy using irrigation water from agricultural reservoirs, river water and redundant water.	4.1	9.2	20.4	29.1	33.1
Strengthen preventive measures against climate change	• Minimize damages from meteorological disasters like drought and flood by promoting crop disaster insurance and taking preventive measures.	3.2	4.5	12.0	31.6	44.9
Build low-carbon green towns and supply environment-friendly houses	• Build pilot low-carbon green towns using biomass, solar power and wind power, and develop and supply environment-friendly, energy-efficient houses to rural districts.	4.2	7.1	14.0	30.0	41.2

To a question which asked whether the green growth of the agricultural sector was needed, 85% answered ‘yes’. The assumption is that this is because the farmers associated the green growth of the agricultural sector with the policies related to climate change and energy (Figure 3-4).

Figure 3-4. Need for green growth of the agricultural sector



With regard to the environmental regulations on the agricultural sector, 44.6% answered 'strengthen the current environmental regulations on agriculture' while 25.4% answered 'deregulate the current environmental regulations on agriculture'.

Concerning their willingness to be responsible for increased environmental conservation, 38.2% answered 'willing to accept the responsibility to a certain extent' while 34.4% answered 'no more responsibility' (Table 3-9).

These results imply that the farmers are willing to accept some responsibility for environmental conservation in conjunction with existing environmental regulations being strengthened.

Table 3-9. Willingness to accept strengthened environmental regulations and responsibility for environmental conservation

Unit: %

	←		Similar		→	
Strengthen the current environmental regulations on agriculture.	17.4	27.2	23.4	13.6	11.8	Deregulate the current environmental regulations on agriculture.
Willing to accept some responsibility for environmental conservation	13.0	25.2	21.8	15.3	19.1	No more responsibility for environmental conservation

To the question asking whether green growth would contribute to GHG reductions in the agricultural sector, 70.5% answered that it would. Whilst on the question of whether the green growth promoted by the government would contribute to future agricultural development, 69.7% answered that it would, implying that the farmers were positive about the expected results of green growth.

To the question asking what is most important for green growth policies for the agricultural sector to have a substantial positive influence, the response 'formulate substantial programs that can improve the farmers' living conditions and income' won the most responses with 54.6%. "Educate farmers on green growth policies for the agricultural sector" won the second most responses at 23.4% (Table 3-10).

Table 3-10. What are the important factors that will substantial influence on farmers

Unit: %

Pay incentive (compensation) for agricultural production activities that lead to reduction of GHG emissions.	17.4
Formulate substantial programs that can improve the farmers' living conditions and income.	54.6
Educate the farmers on green growth policies for the agricultural sector.	23.4

To the question asking what the best way of education for professional development for green growth of the agricultural sector is, the top choice was 'agricultural education through agricultural technology centers' with 68.3% (Table 3-11). Therefore since it appears that farmers prefer to be educated on green growth at an agricultural technology center, it is necessary to carry out these professional development programs related to green growth of the agricultural sector in municipal and/or regional agricultural technology centers. However, there was some interest in devising channels to allow farmers to seek expert's advice on farming for green growth.

Table 3-11. Methods of farmer professional development education for green growth

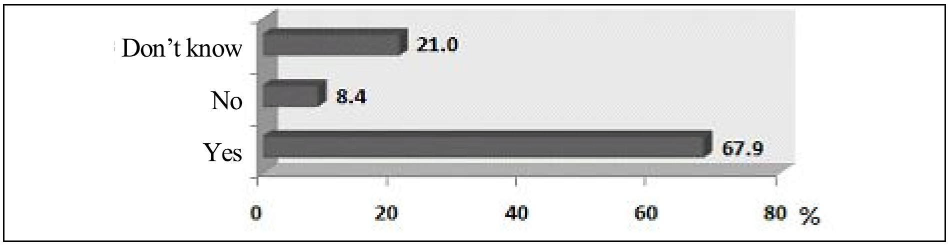
Unit: %

Agricultural education through agricultural technology centers	68.3
Self study through research groups	8.3
Consultation with the experts in agricultural management	16.0
Personal learning through trials and errors in agricultural management, by reading relevant books, or through neighbors	2.0

4.1.4. Participation in Green Growth Policies for the Ag-Sector

To the question asking respondents to what degree they would be willing to participate in the government policies for green growth of the agricultural sector, 67.9% answered 'yes'; 8.4% 'no' and 21.0% 'don't know." With regards to the reasons why respondents were negative or uncertain about participation in the policies, most farmers chose 'The feasibility of government policies is uncertain as they are not verified' plus 'government policies do not seem to be of much help in the improvement of current agricultural management'(Figure 3-5). Therefore, these responses clearly show that in order to induce farmers to participate in the policy programs, it is necessary to develop policy programs that the farmers can easily apply in the field, that are of direct help and which also promote public relations on the policy programs.

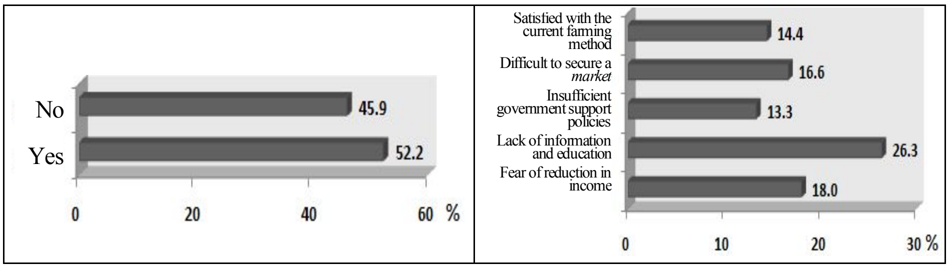
Figure 3–5. Participation in green growth policies for the agricultural sector



To the question concerning their participation in environment-friendly agriculture (organic agriculture), the representative program for green growth of the agricultural sector, slightly more farmers answered 'yes' (52.2%) as opposed to 'no'. Their reasons for not practicing organic agriculture breaks down as follows: 'lack of information and education on necessary technology' (26.3%), 'fear of reduction in income' (18.0%), 'difficulty in finding markets' (16.6%) (Figure 3-6). This result shows that it is necessary to foster organic agriculture, to develop policies for technology support, to securing stable markets and to prepare appropriate reward systems (direct payment) to compensate for the portion of income lost due to the practice of organic agriculture.

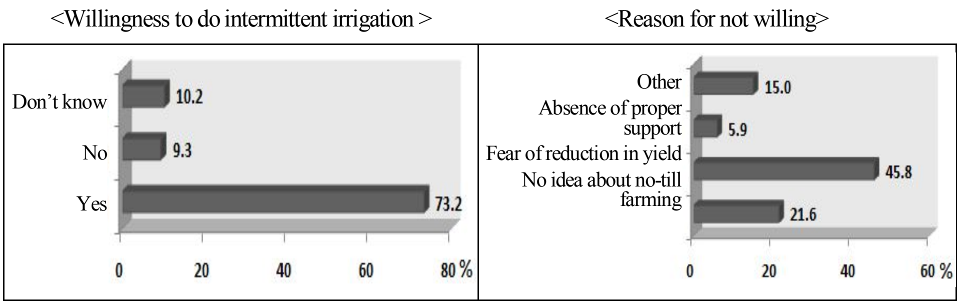
Figure 3–6. Practicing organic agriculture and reasons for not participating

<Practicing organic agriculture > <Reason for not practicing organic agriculture >



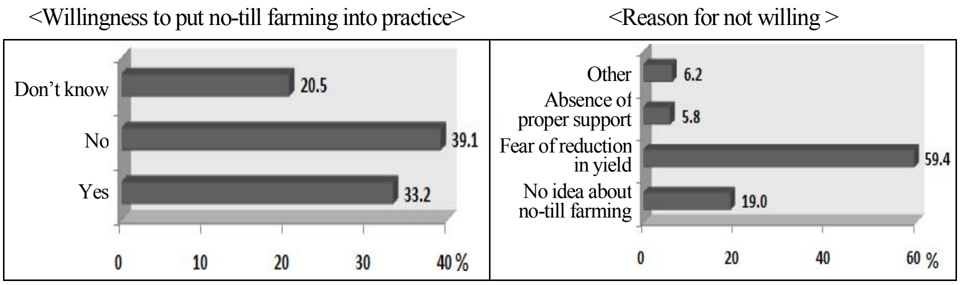
To the question asking respondents whether they would be willing to participate in carbon emission reduction by practicing intermittent irrigation and water depth control, 73.2% answered ‘yes’ showing that respondents were very willing to practice intermittent irrigation (Figure 3-7). The started reasons for not being willing to adopt intermittent irrigation included: ‘it is cumbersome and requires much manpower’ (45.8%) and ‘I have no idea about intermittent irrigation’ (21.6%). This result implies that, in order to spread the practice of intermittent irrigation, methods of reducing the manpower requirement are needed as well as information on intermittent irrigation methods are needed.

Figure 3-7. Willingness to do intermittent irrigation and reasons for not doing



To the question asking respondents whether they were willing to practice no-till farming that could reduce GHG emissions, 33.2% answered ‘yes,’ 39.1% ‘no,’ and 20.2% ‘don’t know. This shows that the willingness of respondents to practice no-till farming was not high when compared to other carbon reducing farming methods. The stated reasons for not putting no-till farming method into practice included ‘fear of a reduction in yield,’ which appeared to be the highest response with 59.4%, and ‘no idea about no-till farming’ (19.0%). This result suggests that it is necessary to promote no-till farming as well as develop proper income maintenance programs (Figure 3-8).

Figure 3-8. Willingness to put no-till farming into practice and reasons for unwillingness



The analysis concludes that, with regard to future environment-friendly agricultural practices, farmers are willing to put intermittent irrigation and no-till farming into practice.

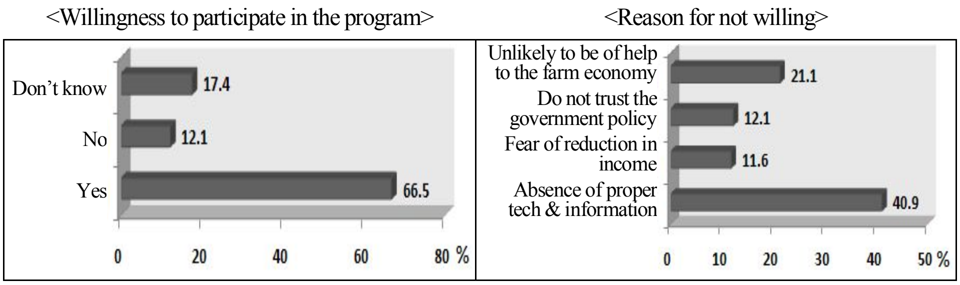
Table 3-12. Willingness to put intermittent irrigation and no-till farming into practice if willing to do environment-friendly agriculture in the future

Unit: %

		Intermittent irrigation			No-till farming		
		Yes	No	Don't know	Yes	No	Don't know
Willingness to do environment-friendly agriculture	Yes	85.4	6.6	7.9	46.1	38.6	16.7
	No	71.7	14.0	14.3	23.7	46.4	27.7

Assuming that the government provided appropriate supports for efficient energy use in the future, 66.5% of respondents answered 'yes' when asked if they were willing to participate in programs for using renewable energy, for example geothermal heat pumps, biogas plants and LEDs. This response seems to indicate that were proper support policies formulated to develop and spread technologies for efficient energy use, it would contribute to GHG reduction in the agricultural sector. The reasons for not participating in the programs for using renewable energy appeared to be the followings: 'absence of appropriate technology and information' (40.9%); unlikely to be of help to the farm economy' (21.1%); 'do not trust the government policy (12.1%).

Figure 3-9. Willingness to participate in the renewable energy program and reasons for unwillingness



4.1.5. Implications of the Results of the Questionnaire Survey

The survey results showed that farmers were highly aware of green growth of the agricultural sector and positively evaluated the co-implementation of environmental conservation and economic growth. The level of recognition of sustainable growth was also high, though lower than that of green growth. With regard to the relationship between green growth and sustainable growth, 45.9% of the farmers considered that green growth and sustainable growth had something in common, though they were separate from each another.

Most of MIFAFF's 33 green growth policy programs for agriculture were evaluated to be important. Examples of important programs were : 'promote the use of biomass energy'; 'develop and supply green technologies'; 'strengthen preventive measures against climate change'; 'develop low-carbon green towns and build environment-friendly houses'; 'foster the environment-friendly agricultural material industry'; 'promote the globalization of Korean food'; 'develop technologies for adaptation to climate change and to cope with meteorological disasters'; and 'create new job opportunities.' In other words, among the green growth policies for the agricultural sector, the farmers attached importance to those that could be of substantial assistance such as policy measures to cope with climate change and raise energy independence.

It was revealed that farmers were willing to accept some responsibility for environmental conservation as well as strengthened environmental regulations. Many of them appeared to recognize that green growth of the agricultural sector would have positive impacts on reducing GHG from the agricultural sector and on the future development of agriculture.

It was shown that farmers were highly willing to participate in the government policy programs for green growth of the agricultural sector. However, in order to increase their participation, it is deemed necessary to promote these programs to farmers, and educate them on the policy programs that they can apply in the field without great difficulty. Furthermore, to promote the practices of intermittent irrigation and no-till farming, both of which can help reduce GHG emissions resulting from agricultural activities, proper education should be provided and income maintenance programs need to be developed.

4.2. Survey on Experts

4.2.1. Overview of the Questionnaire Survey

A questionnaire survey of experts was carried out to evaluate their recognition of green growth in the agricultural sector and of the related policies. The survey respondents were 20 experts in green growth of the agricultural sector (Table 3-13). These respondents held positions in universities, research institutes, central and local governments, The RDA, and The agricultural technology center. The survey was carried out via e-mail in September 2010 and data collected analyzed using SPSS 12.0.

Table 3–13. Socio–economic characteristics of the respondents

Item		No. of Responses	Percentage (%)
Gender	Male	20	100.0
Age	30 and younger	-	0.0
	Between 31-40	3	15.0
	Between 41-50	14	70.0
	Between 51-60	2	10.0
	61 and older	1	5.0
Place of work	University	8	40.0
	Research institute (government/private)	3	15.0
	Central/local government	2	10.0
	RDA	3	15.0
	Agricultural technology center	1	5.0
	Others	3	15.0

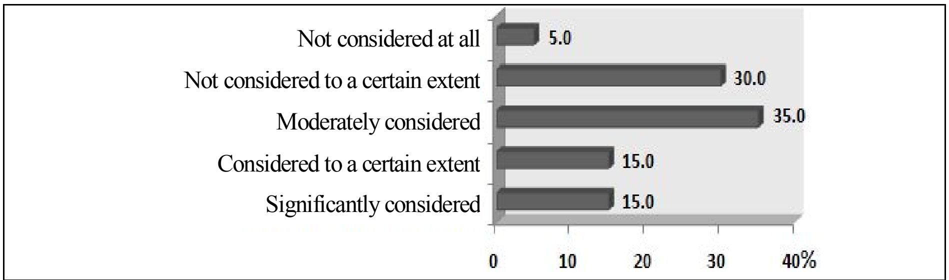
Item		No. of Responses	Percentage (%)
Major	Agricultural economy (Economy)	8	40.0
	Agriculture	6	30.0
	Administration (Law)	-	-
	Others	6	30.0
Work experience in the related fields (average)		15.5 years	
Total		20	100.0

4.2.2. Level of Recognition of Green Growth

Though there were some difference in their general awareness, all the experts appeared to know about "The National Strategies for Green Growth and the Five-year Plan" established in July 2009, with the response 'very well' accounting for 60% of responses.

On the question inquiring as to the degree with which the agricultural sector was considered in "National Strategies for Green Growth and the Five-year Plan," 35% answered 'moderately so,' with the answer 'not much" being given more than the answer 'much' though there were a similar number of answers (Figure 3-10).

Figure 3-10. Consideration given to agriculture in "National Strategies for Green Growth and the Five-year Plan"



On the assumption that green growth signified "growth in which economy and environment are balanced," most of the experts considered the co-achievement of environmental conservation and economic growth in a positive light.

Except for 10% who answered that the significance of economy and that of environment implied by the concept of green growth were similar, the experts appeared to consider economy the more significant of the two. Though economy (60%) still appeared to be more significant than environment (30%) with regard to sustainable growth, the significance of economy appeared to be lower when considering green growth. This result suggests that the experts in the green growth of the agricultural sector consider ‘green growth’ to be much more of a growth concept whereas they view ‘sustainable growth’ as a concept that balances the economy and environment (Table 3-14).

Table 3-14. Significance of economy and environment in the concepts of ‘green growth’ and ‘sustainable growth’

Economy is more important ← Similar → Environment is more important

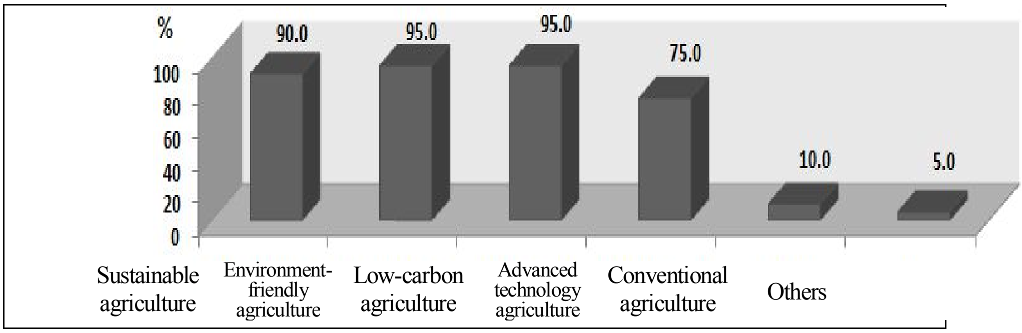
				④	⑤	⑥	⑦	⑧	⑨
Green growth	25.0	25.0	30.0	10.0	10.0	-	-	-	-
Sustainable growth	15.0	20.0	20.0	5.0	10.0	10.0	-	20.0	-

The responses on the question of the relationship between green growth and sustainable growth were as follows, ‘sustainable growth is a bigger concept containing green growth (60%); ‘green growth and sustainable growth have something in common’ (25%); and those answering that ‘green growth is a bigger concept containing sustainable growth’ (15%).

4.2.3. Green Growth Policies for the Agricultural Sector

Regarding the need for the green growth of the agricultural sector, all the experts answered ‘yes’. On the question of what agricultural concepts were contained in green growth for the agricultural sector, many experts chose ‘sustainable agriculture,’ ‘environment-friendly agriculture’ and ‘low carbon agriculture,’ and some even chose ‘advanced technology agriculture’ (Figure 3-11).

Figure 3-11. Concepts contained in green growth of the agricultural sector



On the question of whether environmental regulations should be strengthened to promote green growth for agriculture and their willingness to accept responsibility for environmental conservation many experts agreed on ‘strengthening the current environmental regulations on agriculture’ and ‘taking the responsibility for environmental conservation to a certain extent’ (Table 3-15).

Table 3-15. Willingness to accept strengthened environmental regulations and responsibility for environmental conservation

Unit: %

	←		Similar		→	
Strengthen the current environmental regulations on agriculture.	20.0	60.0	20.0	-	-	Deregulate the current environmental regulations on agriculture.
Willing to accept some responsibility for environmental conservation	30.0	60.0	10.0	-	-	No more responsibility for environmental conservation

On the question of what is most needed for promoting green growth of the agricultural sector, the response ‘in-depth research for the diagnosis and evaluation of the current conditions of green growth of the agricultural sector’ accounted for 25.0% of all responses, followed by ‘the integration of agricultural, environmental and energy policies for green growth’ (22.5%), ‘expansion of investment and financing to the agro-food sector for national strategies for green growth’ (19.2%) (Table 3-16). Therefore, in order to promote green growth of the agricultural sector, the experts deemed it necessary to integrate the related policies by means of diagnosis and evaluation of the current conditions and to expand investment and financing to the agro-food sector.

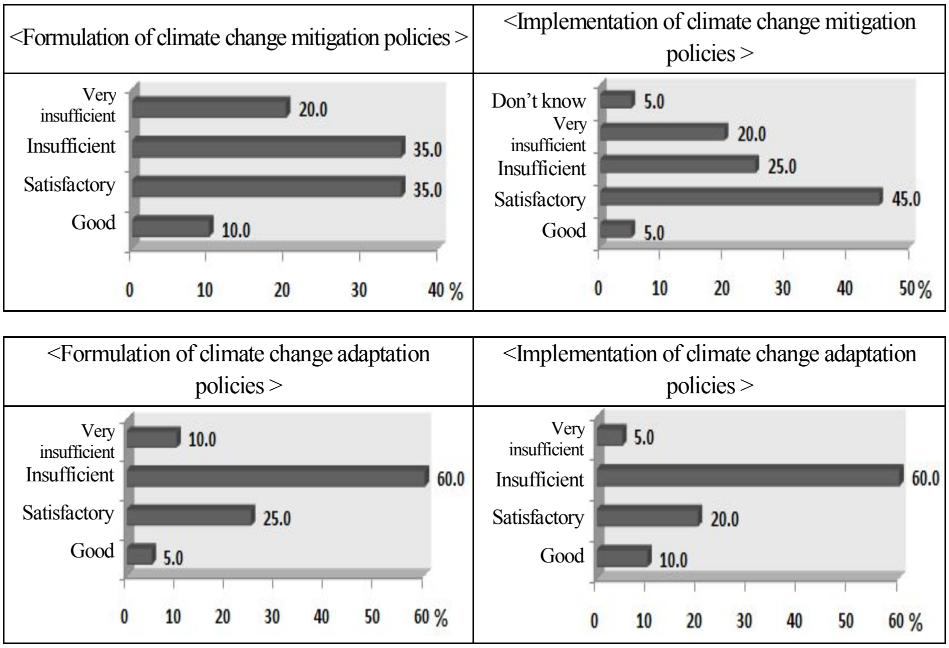
Table 3-16. The Highest priority tasks for promoting green growth in the agricultural sector

Unit: %

Expand investment and financing to the agro-food sector for the national strategy for green growth.	19.2
Integrate green agricultural, environmental and energy policies for green growth.	22.5
In-depth research for the diagnosis and evaluation of the current conditions of green growth of the agricultural sector.	25.0
Develop a green index for measuring the agriculture-related policies.	7.5
Build an organization and an integrated management system for green growth of the agricultural sector.	10.8
Educate and engage in public relations for promoting the green growth of the agricultural sector.	5.0
Develop green industry that can induce private participation.	1.7
Develop green technology for the agricultural sector.	8.3

Green growth policies for the agricultural sector include the policies concerning climate change. Within climate change, policies are divided into either mitigation policies or adaptation policies. With regards whether Korea’s climate change mitigation/adaptation policies for the agricultural sector had been formulated and the degree to which they had been implemented, most experts thought them insufficient (Figure 3-12). In particular, the implementation of the adaptation policies were deemed to be more insufficient that that of the mitigation policies. Therefore, it seems necessary to implement the mitigation/adaptation policies together, while attaching more importance to adaptation policies.

Figure 3-12. Extent of implementation of the policies for mitigation of/adaptation to climate change in the agricultural sector



On the question of whether the 'spread of the environment-friendly agriculture', 'intermittent irrigation and water depth control for rice paddy' and 'no-till farming' would contribute to a reduction in GHG emissions from the agricultural sector, most of the experts answered that they would (Table 3-17).

Table 3-17. Contribution of each policy measure to the reduction of GHG emissions from the agricultural sector

Unit: %

	Very much	Some extent	Fair	Not much	Not at all	No idea
Spread environment-friendly agriculture	30.0	40.0	10.0	10.0	-	5.0
Intermittent irrigation and water depth control for rice paddy	10.0	60.0	20.0	-	5.0	-
No-till farming	10.0	65.0	10.0	10.0	-	-

The Feed-In Tariff (FIT), a renewable energy support system, will be abolished in 2012 and the Renewable Portfolio Standard (RPS) will be introduced instead. Fifty-five percent (55%) of the experts though that the move from FIT to RPS was not appropriate (Figure 3-13). As an alternative most experts chose the option to 'operate FIT and RPS together as both of them have pros and cons, while complementing their cons.'

Figure 3-13. Appropriateness of introduction of RPS after FIT is abolished

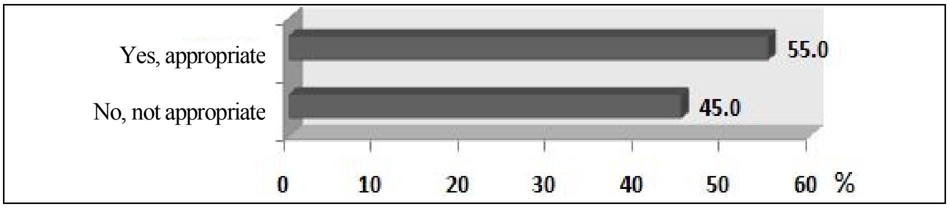


Table 3-18. Alternatives if not appropriate

Unit: %

Keep FIT without introducing RPS.	9.1
Necessary to introduce RPS but later, as it is too early to introduce it.	-
Operate FIT and RPS together as both of them have pros and cons, while complementing their cons.	81.8
Others (Complement with the upper limit of RPS and the remaining amount of FIT, as both systems have advantages)	9.1

It appeared that most of the experts judged that green growth of the agricultural sector would contribute to 'reduction of GHG emissions from the agricultural sector' and the 'development of the future Korean agriculture'.

4.2.4. Significance of MIFAFF's Implementation Strategies and Policies

Concerning "Strategies for Promoting Low-carbon, Green Growth in the Food, Agriculture, Forest and Fisheries Sector" announced by the MIFAFF in November 2008 (Figure 3-19), most of the experts appeared to know about it.

Table 3-19. Strategies for promoting low carbon, green growth in the food, agriculture, forest and fisheries sectors.

<table>
<tr><td>Vision</td><td colspan="3">. Agriculture, forestry and fisheries and rural, mountainous and farming districts that are at the vanguard of national happiness and prosperity</td></tr>
<tr><td>Objectives</td><td colspan="3">. CO_2 emissions: 14.7 million ton CO_2 in 2005 → Set according to the national reduction plan.
. Bio-energy supply rate: 6.6% in 2007 → 8.8% in 2013 → 15.7% in 2020
. Environment-friendly agricultural product rate: 3.0% in 2007 → 10.0% in 2013 → 15.0% in 2020</td></tr>
<tr><td>3 strategies</td><td>. Low-input high-efficiency green industry</td><td>. Sustainable utilization and management of natural resources</td><td>. Enhance the national health of the Korean people and raise the national brand.</td></tr>
<tr><td>9 initiatives</td><td>. Promote the use of biomass energy
. Spread green technology & equipment
. Strengthen the capacity for coping with climate change</td><td>. Increase the vitality of agricultural, mountainous and fishing districts
. Expansion of green space for Carbon absorption
. Foster high value-added bio-industry</td><td>. Develop the foundation for environment-friendly agriculture
. Establish a national low-carbon food system
. Spread the practice of green living</td></tr>
</table>

On the question as to whether the vision established in “Strategies for Promoting Low-carbon, Green Growth in the Food, Agriculture, Forest and Fisheries Sector” was appropriate, the “yes” response accounted for 65% while ‘no’ accounted for the remaining 35%.

Table 3-20. Opinions voiced on why the vision is not appropriate

• Actual policies do not create balance for agriculture and rural districts and there are not many policies that are practical for farmers. • The vision does not contain the characteristics of green growth and is too general to be distinguished from the objectives of the general agricultural administration.

On the question of whether the final target for green growth of the agricultural sector was appropriate, 60% of respondents replied that it was ‘not appropriate.’ When asked to explain their reasons why the final target was not appropriate, they responded that a 4.6% reduction in CO_2 emissions by 2020 from a total of 14.7 million ton CO_2 emissions in 2005, was higher than 4% national GHG reduction target. The bio-energy supply rate appeared to be similar to the national target with 6.6% in 2007, 8.6% in 2013 and 15.8% in 2020, while the environment-friendly agricultural product rate was analyzed to be higher with 3.0% in 2005, 10.5% in 2013 and 19.0% in 2020.

Table 3-21. Appropriate level of the final target for green growth of the agricultural sector

	2005 (2007)	2013	2020
CO_2 emissions (million ton)	14.7	-	0.46
Bio-energy supply rate (%)	6.6	8.6	15.8
Environment-friendly agricultural product rate (%)	3.0	10.5	19.0

Note: CO_2 emission is as of 2005, and the bio-energy supply rate and the environment-friendly agricultural product rate are as of 2007.

For the appropriateness of the 3 strategies and the 9 initiatives formulated as "Strategies for Promoting Low-carbon Green Growth of the Agricultural Sector," many of them responded that they were appropriate (Table 3-22).

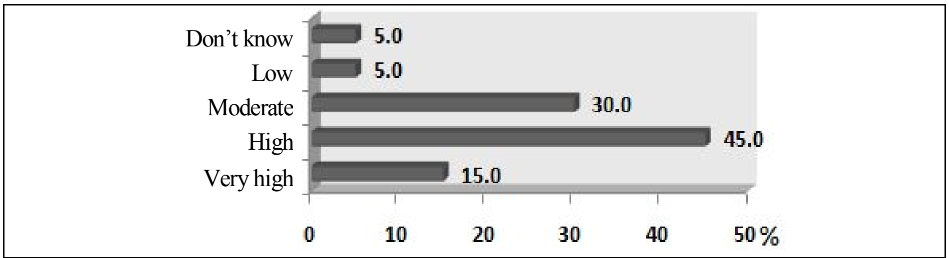
Table 3-22. Suggestions made when the 3 strategies were not appropriate

	Suggestions
3 strategies	. Improvement of grain self-sufficiency is directly related to transportation energy saving and CO_2 reduction. Therefore, the improvement of grain self-sufficiency needs to be added to the strategy. . 'Sustainable utilization and management of agro-environmental resources' is a better expression than 'Sustainable utilization and management of natural resources'. . The 3 strategies are mostly focused on efficient utilization and management of the existing resources. However, it is necessary to include the conservation of resources and the improvement of intrinsic values like traditionalism. . 'Enhance the national health of the Korean people and raise the national quality' is inappropriate as a strategy for green growth of the agricultural sector.
9 initiatives	. It is necessary to promote policy programs by properly allocating food crops and bio-energy crops. . 'Foster high value-added agro-food bio-industry' is more appropriate than 'Foster high value-added bio-industry.' . Support of green finance for the agricultural sector is insufficient. . Promotion of green job opportunities in the agricultural sector and re-education for the existing green workers both need to be supplemented. . The initiative for strengthening the capacity for coping with climate change needs to be refocused to a strategy for sustainable utilization and management of natural resources, while the initiative for fostering the foundation for environment-friendly agricultural industry should be refocused to a strategy for low-input high-efficiency green industry. . As the management by objectives and the emission trading system are planned to be enforced across the entire industry sooner rather than later, it is necessary for the agricultural sector to get ready itself for them too.

	Suggestions
	. It is necessary to suggest strategies and policy programs to make the conventional agriculture and the agricultural administration green. . Detailed tasks need to be suggested with regards to the sustainable utilization and management of natural resources. . It is necessary to systematize the relations between objectives, strategies and initiatives.

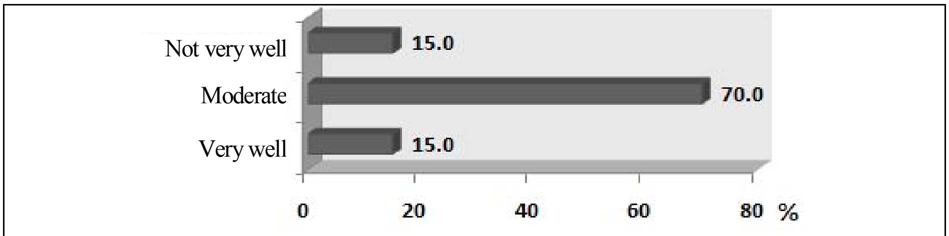
With regard to the effectiveness of green growth of the agricultural sector when MIFAFF's "Strategies for Promoting Low-carbon Green Growth of the Food Agriculture, Forestry and Fisheries Sector" were promoted as planned, 60% of the expert's responded that this was 'highly' effective, while 30% of the polled experts responded that the effectiveness was 'moderate' (Figure 3-14).

Figure 3-14. Effectiveness of green growth of the agricultural sector when MIFAFF strategies are promoted as planned



On the question of how well "Strategies for Promoting Low-carbon Green Growth of the Food Agriculture, Forestry and Fisheries Sector" are making progress, 70% responded with "moderate" while 15% responded respectively "not very well" and "very well' (Figure 3-15).

Figure 3-15. Progress of MIFAFF strategies



One question asked for the level of importance of each of the 33 policy programs promoted by MIFAFF for green growth of the agricultural sector. On the question, more than 90% of respondents believed the following policies to be ‘important’: ‘expand the research and development of green technology’ and ‘develop a statistical system to cope with climate change.’ These were followed by ‘promote the use of biomass energy’; ‘introduce a carbon labeling system to the agricultural sector’; and ‘develop a network for forecasting the crop yield of major countries.’ However, the following were considered relatively less important: ‘build green space specific to each region’; ‘develop Saemangeum into an outpost of green growth’; and ‘develop environment-friendly food clusters’ (Table 3-23). In other words, the policy for coping with climate change and the one for enhancing energy independence were evaluated to be relatively more important while the space-related policies that would have difficulty in producing visible effects in a short period of time were evaluated to be less important.

Table 3-23. Importance of MIFAFF green growth policy programs

Unit: %

Task for each sector	Details	Not important ①	②	③	④	Important ⑤
Promote the use of biomass Energy	• Expand the facilities for recycling livestock wastes and for turning them into energy, and develop bio-energy technology that uses agricultural crops.	-	-	15.0	35.0	50.0
Expand the investment in development of green technology	• Expand the financing for the development of green technology, and encourage the private investment by introducing the green technology certification system.	-	5.0	5.0	35.0	55.0
Develop and supply green technologies	• Improve the thermal insulation for the horticulture facilities, and install the energy saving systems to substitute fossil fuel with geothermal heat pumps and LEDs.	-	-	25.0	40.0	35.0
Spread the equipment that uses green technology	• Produce and supply electricity using the irrigation water from the agricultural reservoirs, rain water from rivers, and redundant water.	-	10.0	55.0	25.0	10.0
Develop a statistical system to cope with climate change	• Develop a statistical system for calculating accurate amount of GHG emissions from each sector (agriculture, livestock farming, and food) in preparation against implementation of the GHG reduction target.	-	-	10.0	50.0	40.0

Unit: %

Task for each sector	Details	Not important ①	②	③	④	Important ⑤
Monitor the ecosystem in response to climate change	. Improve the adaptability of production to climate change, including monitoring of the ecosystem change.	-	10.0	20.0	45.0	25.0
Strengthen the preventive measures against climate change	. Minimize the damages from meteorological disasters like drought and flood, by promoting crop disaster insurance and taking proper preventive measures.	-	5.0	15.0	50.0	30.0
Form green spaces specific to each region	. Form green spaces specific to each region such as experience facilities and leisure facilities.	10.0	35.0	25.0	15.0	15.0
Build Saemangeum area into an outpost of green growth	. Build Saemangeum area into the center outpost of green growth.	10.0	25.0	40.0	15.0	10.0
Build low-carbon green towns and develop environment-friendly houses	. Build model low-carbon green towns using biomass, solar power and /or wind power, and develop and spread environment-friendly energy-efficient rural houses.	5.0	-	40.0	40.0	15.0
Prevent disasters by improving the water quality of 4 Major Rivers	. Strengthen the water management including infrastructure maintenance to improve the water quality of 4Major Rivers and prevent natural disasters.	10.0	10.0	35.0	40.0	5.0

Among MIFAFF's 33 policy programs for green growth of the agricultural sector, the following programs appeared to be considered most important, they are listed in rank order from most important to least important: 'promote the use of biomass energy'; 'expand the research and development of green technology'; 'spread the environment-friendly agricultural district development programs'; and 'introduce carbon labeling system to the agricultural sector' (Table 3-24).

Table 3-24. Most important policies among 33 policy programs

Unit: %

Promote the use of biomass energy	17.5
Expand the research and development of green technology	13.3
Spread the environment-friendly agricultural district development programs	9.2
Introduce carbon labeling system to the agricultural sector	6.7
Spread the green food culture	5.8
Develop a statistical system to cope with climate change	5.8

Form a foundation for using the domestic food materials	5.0
Develop adaptation technology and cope with meteorological disasters	5.0
Evaluate and forecast the impacts of climate change	5.0

4.2.5. Implications of the Results of the Survey of Experts

It appeared that the experts were highly aware of the national strategies for green growth and the five-year plan but were of the opinion that the agricultural sector's contribution to them was moderate or relatively low.

They judged the co-implementation of environmental conservation and economic growth positively, and assessed that the concept of 'green growth' took only economy into consideration while that of 'sustainable growth' considered environment along with economy. With regard to the relation between 'green growth' and 'sustainable growth,' many of them considered that sustainable growth was a larger concept that contained green growth.

All of the experts agreed with the need of green growth of the agricultural sector and evaluated the green growth of the agricultural sector as a concept that included sustainable agriculture, environment-friendly agriculture, low carbon agriculture, and even advanced technology agriculture.

For promoting green growth of the agricultural sector, most of them agreed to strengthen the environmental regulations for agriculture and were willing to take the responsibility for environmental conservation. They chose the followings as most important in promoting green growth of the agricultural sector: 'in-depth researches for diagnosing and evaluating the current conditions of green growth of the agricultural sector'; 'integration of agricultural, environmental and energy policies for green growth'; and 'expand the investment and financing for the agro-food sector for national green growth strategies'.

With regard to the progress of climate change policies for the agricultural sector, they thought that the policies had made insufficient progress and that the followings would contribute to reduction of GHG emissions from the agricultural sector: 'spread the environment-friendly agriculture'; 'intermittent irrigation and water-depth control for rice paddy'; and 'no-till farming'.

For the introduction of RPS in place of FIT, more experts expressed negative opinions and among the alternatives, 'operate FIT and RPS together as both of them have pros and cons, while complementing their cons' won the most responses.

Most of the experts appeared to know "Strategies for Promoting Low-carbon Green Growth of the Agricultural Sector' announced by the MIFAFF and evaluated that the vision, 3 strategies and 9 initiatives were appropriately formulated, though many of them considered that the final target was not appropriated. The level suggested by the experts to be appropriate as the final target was similar to or higher than the current target level.

Among MIFAFF's 33 policy programs for the agricultural sector, the following programs were evaluated to be important in order: 'expand the research and development of green technology'; 'develop a statistical system to cope with climate change'; 'promote the use of biomass energy'; 'introduce carbon labeling system to the agricultural sector'; and 'develop a network for forecasting the crop yield of major countries.' On the other hand, 'build green space specific to each region', 'develop Saemangeum into an outpost of green growth' and 'develop environment-friendly food clusters' were evaluated to be not important. In other words, it seems that the experts evaluate the policies that could be practical in coping with climate change and those that could enhance energy independence, to be important while evaluating those that are difficult to produce visible outcomes in a short period of time to be less important.

Overall, the result of the survey shows that the experts evaluate, among MIFAFF' 33 policy programs for green growth of the agricultural sector, the following programs as most important in order: 'promote the use of biomass energy'; 'expand the research and development of green technology'; 'spread the environment-friendly agricultural district development programs'; and 'introduce carbon labeling system to the agricultural sector'.

With reference to the result of questionnaire survey for reference, the first thing needed is to carry out accurate diagnostics and assessment of green growth of the agricultural sector for promoting green growth thereof, and another thing needed is integration and enforcement of related policies to avoid redundancy, investment and financing.

For intensified effects of green growth of the agricultural sector, it is necessary to diffuse the technology of reducing greenhouse gases in agriculture, to manage related systems, and to complement them by means of interim examination, not post evaluation for the promotion plan. It is also necessary to select and enforce policies highly important and most requested, e.g., policies for coping with climate change and for enhancing energy-independence.

4.3. General Evaluation of Green Growth Policy Programs for the Agricultural Sector

4.3.1. Level of Awareness of Green Growth

When questioned about the parallel promotion of environmental conservation and economic growth, 61.3% of farmers said ‘yes’ they were aware of it. This figure was significantly less than the yes responses from experts at 80%. Concerning the relationship between ‘green growth’ and ‘sustainable growth’, 46% of farmers said that there ‘was some commonality between ‘green growth’ and ‘sustainable growth’’. This was the most popular response by farmers. In contrast, 60% of experts said that ‘sustainable growth is a higher concept that contains within it the concept of green growth’. Clearly there is marked difference in these viewpoints on sustainable growth and green growth.

Most experts agreed that ‘environmental regulations in the agricultural sector’ should be strengthened beyond their current level in promoting the green growth of the agricultural sector and that ‘a certain level of burden should be accepted for environmental conservation’. Farmers agreed less than the experts on these two points, the strengthening of current environmental regulations and accepting some of the burden of conservation (as opposed to easing the environmental regulations and rejecting their burden). Farmers said that they would be more willing to accept the level of environmental regulations be strengthened and accept some burden for environmental conservation as well, but farmers were less willing than the experts’ on these points because the farmers themselves will be directly affected when strengthening the environmental regulations and accepting the burden.

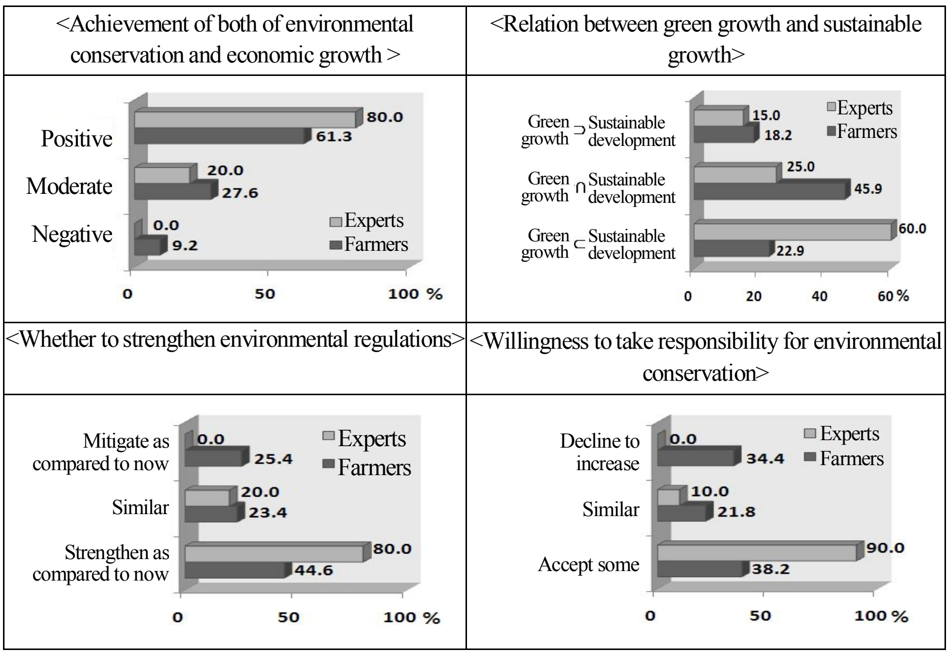
Although both farmers and experts responded positively on the need for reductions in GHG emissions from the agricultural sector for green growth thereof and the development of future Korean agriculture, the ratio of farmers giving negative answers was greater than the experts.

4.3.2. Evaluation of Green Growth Policies for the Agricultural Sector

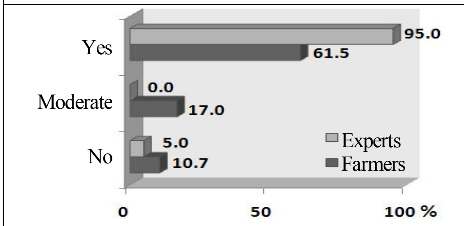
In their evaluation of the relative importance of the 33 green growth programs related to agriculture among those of MIFAFF, experts assigned greater importance to the following: 'expand the research and development of green technology', 'develop a statistical system to cope with climate change', 'promote the use of biomass energy', 'Introduce carbon labeling systems to the agricultural sector', and 'develop a network for forecasting the crop yields of major countries'. Farmers on the other hand, assigned greater importance to the following: 'promote the use of biomass energy', 'develop and supply green technologies', 'strengthen preventive countermeasures against climate change', and 'build low-carbon green towns and supply environment-friendly houses'. Both farmers and experts agreed that policies for coping with climate change and those for enhancing energy independence were important. However farmers selected policies that would be immediately helpful on the ground, while the experts assigned greater importance to the creation of databases and introduction of new programs from among the related policies.

However, both farmers and experts agreed that 'develop Saemangeum into an outpost of green growth' and 'develop environment-friendly food clusters' were programs of lesser importance among the 33 programs. This demonstrates that both farmers and experts assigned less importance to those policies which could not easily produce visible effects in the short term.

Figure 3-16. Comparison of the results of surveys for farmers and experts



<Contribution of green growth to GHG reduction in the agricultural sector>



<Whether green growth will contribute to developing agriculture in the future>

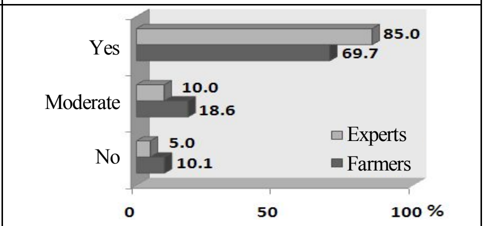


Table 3-25. Comparison of importance on green growth policies for the agricultural sector program

	Farmers	Experts
Important	- Promote the use of biomass energy - Develop and diffuse green technologies - Strengthen the preventive measures against climate change - Build low-carbon green towns and develop environment-friendly houses - Foster the environment-friendly agricultural material industry	- Expand the research and development of green technology - Develop a statistical system to cope with climate change - Promote use of biomass energy - Introduce the carbon labeling system to the agricultural sector - Develop a network for forecasting the crop yield of major countries
Less important	- Develop Saemangeum into an outpost of green growth - Provide more green space for carbon absorption - Develop environment-friendly food clusters	- Build green space specific to each region - Develop Saemangeum into an outpost of green growth - Develop environment-friendly food clusters

Table 3-26. Evaluation of progress of and importance to MIFAFF green growth initiatives

Unit: %

Task	Progress in objective of initiatives in 2010		Evaluation of importance in agricultural sector	
	50 practical tasks	Progress	Farmers	Experts
Promote biomass Energy	Livestock wastes resources · energy	80.0	73.9	85.0
	Agricultural biomass energy	83.5		
Expand research and development of green technologies	More investment in green technology R&D	73.5	62.2	90.0

Task	Progress in objective of initiatives in 2010		Evaluation of importance in agricultural sector	
	50 practical tasks	Progress	Farmers	Experts
Develop and diffuse green technologies	Supply energy saving instruments for greenhouses	119.0	71.0	75.0
	Improve the efficiency of using LED lighting for farming	116.5		
Supply more equipment, using green technology	Micro hydropower generation	100.0	62.2	35.0
Develop a statistical system to cope with climate change	Build up a greenhouse gas inventory	68.7	61.6	90.0
	Introduce emission trading systems	50.0		
	Develop the technology for reducing GHG from the agricultural/livestock farming sector.	75.0		
Monitor the ecosystem to cope with climate change	Manage diseases of animals, plants and aquatic lives	66.7	63.7	70.0
	Informationize and automate agricultural management organizations	66.7		
Enhance preventive measures for coping with climate change	Collect overseas agricultural information	75.0	76.5	80.0
	Encourage farmers to insure crop cultivation	100.0		
Create green space specific to each region	Construct more experience & eco-tourism infrastructures	85.7	56.7	30.0
Saemangeum area as an outpost for green growth	Build Saemangeum area into an outpost for green growth	57.0	48.7	25.0
Build low-carbon green towns and develop environment-friendly houses	Build rural district-type low carbon green towns	75.0	71.2	55.0
	Develop and supply standard blueprints for environment-friendly houses in rural and fishing districts	90.0		
Improve water quality and prevent disasters in 4 major rivers	Strengthen the management of water used for agriculture	75.0	58.4	45.0
Expand urban-rural exchange programs	Encourage urban-rural exchanges	104.0	56.7	50.0
Develop future rural district models	Beautiful Paldogangsan project	75.0	58.8	45.0
Provide more green space for carbon absorption	Encourage general horticulture	80.0	46.7	55.0
High value added life industry using bio-resources	Develop functional crops for new material	100.0	57.3	55.0

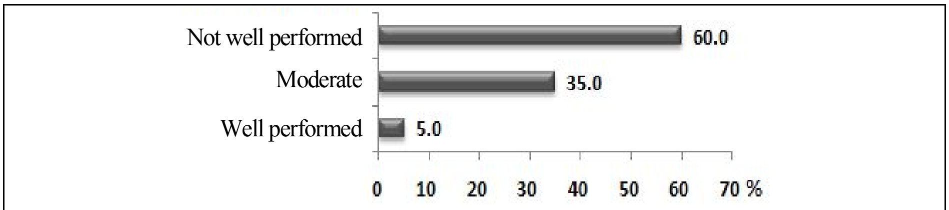
5. Diagnosis of the Current Integration of Green Growth Policies

The integration of policies related to green growth was diagnosed on the basis of the result surveys of experts for each instrument and theories of policy integration and related data.[14] Since green growth policies themselves are considered to be policies for policy integration, it is considered that policy integration related to agricultural and rural districts for green growth is already in progress.

MIFAFF will invest a total of 15.8 trillion won for the period of 2009-2013 to support green growth in the agro-food sector. The economic effect of the investment and financing in green growth is predicted to be 18.5 trillion won. By 2013, the phase when research and investment in facilities is completed the predicted real economic effect will materialize. It is estimated that some 44.9 trillion won of economic value will be created by 2020. By 2013, it is estimated that 710,000 job opportunities will have been created (MIFAFF, 2009).

As described above, since the Korean government is investing a significant amount of budget on green growth, it is predicted that economic value will materialize and job opportunities will be created. However, it is difficult to conceive that policy integration, the requirement for efficiently promoting green growth policies, is fully achieved. This was borne out by the survey of experts, fully 60.0% of whom felt that the effort for policy integration related to agricultural and rural districts is ‘not completed satisfactorily’ as against only 5.0% who felt that the effort had is ‘being made satisfactorily’.[15]

Figure 3-17. Level of effort for policy integration



[14] The policy integration in this study signifies the integration between agriculture/rural district policies and environment/energy policies, but not the integration between agricultural policies and rural districts policies.

[15] Questionnaire survey for experts was carried out to identify the direction of policy integration for green growth of the agricultural sector in August to September, 2010 for 20 green growth experts in the agricultural sector (survey by e-mail).

Sixty-four point six percent of experts believed the reason why policy integration was not effective was low awareness of the necessity for policy integration. Fourteen point three percent of experts believed the reason why policy integration was not effective was lack of sufficient legal framework and an institutional system and the small number of government organization and related personnel.

5.1. Setting basic direction of agricultural administration for which economy and environment is harmoniously balanced

It is very important to set the vision for agricultural administration and the basic direction as this emphasizes the harmonious balance between objectives and targets to be achieved by policies. This should be undertaken in each sector in order to achieve the highest objectives and targets, which are green growth and policy integration. The Korean government has set the general policy agenda of "green growth" and the long-term objectives for the nation-wide conversion of economic and social systems.

MIFAFF has, through Vision 2020, set the agricultural administration's vision of "agriculture, forestry and fisheries and rural areas, with forest and fishing districts full of life, health and attraction" Vision 2020 is composed of three distinct categories being the new growth of the green life industry, healthy living and delicious food and revitalized rural and fishing districts. MIFAFF specified that agriculture should be converted to 'an environment-friendly industry focused on energy efficiency and material circulation' in order to achieve the mission of 'new growth of green life industry'.

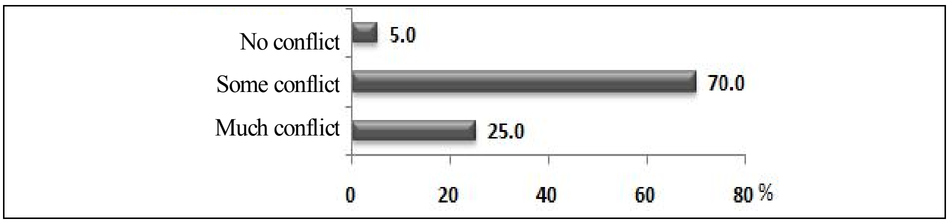
MIFAFF also specified 'the direction of environment-friendly rural, forestry and fishing districts and green cities' in order to accomplish the mission of 'pleasant and revitalized rural, forestry and fishing districts'. Therefore, it is considered that the agricultural administration's visions and mission are set, and that they are focused on achieving a harmonious balance between agricultural policies, rural district policies, energy policies and environment policies.

Meanwhile, Article 6-1 (Basic Principles for Establishing and Enforcing Policies) in Chapter two of the 'Framework Act for Agriculture, Fisheries, Rural and Fishing Districts and Food Industry' -Basic Direction of Policies of Agriculture, Fisheries, Rural and Fishing Districts and the Food industry, specifies that "the government and local bodies should pursue efficiency based on the principle of the market economy but should also consider maximizing the public profit of agriculture, fisheries, rural and fishing districts when preparing and enforcing policies for agriculture, fisheries, rural and fishing districts and the food industry.

The Framework Act includes an article which specifies that the public role should have an environmental aspect, and that when promoting policies and fostering sustainable environment-friendly farming and fishing, the public role should be maximized. Therefore, it is considered that the Framework Act specifies the concept that policies for agriculture and rural districts should be harmoniously balanced with environmental policies.

However, "…pursuing efficiency on the basis of the principles of the market economy, but maximize public profit for agriculture, fisheries, rural and fishing districts" is taken to mean that efficiency based on the principle of market economy should first be ensured and public profit for agriculture, fisheries, rural and fishing districts should then be maximized. Therefore, this can only be taken to mean that economic efficiency is the focus rather than any environmental aspect. In the basic direction for the Framework Act, there is no article on energy which emphasizes green growth. On the other hand, it appeared, through a survey for experts, that most believed there to be conflicts between the purposes of agricultural policies and those of energy/environmental policies (Figure 3-18).

Figure 3-18. Conflict between the purposes of agricultural policies and energy/environmental policies

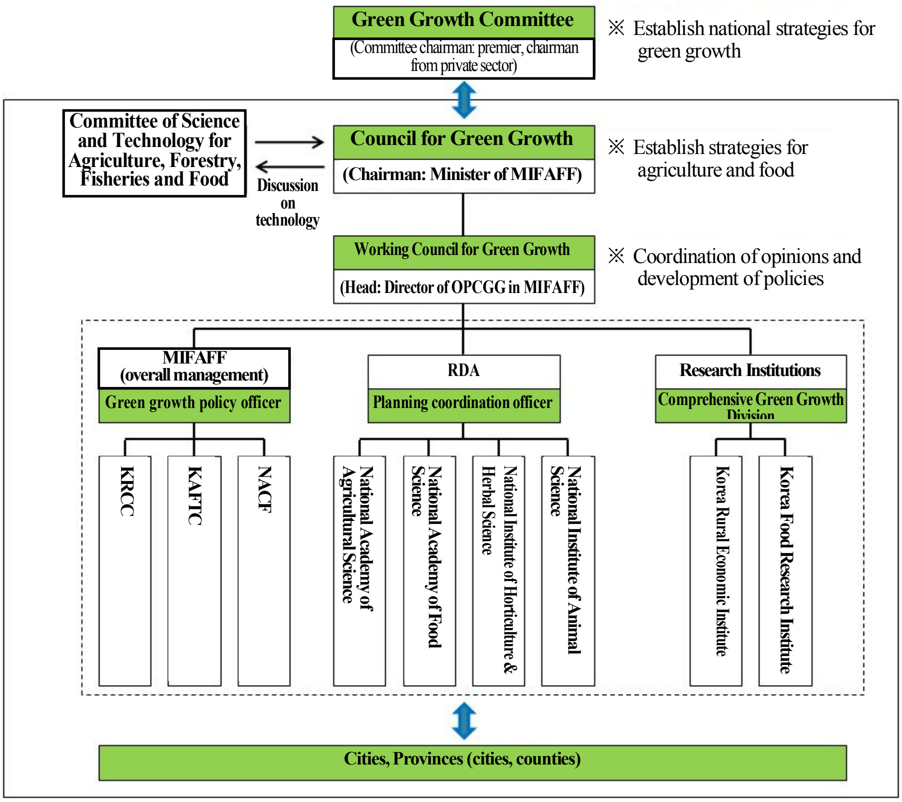


Therefore, it is necessary that a larger framework be suggested to reduce the conflicts between the purpose of agricultural policies and those of energy/environmental policies, such that economy can be and environment can be balanced. This will allow the establishment of a basic direction for the agricultural administration that also encompasses the energy sector.

5.2. Necessity for strengthening policy integration system

MIFAFF appointed a Director General for Green Growth responsible for green growth policies and also established the Department of Green Future Strategy. The Department formulates low carbon strategies for promoting green growth in the food, agriculture, forestry and fisheries sectors and promotes green growth policies in cooperation with other departments and offices within the Ministry. MIFAFF has a Council for Green Growth headed by the Minister, and a Working Council for Green Growth, headed by the Director General of Office of Planning and Coordination in MIFAFF. MIFAFF has also constructed a system for promoting green growth in which MIFAFF, the RDA, and various related R&D institutions participate.

Figure 3-19. System for promoting green growth in agriculture and rural districts



Note: Institutions related to fisheries and forestry are not included.
Source: **MIFAFF (2009).**

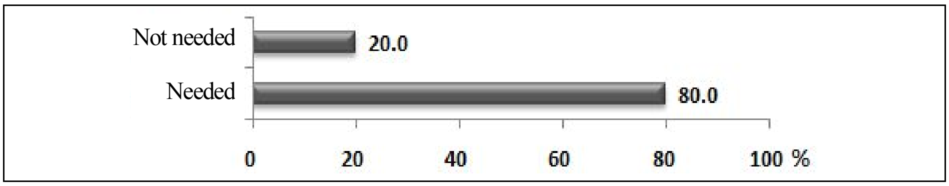
In addition to the Office of Green Future Strategy, there is the division of Environment-friendly Agricultural Policies Division, which generally manages environment-friendly agriculture and acts as a government organization for policy integration related to green growth in agriculture and rural districts.

For energy, there are is the Division of Vegetable and Special Crops which is executing the 'Project for the efficient use of energy for greenhouse horticulture' and the Division of Livestock Farming Policies which is executing the 'Project of supporting livestock waste treatment'. In addition, some other divisions and offices in the government are also promoting policies related to green growth.

It is not necessary to bring all these related divisions and offices under the purview or oversight of one organization for policy integration in order to maintain the autonomy of individual policies. Reconstructing organizations is not a precondition for success in policy integration. However, there is a need for a division specialized in comprehensively managing environment-friendly agriculture, natural resources and energy, since these are the key policies for green growth. There is also a need for a system for promoting policies which take into consideration both the environment and energy for the overall administration of the agricultural sector.

Most experts believe that 'modification of government organizations is needed'. From the results of a survey of experts, 80.0% of respondents agreed with this statement. It was viewed as a precondition for integration between the policies for agriculture, energy and environment. On the other hand, only 20% of experts said that it was 'not needed'.

Figure 3-20. Necessity for modification of government organizations for policy integration



With regards the modification of government organizations, 53.3% of experts, the largest group of respondents, answered 'install a division specialized in policies related to energy and environment for agriculture and rural districts'. The smaller groups of respondents suggested various alternatives including: 'organizing the coordination and enforcement of policies via a meeting division consisting of directors'; 'to bring together personnel from each division related to green growth to create an umbrella division specialized in these policies', 'to increase the number of experts in energy policies along with their support staff', and 'the positive participation of MIFAFF staff and invited experts' (from the Ministry of Strategy and Finance (MSF), Ministry of Knowledge and Economy (MKE), Ministry of Environment (ME) The Ministry of Land, Transport and Maritime Affairs (MLTM), experts, related enterprises, NGO, etc.).

In Japan, the Ministry of Agriculture, Forestry and Fisheries (MAFF) reorganized the division of Environmental Policies into the division of 'Environment Biomass Policies' in 2007. This was undertaken to comprehensively manage both environment/agricultural policies and bio-energy policies. In December, 2003, MAFF prepared the 'basic direction of environmental policies in agriculture, forestry and fisheries' which laid out the policies to be promoted for the conservation and shaping of a healthy and rich natural environment, together with the maintenance and enhancement of natural circulation in the industries of agriculture, forestry and fisheries. This effort would be led by farmers, forestry farmers and fishermen who would comply with the basic direction. On the basis of such preparation, MAFF introduced a system for environmental management, based on ISO14001, in March, 2006, and decided to promote the project to reduce strains on the environment and for environmental conservation.

Meanwhile, there is a council for green growth, and for governance, which operates like a watchtower, organizing cooperation among the private sector, the government and universities, while comprehensively managing and controlling policy-related communication and strategic knowledge. From the survey, 5.0% of the experts answered that this was 'satisfactory', 45.0% of them that it was 'not satisfactory' and 45.0% of them 'sometimes' in terms of the current performance of communication, the building up of joint knowledge bases and the strategic management of knowledge related to energy and environmental policies and research on agriculture and rural districts.

5.3. Need for a budget system associated with performance management plus mid– and long–term plans

The basic direction of budget allocation outlined in the 'Overview of Budget and Plan for Fund Management in 2010' by MIFAFF specifies the 'promotion of national policies, e.g., low carbon, green growth'. The key direction of allocation also specified 'to create a basis for future growth in the sectors of agriculture and fisheries in terms of biomass resources, highly efficient energy, and the seed industry'.

Details of finance allocation for key projects in each sector include 113.8 billion won in 2009, and 243.7 billion won in 2010 in order to 'support projects for biomass energy, highly efficient energy, the seed industry' so as to expand investment in low carbon and environment-friendly green growth.

As described above, green growth is specified in the key direction of budget (fund) allocation and the budget for green growth has been expanded, but there is still a need for a budget system to support policy integration related to agriculture and rural districts. The budget system can improve the efficiency and effect of financial projects when operated in close conjunction with the system for identifying results (assessment).

An exemplary program budget system would be one which is closely related to the management of financial performance. The program budget system is a budget structure for linking policies with a budget through program contents. In other words, it is a budget technique for managing outcomes by structuring the whole process of budget planning, preparing, allocating, executing, accounting, evaluating and the feedback channels to be focused on the program and then by associating it to the assessment system of contribution for management performance.[16] According to 'the 2010 Budgeted Projects Manual' issued by The National Assembly Budget Office (NABO), MIFAFF had 31 budget programs in 2010 with a combined budgeted allowance of 14. 81 trillion won.

Within the 31 budget programs there are 149 unit programs. And within these 149 unit programs are 349 sub-unit programs.

There is no program entirely comprised of only green growth policies (Table 3-27). Therefore, given the structure shows it is difficult to perform important green growth policies in close conjunction with planning, assessing and budgeting.

[16] A program means a collection of of unit projects designed to achieve a policy objective and is an independent minimum unit with respect to policies.

Table 3-27. Programs of MIFAFF in 2010

Program	
1. Stabilize farmer's management	17. Quality control of farm products
2. Foster agricultural and fishery management organizations	18. Study agriculture
3. Manage grains	19. Research for preventing livestock epidemics and quarantine and veterinary science
4. Foster environment-friendly agriculture	20. Food quarantine
5. Research policies for developing agricultural and forestry technology	21. Seed management
6. Farmland bank (farmland, financing)	22. Distribution and safety control of marine products
7. Stabilize farm product prices and promote efficiency of distribution	23. Manage and prepare marine resources
8. Enhance competitive power	24. Develop fishing districts and ports
9. Enhance competitive power (funds, financing)	25. Fishery management
10. Promote livestock farming	26. Cooperation for distant water fisheries
11. Promote livestock farming (develop livestock farming, financing)	27. Research fisheries
12. Expand the foundation for agricultural production	28. Distribution and safety control of marine products (funds, financing)
13. Promote farmers and fishers' welfare	29. Quality control of marine products
14. Develop rural districts and vitalize urban-rural exchanges	30. Manage fishery maps
15. Informationize agriculture and rural districts	31. Foster the food industry
16. International cooperation and negotiation	

Source: Office of National Assembly Budget Policy

The program budget system is a sub-structure for appropriately managing financial performance[17]. With the performance management system in which performance management and the objects of assessment are selected without any program budget structure, it is hard to achieve comprehensive and systematic connection between

[17] The financial performance management system of Korea aims to consolidate the relationship between performance information and budget distribution (i.e provide a feedback mechanism) to achieve rational budget allocation and improve the operation of budget projects and by doing so enhance project efficiency.

budget preparation and accounting process. Therefore, it is necessary to ensure consistency between the performance plans submitted by each Ministry and the program budget system used by the budget division for preparing budgets for substantial operation of the performance management system which requests the relevant ministry or institution to submit performance plans and reports to the budget authority and the National Assembly.[18]

In the plan for enforcing performance management by MIFAFF in 2010, the performance objectives directly related to green growth is 'fostering environment-friendly agriculture and fisheries' and 'green growth and progress of R&D for the agro-food sector'. Table 3-31 shows tasks for management related to the objectives.

The following shows comparison of the performance objectives and tasks for management in the plan for enforcing the programs of the program budget system, unit programs and performance management. There is a program of 'fostering environment-friendly agriculture' in the MIFAFF program in 2010, but there is no program directly associated with 'green growth and progress of R&D for the agro-food sector'. Instead, tasks for management corresponding to the performance objectives of the plan for enforcing performance management, 'green growth and progress of R&D for the agro-food sector', belong to some programs. For example, the tasks for management of 'improving distribution of farm products (special task for energy)' in the performance objectives of the plan for enforcing performance management, 'green growth and progress of R&D for the agro-food sector', corresponds to the unit program 'improving distribution of farm products (support/financing)' of program 7 'Stabilizing Prices of Farm Products and Efficient Distribution'.

[18] The performance plan is comprised of 'strategic missions--s-strategic targets-performance targets-management tasks –detailed activities', and the program budget comprises 'field-sector-programunit project'. For consistency between them, the 'Guideline for preparing performance plans in 2010' specifies the corresponding ratio of 1:1 between tasks for management and unit projects.

Table 3-28. Plan for enforcing performance management in 2010 of MIFAFF related to green growth

Performance objectives	Tasks for management
1. Foster environment-friendly agriculture and fisheries for environmental conservation and increased provision of safe agricultural and marine products	① Create a basis for environment-friendly agricultural production
	② Encourage consumption and distribution of environment-friendly farm products
	③ Foster increased output of the products of environment-friendly livestock farming
	④ Continue to promote improvement of the fishing ground environment
	⑤ Foster open sea fish farming
	⑥Environment-friendly fertilizers
	⑦ Environment-friendly agriculture infrastructure
	⑧ Build up environment-friendly agriculture infrastructure in wide areas
	⑨ Prevent damages to crops
	⑩ Support environment-friendly livestock farming
	⑪ Support environment-friendly livestock farming
	⑫ Inland fisheries
	⑬ Support environment-friendly fisheries
2. Improve the constitution of agriculture and fisheries and reduce the energy consumption and costs of the agro-food sector through the progress of green growth and agro-food R&D (green growth and progress of R&D for the agro-food sector).	① Strengthen low carbon and green growth infrastructure
	② Improve R&D efficiency for agricultural and marine foods
	③ Strengthen the basis for the seed and life industry
	④ Promote to reduce energy consumed in agriculture and fisheries and to supply new renewable energy
	⑤ Improve distribution of farm products
	⑥ Manage seeds
	⑦ Improve competitive power
	⑧ Construct a basis for radiation breeding
	⑨ Develop agricultural and forestry technology
	⑩ Research fishery experiment
	⑪ Research and development specific to fisheries
	⑫ Support fishery research
	⑬ Informationize resources of species
	⑭ Informationize the fishery research and development institutes

⑩ Support the environment-friendly livestock farming (special agriculture) and ⑪ support the environment-friendly livestock farming (livestock development) of the performance objective 'fostering environment-friendly agriculture and fisheries' of the plan for enforcing performance management corresponds to the unit programs 'support environment-friendly livestock farming (special farming)' and 'support environment-friendly livestock farming (livestock development)' of program 10 'fostering livestock farming'.

As described above, since policies related to green growth in the sector of food from farming, forestry and fisheries are classified differently within the plan for enforcing performance management and the program budget projects, it is not easy to structure the whole process of planning, preparing, allocating, executing, accounting, assessing and feedback of budgets to be focused on a program and to connect it to a performance assessment system for managing the performance.

It is also no easy matter to continue to promote projects and secure budgets without mid- and long-term plans, e.g., the 'Plan for Sustainable Management and Utilization of Natural Resources and Environment of Rural Districts (tentative)' and the 'Master Plan for Energy Management for Agriculture and Rural Districts (tentative)'.

A variety of energy related policies are enforced in the agriculture sector and rural districts.[19] However, there is no system for comprehensively planning and promoting energy 'supply and demand' for the agricultural sector and no mid- and long-term policy.

In the survey of experts, 85.0% of respondents believed that establishing a master plan was 'necessary' to presenting the visions of, and strategies for, executing long-term energy policies in the sector of agriculture and rural districts. This percentage was significantly higher than the 10.0% of respondents who believed it was 'not necessary' (Figure 3-21).

Those respondents who answered that a master plan was necessary were asked to elaborate on what they felt would be the plan's highest priority item. On this question 50.0% of these respondents answered 'develop detailed policies', 45.0% answered 'prepare legal and institutional bases' and 'install more dedicated teams and staff

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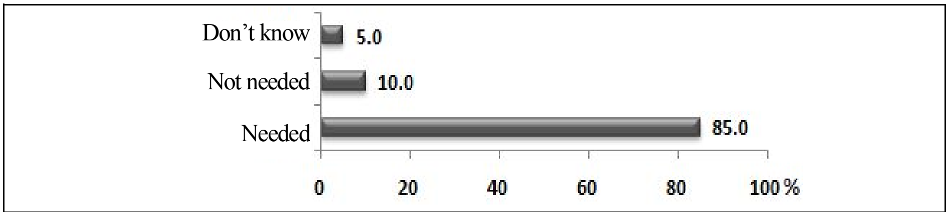
[19] MIFAFF set green energy as six major initiatives in 2010 having detailed initiatives of producing resources and energy with livestock waste, supplying renewable energy in the agricultural and fishery sectors, constructing energy-independent green villages in rural districts, introducing and diffusing the quality marking system for wood pellets, producing biomass energy with seaweeds, encouraging fishers to use LED lights and developing electric propulsion systems.

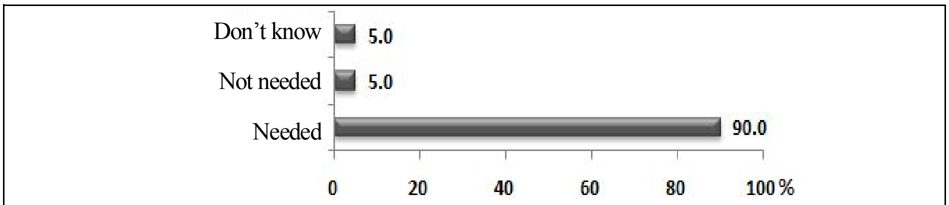
members', respectively, 35.0% answered 'build up a knowledge basis through continuous communication among concerned workers, experts and officials working in the government', and 15.0% of them answered 'publicize the necessity'.

Figure 3-21. The need to formulate a master plan for long-term energy policies



MIFAFF is promoting a plan for fostering environment-friendly agriculture for developing environment-friendly agriculture. This must occur every five years according to the 'Law for Fostering Environment-friendly Agriculture'. However, it does not specify the purpose of policies for agriculture, natural resources in rural districts or conservation of the sustainable environment, all of which are important with respect to green growth and sustainability. From the survey of experts, 90% of respondents answered that it was 'Necessary' 'to establish a plan for managing sustainability of and use of natural resources and the environment (tentative) in agriculture and rural districts'. On the question of what should be first thing to be established if necessary, 50.0% of experts responded 'prepare a legal and institutional basis, 45.0% responded 'develop detailed policies' and 30.0% responded 'Position more dedicated staff members and install teams'.

Figure 3-22. Necessity for establishing a plan for managing the sustainability and use of natural resources and the environment (tentative) in agriculture and rural districts



5.4. Assessment System

Government policies, including green growth policies, are assessed according to the financial performance management acts. According to Article 8 of the 'Finance Act of Korea', more particularly Article 3 of Enforcement ordinance thereof, the National Fiscal Act of Korea is comprised of 3 categories: management of performance objectives, assessment of financial initiatives, and further assessment of financial initiatives.

In relation to the management of performance objectives, the plan for enforcing performance management of MIFAFF in 2010 is shown in Table 3-27.

The performance objectives which MIFAFF specified were as follows: 'foster environment-friendly agriculture and fisheries for environment conservation and expanding safe farm and marine product supply' and 'improve the performance of agriculture and fisheries and reduce energy and cost in the sector of agro-food through progress of green growth and agro-food R&D'. These objectives have 13 and 14 management tasks, respectively.

In relation to assessment of financial initiative, the result of assessment of comprehensive financial initiatives of MIFAFF in 2008 shows the initiatives related to green growth to include 'support organic fertilizers, conservation of soil environment, and support environment-friendly agriculture infrastructures' among 30 initiatives.

Meanwhile, according to the Act for Assessment of Government Performance Framework (Article 16-3), the assessment committee installed under MIFAFF assesses the performance results for core policies and submits the result to the assessment committee for government performance.

Assessed performance is a core task for policies contained in the plan for enforcing performance management of the previous year and there were 91 key tasks for policies in the plan for enforcing performance management during 2009 in case of 2010. Exemplary tasks for management related to green growth include 'create a basis for environment-friendly agricultural production', 'encourage consumption and distribution of environment-friendly farm products' and 'promote low carbon and green growth', etc.

As described above, the performance of green growth related policies has been subject to assessment. The regulations governing this assessment are those specified in both 'The National Fiscal Act' and the 'Framework Act for the Assessment of Government Performance'.

In addition the performance of policies related to green growth have been assessed, both by The Presidential Committee on Green Growth and by MIFAFF itself. The Presidential Committee on Green Growth examines the results of performance on a quarterly basis for 50 tasks undertaken within the food sector from agriculture, forestry and fisheries. The Premier’s Office selects representative tasks in each institution to assess, mainly with respect to performance.

MIFAFF prepared a plan in 2010 to enhance in-house inspection so as to promote green growth in the agro-food sector. Under this plan an in-house assessment team consisting of sector experts began carrying out inspections on a quarterly basis. In addition, MIFAFF has held workshops and gatherings, to which people working for green growth were invited. The purpose of this was to ensure smooth communication between the in-house staff and external parties.

As described above, green growth policies have been assessed by means of various systems, but pre- and post- assessment is carried out depending on how much other policies affect green growth in terms of policy integration.

Therefore, it is necessary to introduce an institution to tentatively assess the impact and contribution of policies related to agriculture and rural districts both before and after enforcement, e.g., ‘Assessment of Impact of Green Growth (tentative)'.

From the survey of experts, 55.0% of respondents were of the opinion that ‘a special assessment system is required’ for the necessity of introducing a system for assessing the impact of each policy for agriculture and rural districts on environment, natural resources, emitted carbon, consumption of energy before and after enforcement. A smaller number of respondents; 35.0% deemed that ‘a special assessment system was necessary but may be added to the existing plan for enforcing performance management’. Accordingly, it is considered that it is necessary to introduce some type of assessment system.

Empirical Analysis of Green Growth of the Agricultural Sector

Chapter 4

Empirical analysis of green growth in the agricultural sector is very important to the development of persuasive strategies for green growth. Empirical analysis provides the basic data for "developing an assessment index" which is one of the 1st year research objectives of this report. From a practical perspective, a wide range of methodologies can be utilized for this empirical analysis. Chapter four presents an eco-efficiency analysis, an empirical analysis method for ensuring the justness of green growth; the marginal abatement cost analysis is an empirical tool for selecting a cost-effective means of green growth; the green productivity analysis is used for comparing and analyzing the performance of promoting green growth in each sector, and an analysis of green growth potentials to identify the actual conditions of green growth in rural districts.

1. Eco-efficiency analysis

If the level of green growth is to be assessed then an index is required. There are a number of indices for measuring green growth and the concept of eco-efficiency, one such index having appeared relatively recently.

Eco-efficiency is an index for assessing green growth, green growth being where the impact on environment is minimized while economic development is maximized. Here, the concept of green growth and the methodology used to measure it will be described. The eco-efficiency index will be used to measure the level of green growth associated with key green growth initiatives, e.g. organic agriculture, geothermal heat pumps, etc.

1.1. Concept and method of measuring eco-efficiency

1.1.1. Concept of eco-efficiency

Eco-efficiency is a compound of eco- and of -efficiency with its origins in ecology and economics. It was proposed by the WBCSD (2000) and formally recognized at the Earth Summit held in Rio de Janeiro, Brazil, in 1992. [20]

Eco-efficiency, which connects resource efficiency with resource intensity[21], is used as an index for assessing green growth. Green growth being the minimization of impact on the environment while achieving economic development. It may also be thought of as a measure of the efficient use of resources. Eco-efficiency is calculated by dividing the value in the industrial sector (economic productivity) by the level of strain on the environment and may be defined as in the following equation (1).

$$EE_r = \frac{y_r}{x_r} \qquad (1)$$

wherein, EE: eco-efficiency, r: r'th object for measurement, r = 1, 2, ..., k, x: input variable (environmental load), and y: output variable (economic value).

In order to improve eco-efficiency, as presented in equation 1 above, production efficiency is maximized by maximizing the economic value which is an output variable (more is better), or minimizing the environmental load which is an input variable or by achieving both simultaneously.

1.1.2. Method of measuring eco-efficiency

The method of measuring eco-efficiency generally uses the input index of strains

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20 WBCSD defines eco-efficiency as the provision of competitively-priced products and services which satisfy human desires and improve quality of living while gradually reducing the ecological impact and resource intensity to a minimum level corresponding with the estimated carry capacity of the earth' (WBCSD, 2000, p.4).

21 Resource efficiency is defined as a ratio of input resources to outputs (Ekins and Tomei, 2007, p.10) and the resource intensity is defined as the inverse number of resource productivity).

on the environment for the input variable and the economic productivity index for the output variable. To determine the impact on the environment, physical indices are used, but monetary indices, e.g., sales and the like, are used for the economic index (Table 4-1).

Table 4-1. Assessment of eco-efficiency

Category	Output index (y)	Input index (x)
Type	. Sales(or sale price) . Yield . Productivity . Annual profit	. Unit element (energy, resources, water, land, waste, etc.) . Collective element (Collective impact on the environment)
Assessment category	Production process (gate to gate) Upper process (cradle to gate) Entire process (cradle to grave)	

Source: Soo-Yeol Lee (2004), some of the data was added on the basis of p.4.

An international conference on “Eco-Efficiency for Sustainability: Quantified Methods for Decision Making” was held at Leiden University in the Netherlands, in 2004. The purpose of the conference being further study on the calculation of eco-efficiency indices and to share information so as to establish a methodology (Huppes and Ishikawa, 2007).

Generally, eco-efficiency is represented as a ratio of economic performance and an environmental load of a product. However in a scenario where the environmental load is not reduced but economic performance is improved, the eco-efficiency of the relevant product increases, causing problems in precisely assessing the environmental performance. The Factor-X (shown in equation 2) was proposed to solve such problems.

$$FX = \frac{EE_r^t}{EE_r^0} \qquad (2)$$

wherein EE_r^t: eco-efficiency at the comparison time (t) and EE_r^0: eco-efficiency at the reference time (0)

For measuring efficiency with respect to multi-inputs and multi-outputs, a process is necessary for calculating the aggregate input (where a weight is given to a plurality of input elements) and the aggregate output (where a weight is given to a plurality of outputs). DEA (Data Envelopment Analysis) as developed by Charnes, Cooper, and Rhodes (1978) is generally used for assessing the eco-efficiency of a production organization (which uses a plurality of outputs and a plurality of input elements) in which both desirable outputs and undesirable byproducts acting as environmental pollutant are produced. DEA was proposed as a management science technique and is widely used as a tool for measuring the efficiency of a decision making unit, analyzing causes of inefficiency and also setting a target of efficiency improvement.

Since the mid-1990s, many researchers have studied the application of eco-efficiency methodologies to the agricultural sector (McGregor *et al*., 2003, Maxime *et al*., 2006, Meul *et al*., 2007, etc.). McGregor *et al*. (2003) utilized a system-based approach to eco-efficiency, using LCA (Life Cycle Analysis) to study grains in Australia. LCA in the grain sector in Australia is utilized to analyze the environmental load which occurs in the entire process from production to consumption of processed grain products. Maxime *et al*. (2006) analyzed eco-efficiency, using an intensity index for addressing environmental issues, e.g., consumption of energy, emission of greenhouse gases, use of water and discharge of sewage, residues, packaging waste, etc., for the sector of food and beverage in Canada. Meul *et al*. (2007) combined nitrogen use efficiency with energy use efficiency for the dairy sector in Finland to analyze eco-efficiency in the dairy sector. The result of analysis showed that good farms of higher eco-efficiency produced 29% higher added value as compared to other farms.

1.2. Eco-efficiency analysis of organic agriculture

1.2.1. Method and data of analysis

In order to compare the eco-efficiency of organic agriculture, promoted as the core task of green growth, with the eco-efficiency of conventional agriculture, the nitrogen efficiency is measured. The method of analyzing the nitrogen efficiency of organic agriculture is to measure the amount of total income derived from organic agriculture and the amount of nitrogen input then to divide the total income by the amount of nitrogen, as shown in equation 3.

$$EE_r = \frac{Inc_r}{N_r} \tag{3}$$

wherein EE: eco-efficiency, r: r'th farmer for organic farming, r = 1, 2, ..., k, N: amount of input nitrogen, Inc: amount of income.

In order to analyze the eco-efficiency of organic agriculture, questionnaire data (Aug. 20 to Sep.30, 2009) was used. The questionnaire sample was 32 farmers who produce organic rice on rice/duck farms in Hongdong-myun, Hongseong-goon, Choongnam. This area is well known for organic agriculture in Korea. The data showed revealed that the average age of the farmer respondents was 56.3 years old; their average years of schooling amounted to 12.1 years, a period that signified at least a high school education; the number of years practicing environment-friendly agriculture was 9.7 years on average; they were trained for organic agriculture on average 3.8 times per year; and the average area devoted to growing organic rice farming was 5,017 pyung (shown in Table 4-2).

Table 4-2. Data for farmers who produce organic rice.

Category	Average	Standard Deviation	Lowest	Highest
Age(years)	56.3	8.3	39	70
Education (years)[1)]	12.1	3.1	6	16
Years of practicing environment-friendly agriculture	9.7	4.2	2	20
Frequency of training for organic agriculture (times/year)	3.8	2.5	1	15
Area for organic agriculture farming (3.3m^2)	5,017	3,195.4	1,500	14,000

Note: 1) Average of elementary school education= 6 years, middle school education= 9 years, high school education= 12 years, university education= 16 years.

In order to analyze the eco-efficiency of conventional agriculture, it is necessary to utilize questionnaire data for farmers who practice conventional agriculture. However, data from Choongnam concerning the volume of main inputs to paddy rice in each county for 2008 was already available from the publication 'Statistics of Farm Product Production Cost' by Statistics Korea. This data was used instead due the limited amount of available data. The statistics data for production cost in each county includes management outcome data, e.g., the volume of main inputs, yields, sale price, etc.

1.2.2. Result of analysis

The basic data for analyzing eco-efficiency includes such variables as the ratio of nitrogen content in oil cake fertilizer, top soil, animal manure, cattle manures and rice bran the last three which are the input materials applied to organic farming (Table 4-3). The ratio of nitrogen contents of oil cake fertilizer was 4.2%, considering the weight of each use with respect to the ratio of nitrogen contents in oil cake fertilizer applied to the case area. Top soil is the top layer of soil for a rice seedbed and organic top soil is specified not to contain nitrogen. Animal manures (muck) are one form of organic fertilizer and this had a value of 0.065%, a median of 0.06 and 0.07%, according to expert's advice from the Rural Development Administration (RDA). With respect to the ratio of nitrogen contents in cattle manure and chicken manure, cattle manures had a value of 2.06% and chicken manures a value of 5.10% calculated on the basis of dry weight. However, farmers use the mixture of cattle and chicken manures supplemented with rice bran, sawdust, etc.[22]

Table 4-3. Ratios of nitrogen contents input to organic agriculture

Source of organic matters		Ratio of nitrogen contents (%)
Oil cake		4.20
Top soil		0.00
Animal manure (muck)		0.65
Cattle manure		0.80
Chicken manure		2.00
Rice bran (rice bran oil cake)		2.00
Green manures	Hairy vetch	0.60
	Astragalus sinicus	0.42
	Green barley	0.23
	Rye	0.15

[22] The nitrogen content ratio was estimated with 0.08% for cattle manures and 2.0% for chicken manures according to the RDA expert's advice. The nitrogen contents of rice bran oil cake are 2.0%, those of dry green manures are 3.5 to 4.0% for hairy vetch, 2.08% for astragalus sinicus, 1.4% for green barley and 1.0% for rye, according to the 'Fertilizer Process Specification'.

The data for the ratio of nitrogen contents of inputs used to calculate the amount of nitrogen used in conventional agriculture is sourced from the 'Fertilizer Process Specification' of RDA' and the fertilizer component data is sourced from the Korea By-product Fertilizer Association. Some of this data was also prepared with the assistance of experts at in the National Academy of Agricultural Science (Table 4-4). The ratio of nitrogen contents in nitrogenous urea and ammonium sulfate were 45% and 20%, respectively, and other nitrogenous component were 33% which is an average component ratio of urea and ammonium sulfate. Since phosphate and potassium soil inputs are not guaranteed to contain a nitrogen component, 0.0% was applied. For compound fertilizer, the ratio of nitrogen contents in 21-17-17 was specified as 21%, 17-21-17 as 17%, and other compound fertilizers as 19% which is an average component ratio of the aforementioned two component ratios. For organic fertilizers, applied ratios were 0.65% for organic materials, 1.0% for green manures and 1.0% for wild grasses according to RDA experts. For ash, 0.0% was applied since they have a virtually zero nitrogen component. For human manures, 1.84% was applied which is half of the 3.68% for pig manure, on the basis of dry weight. The known ratios of other organic fertilizers used in conventional agriculture include 60% to 70% for livestock manure and home-made compost, 25% to 35% for commercial compost and approximately 5% for oil cakes and others (data from Korea By-product Fertilizer Association). Therefore, a value of 0.94% was applied for the ratio of nitrogen contents in other organic fertilizer. The ratio of nitrogen contents was shown to be 0.94% by applying the weight of use ratio for each type of compost for conventional rice farming in the area for analysis.

Table 4-4. Ratios of nitrogen contents used in conventional agriculture

Input		Ratio of nitrogen contents (%)
Nitrogen	Urea	45.00
	Ammonium sulfate	20.00
	Others	33.00
Phosphate	Triple superphosphate	00.00
	Fused phosphate fertilizer	00.00
Potassium	Potassium chloride	00.00
Compound fertilizer	21-17-17	21.00
	17-21-17	17.00
	Others	19.00

Input		Ratio of nitrogen contents (%)
Soil conditioner	Lime	00.00
	Silica	00.00
Organic fertilizers	Muck	00.65
	Green manures	01.00
	Wild grasses	01.00
	Ashes	00.00
	Human manures	01.84
	Others	00.94

The ratios of nitrogen contents calculated in the table above were multiplied by the amount of input used in organic agriculture and conventional agriculture so as to arrive at an the amount of nitrogen used. The result of calculation for nitrogen used produced the following figures: 13.4kg per 10a in organic agriculture and 20.6kg per 10a in conventional agriculture (see Table 4-5).

The yield of rice/10a and the price of sold rice/kg produced by organic farming were 582kg and 1,918 won, respectively, resulting in a total farmer income per 10a of 1,117,000 won. Making the assumption that there is no difference in the varieties grown in organic rice farming, the yield of production/10a was thus calculated. The yield of rice/10a by conventional rice farming in the Choongnam province was 734kg (husked rice) from Korea Statistics 2008 publication of the 'Survey of Produced Farm Products'. Income/10a for conventional rice farming was calculated by using the same publication. The data showed that the total income of a conventional farmer in the Choongnam province was 1,058,000 won/10a. The sale price was calculated by dividing the total income by the rice yield and resulted in a value of 1,442 won/kg.

The eco-efficiency index is an index of the environmental burden ratio with respect to economic performance. Thus the eco-efficiency of organic agriculture and conventional agriculture was calculated by means of the following equation: 'total income/the amount of used nitrogen'. The eco-efficiency index of organic agriculture was 83.4, 32.0 index points higher than the eco-efficiency index of conventional agriculture at 51.4. If the measurement for the level of environmental burden is confined to the amount of used nitrogen, the analysis shows that organic agriculture contributes considerably more to green than conventional agriculture.

Table 4-5. Comparison of eco-efficiency index of organic agriculture and conventional agriculture

	Amount of used nitrogen (kg/10a)	Yield (kg/10a)	Sale price (won/kg)	Total income (1,000 won/10a)	Eco-efficiency index
Organic agriculture (A)	13.4	582	1,918	1,117	83.4
Conventional agriculture (B)	20.6	734	1,442	1,058	51.4
A-B	-7.2	-151.7	476.0	58.7	32.0

1.3. Analysis and comparison of eco-efficiency and technical efficiency in organic farming

1.3.1. Model and data for analyzing technical efficiency

In order to analyze the technical efficiency of farmers practicing organic farming, a nonparametric method, in this case DEA (Data Envelopment Analysis), was applied. DEA is a useful method for comparing management organizations. DEA provides a measurement of efficiency of each organization given that they are pursuing similar objectives, and are producing a plurality of products from a plurality of input elements. It can thus be used to provide direction to an organization that assessment has shown to be inefficient.

The technical efficiency of input orientation is estimated for the analysis focusing on the excessive input problem of farmers practicing organic agriculture.

The estimate of technical efficiency in terms of input orientation is then made, considering that the level of output has been determined in advance. Given input vector X and the output vector Y, the possible set of production is calculated as in equation 3 below. It assumes CRS (Constant Returns to Scale) and SDI (Strong Disposability of Inputs).

$$L(y/C,S)=x : y \leq \lambda Y,\ \lambda X \leq x, \lambda \in R^{J}_{+} \tag{3}$$

x: input of a farmer *y*: output of a farmer
X: input of a compared group, *Y*: output of a compared group
λ: potential price, *C*: *CRS*, *S*: *SDI*

The linear programming model for measuring technical efficiency in terms of input takes the form of equation 4 in the vector type.

$$Min\theta_j = TE_I\left(y^j, x^j \middle| C, S\right) \quad (4)$$

$$\text{s.t.} \quad y^j \le \lambda Y$$
$$\lambda X \le \theta_j x^j$$
$$\lambda \in \mathrm{R}^J_+$$

For measuring the efficiency of farmers who produce organic rice in Hongseong-goon area, the nonparametric method was modified so as to use the total income of farmers who produces organic rice, the amount of organic rice/10a as a yield variable, the cost of organic fertilizer, the cost of organic agricultural materials, the cost of labor and the amount of used nitrogen as input variables. The analysis was carried out for 30 farmers who produce organic rice in the Hongseong-goon area. In this case, the linear programming model for calculating technical efficiency of j'th farmer in the Hongseong-goon area is as shown in equation 5 below. Here, λ_j is the weight applied to the *j*"th farmer to modify the farmer's yield or inputs so as to achieve piecewise linearization.

$$Min\theta_j \quad (5)$$

$$\text{s.t.} \quad y_{jm} \le \sum_{j=1}^{I} \lambda_j y_{jm}, m = 1, 2, \ldots, M$$
$$\sum_{j=1}^{I} \lambda_j x_{jn} \le \theta_j x_{jn}, n = 1, 2, \ldots, N$$
$$\lambda_j \ge 0, j = 1, 2, \ldots, J$$

1.3.2. Result of analysis

The results of analyzing technical efficiency of the 30 farmers who produce organic rice in the Hongseong-goon area showed that nine farmers were technically efficient. These nine farmers formed an efficiency frontier and the efficiency relative to these nine farmers was determined for the remaining 21 farmers. The average technical efficiency was found to be 0.795 which then holds out the possibility for a 21% improvement in management (Table 4-6).

Table 4-6. Level of input and output of technical efficiency for farmers practicing organic farming

Unit: Thousand won, kg/10a

Distribution of technical efficiency	Farmer No.	Technical efficiency	Output element		Input element				Eco-efficiency index
			Total income	Yield	Cost of organic fertilizer	Cost of organic farming material	Cost of labor	Amount of used nitrogen	
Group A (1.0)	F3	1.000	1,538	600	112	28	304	15.64	98
	F4	1.000	1,097	572	6	52	106	9.60	114
	F7	1.000	1,115	594	74	81	357	4.18	266
	F13	1.000	1,125	600	57	50	311	4.49	250
	F15	1.000	1,110	592	39	26	286	14.35	77
	F18	1.000	1,125	600	176	29	165	18.57	61
	F21	1.000	1,385	659	78	39	122	18.33	76
	F24	1.000	1,500	800	80	47	362	15.62	96
	F25	1.000	1,572	786	21	142	70	14.59	108
	Average	1.000	1,285	645	71	55	231	12.82	100
Group B (0.7～less than 1.0)	F29	0.976	1,224	720	69	69	384	5.73	214
	F16	0.968	1,218	650	81	77	206	8.82	138
	F11	0.877	1,116	582	107	38	144	18.04	62
	F26	0.851	1,116	582	70	47	227	12.95	86
	F9	0.779	921	491	95	36	240	14.00	66
	F10	0.761	988	521	96	37	286	15.16	65
	F28	0.753	1,266	675	39	59	304	22.35	57
	F2	0.750	1,234	660	52	57	426	16.28	76
	F1	0.741	1,049	561	105	58	209	13.98	75
	F30	0.741	1,125	600	121	91	175	12.72	88
	F22	0.716	1,120	578	76	64	377	8.92	126
	F5	0.713	875	468	26	45	206	20.75	42
	F23	0.701	1,095	584	37	74	258	11.09	99
	Average	0.794	1,104	590	75	58	265	13.91	79

Distribution of technical efficiency	Farmer No.	Technical efficiency	Output element		Input element				Eco-efficiency index
			Total income	Yield	Cost of organic fertilizer	Cost of organic farming material	Cost of labor	Amount of used nitrogen	
Group C (less than 0.7)	F20	0.681	1,120	597	108	82	177	14.28	78
	F6	0.633	1,101	527	83	65	164	19.01	58
	F27	0.630	1,013	540	101	60	675	11.34	89
	F19	0.581	794	424	182	46	350	12.41	64
	F14	0.566	928	495	61	77	172	15.08	62
	F17	0.540	800	429	115	63	289	11.46	70
	F12	0.455	701	374	92	61	371	10.80	65
	F8	0.422	688	357	99	83	142	17.20	40
	Average	0.564	893	468	105	67	292	13.95	64
Group average		0.795	1,102	574	82	60	262	13.59	81

It was shown that, as the level of technical efficiency is higher, the level of output is likewise higher while the level of input is lower. The most efficient group (nine farmers) were 1.17 times and 1.12 times the entire group in terms of total income and output, however their level was lower than the average of all farmers in terms of the cost of organic fertilizer, the cost of organic agricultural materials, the cost of labor and in the amount of nitrogen used. That is, the analysis shows that group of nine farmers displaying higher technical efficiency are producing more in terms of income but also producing less of an environmental burden.

A comparison between the indices of technical efficiency and eco-efficiency shows higher technical efficiency level groups exhibit higher eco-efficiency indices. In particular, a farmer of higher eco-efficiency in Group A is considered to be a farmer at a high level of environment-friendly agricultural technology on the basis of nutrient management. The eco-efficiency indices of the classified groups were Group A (1.0) 100, Group B (0.7~less than 1.0) 79, and Group C (less than 0.7) 64, respectively.

1.4. Analysis of eco-efficiency of geothermal cooling and heating

1.4.1. Method and data of analysis

It is necessary to analyze the eco-efficiency of geothermal heat pump systems due to the fact that the use of geothermal heat pump systems were chosen as part of a new program for promoting the green growth of the agricultural sector. The eco-efficiency of a geothermal system is analyzed, as in equation (6), by dividing the geothermal systems level of production by the amount of energy consumed. The eco-efficiency of an oil heating system is calculated in the same manner as for the geothermal system.

$$EE_r = \frac{P_r}{E_r} \tag{6}$$

wherein EE: eco-efficiency, r: r'th farmer applying geothermal heating, r = 1, 2, ..., k; E: amount of consumed energy, and P: amount of production.

Paprika cultivation farmers applying the geothermal system were interviewed for purpose of collecting data to be used in analyzing eco-efficiency (Table 4-7). The type of geothermal cooling and heating systems used is a vertical closed loop type by 7 farmers and the hybrid type, the vertical open loop type and the horizontal closed type by one farmer each. With respect to the greenhouses used, eight farmers used a Venlo-type greenhouse, and two farmers used a vinyl greenhouse. All of the farmers interviewed have applied hydroponics. The area serviced with a geothermal cooling and heating system was on average 11,637m^2 (3,526 pyoung), the cost of installation was on average 1,212,300,000 won, and the capacity of the system was 269RT.

In order to analyze the eco-efficiency of an oil heating system, questionnaire data should be obtained from farmers who apply the oil heating system, so that a comparison could be made with the geothermal system. To reduce the effort involved in such a survey, the management performance data of the oil heating system used by the ten selected farmers was recorded prior to the installation of their geothermal systems. In order to obtain a fixed cost for the oil heating system, the fixed cost data of the RDA's oil heating system was used. This was due to the fact that the period in which oil heating was applied varied greatly depending on the farmer it was thus difficult to obtain accurate data.

Table 4-7. Details of geothermal heat pumps of farmers who applied the system

No.	Type	Area (m^2)	Cost of installation (10 thousand won)	Capacity (RT)
Farmer 1	vertical closed loop	9,900	100,000	320
Farmer 2	vertical closed loop	26,730	270,500	600
Farmer 3	hybrid	22,770	200,000	450
Farmer 4	vertical closed loop	11,362	155,400	300
Farmer 5	vertical closed loop	14,652	194,900	390
Farmer 6	vertical closed loop	6,930	66,400	140
Farmer 7	vertical closed loop	5,544	53,100	103
Farmer 8	vertical closed loop	8,580	88,000	190
Farmer 9	vertical open	4,950	42,000	100
Farmer 10	horizontal closed loop	4,950	42,000	100
Average		11,637	121,230	269

Source: Result of survey for sample farmers by Korea Rural Economic Institute (2010).

1.4.2. Result of analysis

To calculate the amount of emitted CO_2 resulting from the use of both electricity and oil, it is necessary to know the coefficient of CO_2 for each type of energy. The result of calculating the coefficient of the emitted CO_2 for both systems revealed that the geothermal heating system had emitted 71,416kg of CO_2 while the oil heating system had emitted 79,638kg of CO_2. It was thus shown that the geothermal system had produced 10.3% less CO_2 than the oil fired system.

Table 4-8. Coefficient of CO_2 emission for each type of energy

Category	TOE (10^{-3}TOE/each unit)	Coefficient of carbon emission (tonC/TOE)	Carbon (kg C)	CO_2 (kg CO_2)
Crude oil (kg)	1.010	0.829	0.837	3.07
Diesel (l)	0.845	0.837	0.707	2.59
LNG (Nm^3)	0.955	0.637	0.608	2.23
Electricity (kWh)	0.215	-	-	-

Note: TOE is a unit specified by the International Energy Agency (IEA), and defined as 107kcal. In TOE conversion, the gross calorific values of energy conversion factors/oil equivalent (Framework Act on Energy) is used for conversion, but IPCC recommends that net calorific values be applied when calculating the amount of emitted CO_2.

Source: Gross calorific values of energy conversion factors/oil equivalent (Article 5, Paragraph 1 of Framework Act on Energy), MKE (Ministry of Knowledge Economy), IPCC, Carbon Emission Factors.

An investigation was carried out for each farmer's gross income, fixed costs, energy usage, energy consumption, additional management cost, etc., both prior to and after installation of geothermal heat pumps (Table 4-9). The result for the production values showed 55,627,000 won for geothermal heating and significantly less, at 48,911,000 won, for oil heating. The fixed cost was 12,615,000 won for geothermal heating and 677,000 won for oil heating, again indicating a significant difference, given the 100% payment by farmers themselves. However, the difference significantly decreased when a smaller percentage of this cost was paid for by the farmers themselves.

A comparison of energy usage for heating revealed 930,500MJ for geothermal heating, however the figure for oil heating was greater at 1,179,600MJ. The energy cost was shown to be 7,217,000 won for geothermal heating and 18,535,000 won for oil heating, indicating that the cost of geothermal heating was 61.0% lower than oil heating. Additional management cost was shown to be applied only to geothermal heat pumps which incur an additional cost as it was used over a longer period. The additional management costs were 4,281,000 won for labor, 1,047,000 won for the hydroponic solution and agricultural chemicals, 922,000 won for materials the sum of which was 6,250,000 won in total. The operating cost was revealed to be 26,082,000 won for geothermal heating but less at 19,212,000 won for oil heating, given that farmers using geothermal heating were liable for 100% payment by. However levels of payment below 100% by farmers themselves would result in higher operating cost for oil heating.

Table 4-9. Comparison of management performance for each system (per 10a)

		Geothermal cooling/heating		Oil heating	
Gross income	yield(kg)	1,854.2	(100)	1,630.4	(88)
	Production value (1,000 won)	55,627	(100)	48,911	(88)
Fixed cost (1000 won)	Fixed cost I (100% payment by farmers)	12,615	(100)	677	(5)
	Fixed cost II (50% payment by farmers)	6,308	(100)	339	(5)
	Fixed cost III (20 % payment by farmers)	2,523	(100)	135	(5)
Energy consumption	Energy consumption (100MJ)	930.5	(100)	1,179.6	(127)
	Oil (L)	300.9	(100)	2,170.7	(721)
	Electricity (kWh)	14,302.2	(100)	5,248.8	(37)
Energy cost (1000 won)	Energy cost (1,000 won)	7,217	(100)	18,535	(257)
	Oil (1000 won)	2,091	(100)	16,852	(806)
	Electricity (1,000 won)	5,125	(100)	1,683	(33)
CO_2 emissions		7,141.6	(100)	7,963.8	(112)
Additional management cost	Labor (1,000 won)	4,281	(-)		(-)
	Hydroponic solution, agricultural chemicals (1,000 won)	1,047	(-)		(-)
	Materials (1,000 won)	922	(-)		(-)
Sum of operating cost I (fixed cost I+energy value +additional management cost)		26,082	(100)	19,212	74
Sum of operating cost II (fixed cost II+energy cost+additional management cost)		19,774	(100)	18,874	95
Sum of operating cost III (fixed cost III+energy cost+additional management cost)		15,989	(100)	18,671	117

Note 1) Energy consumption is converted into the MJ unit, by means of the conversion factors of 40.68 for diesel and 5.65 for electricity according to Meul, M., *et al*. (2007).

2) The amount of emitted CO_2 was calculated by means of the CO_2 emission factor for diesel and electricity.

3) The fixed cost was calculated for each farmer's detailed cost of installation according to RDA's 'Guidebook to Protected Horticulture (2009). Depreciation expense was calculated with 10 years of service life for facility materials and 20 years for machines. For repair cost, 5% of the machine cost was applied and 5% of the installation cost was applied for the fixed capital interest.

Source: Result of survey for farmers by Korea Rural Economic Institute (2010).

The total benefit of cooling and heating by geothermal heat pumps was calculated for increases in production values and decreases in expenses for each effect (Table 4-10). The effect of both of cooling and heating in the case of a 50% payment by farmers themselves was 5,815 thousand won and the effect was 5,3491 thousand won only for heating effect. However, it was shown that total benefit to the farmer was reduced in instances where farmers had no government support.

Table 4-10. Calculating total benefit for cooling and heating effects (per 10a)

Unit: Thousand won

		Increase in production value	Decrease in expenses	Total
100% payment by farmers	Effect of cooling and heating	6,716	6,869	-154
	Effect of heating		-620	-620
50% payment by farmers	Effect of cooling and heating	6,716	-900	5,815
	Effect of heating		5,349	5,349
20% payment by farmers	Effect of cooling and heating	6,716	2,681	9,397
	Effect of heating		8,931	8,931

Note: 1) Increase in production values represents the increase by heating with geothermal heat pumps.
2) The effect of cooling and heating for decrease in expenses indicates a difference in operating cost of two types of systems, and the effect of heating represents a difference in operating cost except the additional management cost.

Table 4-11 shows the result of the calculation of the eco-efficiency indices of geothermal heat pumps and oil heating. The eco-efficiency index calculated by dividing the production value by energy cost was 7.71 for geothermal heating and 2.64 for oil heating.

Table 4-11. Eco-efficiency index of each system

	Geothermal heat pump	Oil heating	Increase/Decrease
Production value/energy cost	7.71	2.64	5.069
Yield/energy use	1.99	1.38	0.611

1.5. Suggestions from and limitation of eco-efficiency analysis

The eco-efficiency index of organic agriculture is shown somewhat higher than that of conventional agriculture. Farmers of higher technical efficiency were shown to be of a higher eco-efficiency index as well. Interpreting the data reveals that organic agriculture contributes more to green growth than does conventional agriculture. Therefore, it is necessary to more positively enforce the policies for expanding environment-friendly agriculture (including organic agriculture). The Korean Government is promoting organic agro-food policies as a core task for green growth, which is considered to be a very desirable direction. Therefore, it is necessary to prepare more stable organic agricultural production bases and to produce more processed foods from organic farming output in order to create demand for organic farm products.

This analysis revealed that the total economic benefit of geothermal heat pumps is greater than that for oil heating systems and also greater on the eco-efficiency index.

A reduction in energy consumption by means of the installation of geothermal heat pumps is very significant in terms of national energy security. Therefore, it is necessary to encourage farmers to use geothermal heat pumps in addition to renewable energy as a part of green growth. As the cost of materials for facilities and the cost of oil continue to rise, farmers growing in protected facilities will be under increasing pressure to reduce management costs. Therefore, it is also necessary to stabilize management costs by popularizing geothermal heat pumps. However appropriate support measures for farmers are necessary for while renewable energy technology, e.g., geothermal heat pumps, gives economic benefit, the up front installation cost is very high.

In this chapter, an analysis was carried out to determine the eco-efficiency of organic agriculture and geothermal heat pumps. However there are some limitations to this analysis. This is due to the fact that diversified indices can be used as an index to describe both economic performance and environmental burden. This means that a slightly different result will be indicated depending on which index is used. Since it is assessed only according to the ratio of economic performance to environmental burden, those cases where the an increase in the absolute value for environmental burden may be overlooked. That is, an improvement of eco-efficiency cannot indicate the weighted environmental burden, which sometimes exceeds the capacity of environment in analyzing eco-efficiency. Despite such a limitation, the eco-efficiency index is generally used as an index which considers both economic performance and the environmental burden.

2. Marginal Abatement Cost Analysis of Green Growth Countermeasures

Green growth in the agricultural sector can be promoted by various means. Such means include improving the soil for cultivation, improving energy efficiency, using biomass, the application of advanced agricultural technology, etc. However, given that budgets are limited, it is necessary to first promote the most economically efficient abatement means so as to achieve the national objective of abating greenhouse gases. In such a case the Analysis of Marginal Abatement Cost (Marginal Abatement Cost, MAC) is applied. This is defined as the additional expense of abating one unit of greenhouse gases. Such an analysis will allow for the prioritizing of the aforementioned most cost-effective means of abatement. Here, the case in another country (UK) will be described and a possible means for a Marginal Abatement Cost analysis will be calculated for the agricultural sector in Korea.

2.1. Overview of Marginal Abatement Cost Curve

The Marginal Abatement Cost (MAC) is defined as the additional expense required for abating one unit of a greenhouse gas. It is also used as the price of an emission in the emissions trading market. For example, the additional abatement cost (marginal cost) required for abating one ton of CO_2 is calculated by deducting the energy cost for the reduction of a ton of carbon by means of the selected technology taking into account the capital investment cost and annual maintenance cost.

$$A = C - EP \tag{7}$$

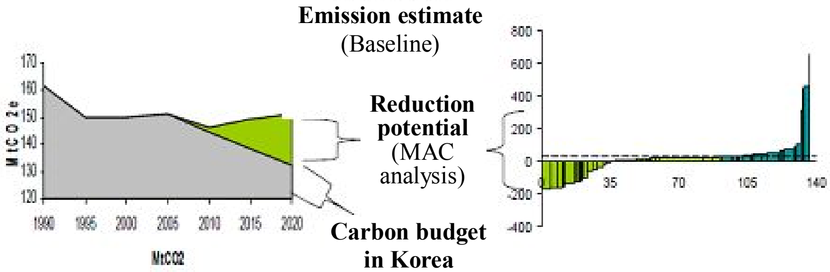
wherein A: additional abatement cost required to abate one ton of CO_2;

C: capital investment cost and annual maintenance cost additionally required to abating one ton of CO_2, *EP*: decrease in energy cost per ton of carbon by selecting technology for taking measures

MAC is a cost input for abating an additional unit of greenhouse gases. In other words the MAC serves as a crucial decision making criteria. If the sign of ablation cost is negative, it is classified as a ‘No regret’ measure; that is the reduction in costs due to energy saving sufficiently compensates for the initial investment cost or operating cost. MAC analysis shows the relation between cost and reduction potential by analyzing the various measures for abating greenhouse gases and the data related to each measure in a bottom-up manner in each sector. MAC analysis assists in identifying the most cost-effective measures for achieving the objective of emission reduction in each sector and in determining the level of efficient emissions.

The carbon budget in Korea is derived from Marginal Abatement Cost Curve (MACC). The series of bars and their height displayed in the right graph below, in Figure 4-1, shows a MAC curve where cost effectiveness and options for abatement are arranged in a descending order from left to right. That is, the options placed on the left of the curve and beneath the x-axis represent a desirable negative cost or social benefit, and those bars on the right side of curve and above the x-axis represent an undesirable social cost. MACC allows this comparison of technologies and options on a limit basis. In addition, the width of each bar represents the abatement potential of the option.

Figure 4-1. Derivation of MACC from the carbon budget



MACC calculates the average of abatement potential and cost effectiveness by various methods (Figure 4-2). The level of the carbon price affects producer and consumer activities, that is, the net emissions of greenhouse gases, farm production, siting, methods of cultivation, etc.

Figure 4-2. Marginal Abatement Cost Curve

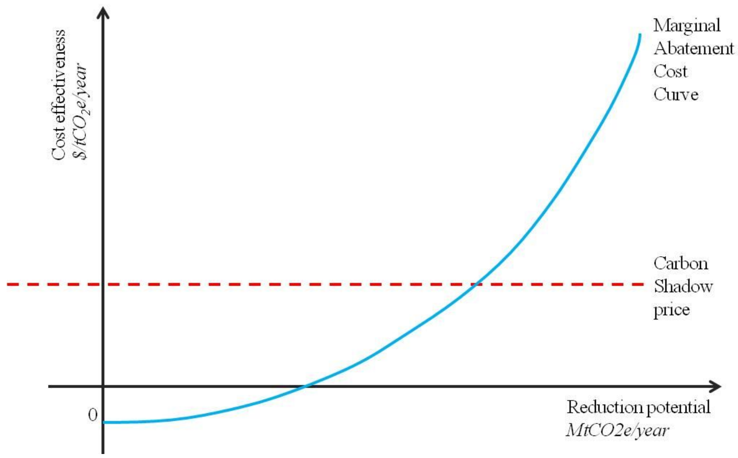
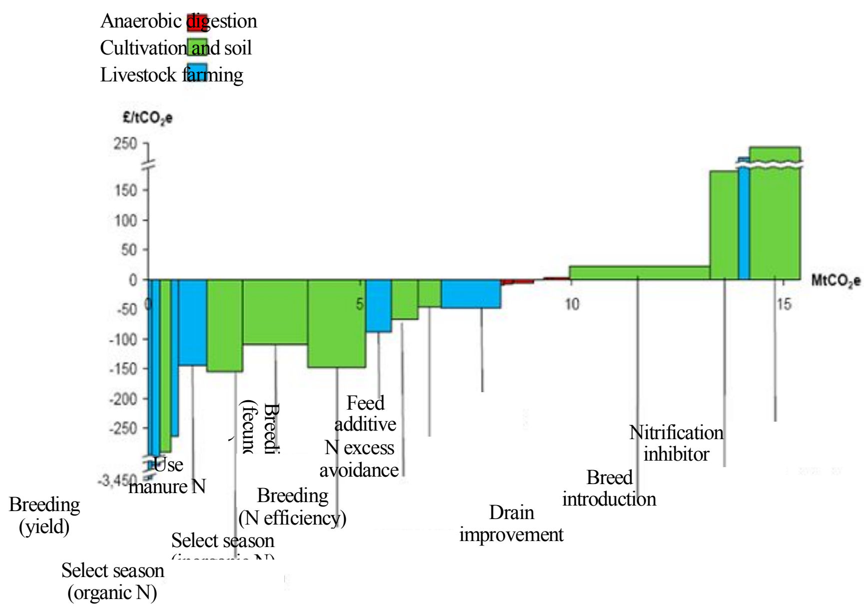


Figure 4-3. Comparison of MACC for alternatives : cases in the agricultural sector



Source: McKinsey & Company (2009).

The agricultural sector can apply MACC analysis for method of abating greenhouse gases abatement, e.g., no-till farming, nutrient management, conservation-tillage farming, organic soil management, land cover, waste management, rice cultivation, management of livestock waste, organic agriculture, etc (Figure 4-3). The MACC so derived can be used for prioritizing the cost-effective of abatement measures, and for providing the basic data in determining policies. Furthermore, if there is a MACC in other sectors, it is possible to compare the relative cost effectiveness of abatement within the agricultural sector with other sectors.

2.2. Case of deriving MACC in UK

The UK has set an ambitious national goal for abating emitted greenhouse gases by 80% by 2050 (compared to 1990) and has established the CCC (Committee on Climate Change) to allocate abatements. The UK's CCC recognized the necessity of pursuing economically efficient forms of emission abatement, and so employed the MACC approach from the bottom-up. The MACC derived by the UK's CCC shows the list of abatement measures in order of their expense (per unit of CO_2).The abatement measures also show additional abatement activities which are predicted to occur when normal economic growth is achieved. MACC also describes the CE (Cost Effectiveness) or cost benefit assessment of each of the measures, and the benefit of damage avoidance by emitted carbon reduction is represented by the SPC (Shadow Price of Carbon) developed by Defra (2007).

MACC is derived first by identifying the abatement or reference emission estimates in 2012, 2017 and 2022 when that economic growth is achieved. The possibility of additional abatement exceeding the abatement estimate within the framework of the business as usual (BAU) scenario in each period is then identified. This is achieved by comparing the measures for abatement with BAU abatement, the measures which comprise the scenarios against their maximum technical possibility with and low, intermediate and high feasibility. Cost-effectiveness is quantified by comparing each measure contributing to additional abatement in each period with the maximum technical abatement and the process outlined in Table 4-12 below. (based on the countermeasure inventory, existing data, examination by expert groups, etc.) in £(/tCO_2).

Table 4-12. Process of quantifying cost-effectiveness

Category	Description
STEP I	Quantification of cost, benefit and their periods
STEP II	Calculation of net present value, using discount rates
STEP III	Indication of cost in ₤ 2006
STEP IV	Listing details of cost used in calculating cost-effectiveness
STEP V	Identifying possibility of worldwide potential effect of emission by the measures

After finishing the quantification of cost-effectiveness, derive the initial changing discount rate of MACC in order to produce a social, private and mixed matrix. Then identify the decreased/increased cost-effectiveness by means of an interaction among the policy and technical measures and then adjust their cost-effectiveness taking into consideration the granularity of MACC for reflecting different average costs. Derive MACC again. First, identify the feasible level of application to quantify feasible potential by means of intermediate, low and high levels of prediction on the basis of examination of observance/application levels in relation to existing policies. Lastly, analyze the feasible potential by means of DA (Devolved Administration) and gases, report it in a summary form and then review independent MACC.

Table 4-13 shows exemplary average CFP (Central Feasible Potential) estimated for 2022. The measure of greatest cost effectiveness is gene improvement in the management of beef cattle farming which is -3,603 ₤ (/tCO_2e). The next is the use of an agent to regulate fermentation in the stomachs of ruminants, in beef cattle, -1,748 ₤ (/tCO_2e). Abatement from crop-soil tillage, -1,053 ₤ (/tCO_2e) is next. The least cost effective measure is biological N-fixation of crops-soil which is 14,280 ₤ (/tCO_2e). The measures which could provide the highest quantity of abatement are drainage of crops-soil at 1,741ktCO_2e, followed by the selection of mineral N periods of crops-soil at 1150ktCO_2e and the selection of organic N periods of crops-soil at 1,027ktCO_2e, respectively.

Table 4-13. Abatement potential in 2022: Estimates for average feasibility

Code	Measures	Abatement for each measures (ktCO_2e)	Progressive abatement (ktCO_2e)	Cost effectiveness (₤2006/tCO_2e)
CE	Management of beef cattle farming – fermentation regulating agent for ruminant stomachs	347	347	-1,748
CG	Management of beef cattle farming –gene improvement	46	394	-3,603

Code	Measures	Abatement for each measures ($ktCO_2e$)	Progressive abatement ($ktCO_2e$)	Cost effectiveness (£2006/tCO_2e)
AG	Selection of crops-soil-mineral N periods	1,150	1,544	-103
AJ	Selection of crops-soil-organic N periods	1,027	2,571	-68
AE	crops-soil- aged livestock manures	457	3,029	-149
AN	Crops-soil tilling abatement	56	3,084	-1,053
BF	Management of dairy farming -productivity improvement	377	3,462	0
BE	Management of dairy farming -fermentation regulating agent for ruminant stomachs	740	4,201	-49
BI	Management of dairy farming -improvement of breeding	346	4,548	0
AL	Crops-soil- cultivation by using improved N	332	4,879	-76
BB	Management of dairy farming -corn silage	96	4,975	-263
AD	Crops-soil- evasion of nitrogen excess	276	5,251	-50
AO	Crops-soil- use compost	79	5,330	0
AM	Crops-soil-delay sludge mineral N	47	5,377	0
EI	Anaerobic digestion of farms –pigs (large)	48	5,425	1
EF	Anaerobic digestion of farms –cattle (large)	98	5,523	2
EH	Anaerobic digestion of farms –pigs (middle)	16	5,539	5
EC	Anaerobic digestion of farms -dairy farming (large)	251	5,790	8
HT	Concentrated anaerobic digestion –chicken (5mW)	219	6,009	11
AC	Crops-soil-drainage	1,741	7,750	14
EE	Anaerobic digestion of farms –cattle (middle)	51	7,801	17
EB	Anaerobic digestion of farms -dairy farming (middle)	44	7,845	24
AF	Crops-soil-introduce varieties	366	8,211	174
BG	Management of dairy farming -growth hormone of cattle breeds	132	8,343	224
AI	Crops-soil-nitrification inhibitors	604	8,947	294
AH	Crops-soil-regulate fertilizer release	166	9,113	1,068
BH	Management of dairy farming -genetic transformation	504	9,617	1,691
AB	Crops-soil-abatement of N fertilizer	136	9,753	2,045
CA	Management of beef cattle – agro-dairy products	81	9,834	2,704
AK	Crops-soil-lowered input dependent system	10	9,844	4,434
AA	Crops-soil- biological N fixation	8	9,853	14,280

2.3. Deriving and applying MACC in agricultural sector of Korea

The following Table 4-14 shows the list of feasible measures for abating greenhouse gases in the agricultural sector in Korea and feasible technologies for reducing emission of greenhouse gases in the agricultural sector. The list comprises rice farming, protected horticulture, livestock farming, and environment-friendly agriculture, though most technologies have been developed for rice farming.

The technology with the highest abatement in the rice farming sector was no-till farming and rotaries which contribute a reduction of 3.827 tons (/ha). The next was intermittent irrigation (2.940 tons /ha), drainage by culverts (2.912 tons /ha), and the removal of rice straw (2.885 tons /ha). The technology with the lowest abatement was early sowing (0.102 tons /ha), The sector of protected horticulture showed very high numbers with 88 tons /ha for the geothermal heat pumps, 56 tons /ha for green perilla illuminated by LED. This is because protected horticulture is both land intensive and energy intensive; energy intensive particularly in terms of cooling, heating and lighting. In the sector of livestock farming, biogas plants demonstrated 1,000 tons /plant. However, it was shown that abatement of greenhouse gases has not been calculated for the improvement of enteric fermentation and the improvement of waste treatment facilities. In the sector of environment-friendly agriculture, organic fertilizers showed 0.003 tons/ha, cultivation of green barley 0.680 tons/ha, and cultivation of rapes for bio-diesel 5.000 tons /ha.

Technologies developed for the abatement of greenhouse gases do not include data on their abatement capacity so there is not much data related to analysis of their economic efficiency. The level of developed technologies which is applied will depend on the willingness of farmers to accept and apply them. This will be determined by the farmers taking into account their economic efficiency. In depth analysis is required to arrive as this determination. An alternative means is to represent the current level of application of currently developed technologies and cross reference this with the current level of government financial support of the government to arrive at a value that will meet the national target of reducing greenhouse gases. The key target of policies of the government for each abatement technology shows supplying geothermal heat pumps for 250ha in 2010, 15 biogas plants for producing energy by 2013, and expanding environment-friendly agricultural production by 10% by 2013.

Table 4-14. List of GHG reduction technologies for the agricultural sector

Unit: Thousand won

No.	Reduction technology	Conventional technology	Abatement of CO_2 (tons)	Target of policies	Bibliography
Rice farming	Intermittent irrigation	Submergence in water all times	2.940/ha	-	a, e
	No-till farming+rotary	Till farming+ rotary	3.827ha	-	a
	Removing rice straw	Apply new rice straw	2.885/ha	-	a, e
	Drainage by culverts	No drainage by culvert	2.915/ha	-	a
	Cultivation by direct seeding on dry paddies [1)]	Cultivation of rice transplantation	1.278/ha	-	a
	Soil conditioner[2)]	Application of rice straw	0.978/ha	-	a
	No-till farming	Tillage	1.801/ha	-	a, d
	Pig feces with sawdust compost	Apply rice straw	0.482/ha	-	a
	Fall tillage	Spring tillage	0.383/ha	-	a
	Sow early maturing varieties	Sow mid-maturing varieties	0.102/ha	-	a
Protected horticulture	Geothermal heat pump	Oil heating	88/ha	Supply 250ha in 2010	f
	LED for green perilla	Conventional apparatus	56/ha	25 units every year during 2010 to 12	b
Livestock farming	Biogas plant	Conventional feces treatment	1000 /plant	15 plants for producing energy by 2013	c
	Improvement of enteric fermentation	Supply conventional feed	-	-	-
	Improvement of manure treatment facilities	Conventional treatment	-	-	-

No.	Reduction technology	Conventional technology	Abatement of CO_2 (tons)	Target of policies	Bibliography
Environment-friendly agriculture	Expand the portion of environment-friendly crop production	Conventional agriculture	-	Expansion to 10% of production by 2013	-
	Organic fertilizers	Chemical fertilizers	0.003/ha	Expansion to 2500 thousand tons in 2012	c
	Cultivation of green barley	No cultivation of green barley	0.680/ha	Expansion to 260ha in 2012	c
Others	Nitrogenous fertilizer management	Conventional application of fertilizers	-	Abatement of 40% of chemical fertilizers by 2012	-
	Rape cultivation for bio-diesel	No rape cultivation	5.000/ha	Aiming at producing 540K kl of bio-fuel by 2012	c
	Use of organic carbon in farm soil	Organic carbon not used	-	-	-

Note: 1) Direct seeding on dry paddies is applicable only to the planar dry paddies.
2) Soil conditioner refers to the use of silicate.
Source: a: National Academy of Agricultural Science (2009); b: RDA (2009, 2010); c: MIFAFF (2009); d: Jihan Goh and 8 researchers (2002); e: Yonggwang Shin and 3 researchers (1995); f: Korea Rural Economic Institute (2010).

MAC is calculated by subtracting the additional capital investment cost required for abating the decrease in energy cost per ton of carbon achieved through employing reduction technology from the capital investment cost required to abate one ton of CO_2 for each abatement technology and its associated annual maintenance cost.

In the list of abatement technologies, a MAC was derived for geothermal heat pumps, biogas plants and LED lighting which had been analyzed for their economic efficiency (Table 4-15). With regards the geothermal heat pump technology, the Government decided to supply geothermal heat pumps from 2010 in the protected horticulture sector and to support 250ha in 2010. Since 88 tons of CO_2 are abated per hectare the target abatement will be 250x88, or 22,065 tons. The additional cost incurred will be 2,120,000 won (the sum of the fixed cost and the management cost) while additional earnings will be 2,624,000 won (the sum of the increase in production value and the reduction of energy cost). This is according to the results of an economic efficiency analysis undertaken by KREI (2010). Therefore, MAC is shown to be -5,041,000 won. This means that the installation of geothermal heat pumps for abating one ton of CO_2 results in earnings of that amount.

With regards to biogas plant technology, the government has determined to install 15 plants by 2013 for energy production and in order to treat livestock manure. Given that one plant can abate 1000 tons of CO_2, the target abatement is 15,000 tons. The additional cost is 11,801,000 won (the sum of the fixed cost and the management cost). The additional earnings amount to 1,560,000 won (the sum of power sales and the fund for supporting the application of manures). This is according to the result of an analysis of the economic efficiency of EASY biogas plants (2008). Therefore, MAC is shown to be -3,791,000 won (i.e. earnings of 3,791,000 won).

The government determined to install 25 units of LED lighting in protected horticulture sector (approximately 9ha) every year during the period 2010-2012 for farmers growing green perillas, chrysanthemums and strawberries, all of which require strong lighting. Since 56 tons /ha of CO_2 is abated, the target abatement is 1,508 tons. The additional fixed cost amounts to 2,041,000 won while the additional earnings are 3,461,000 won (the sum of the increased production value and reductions in energy use). Therefore, MAC was shown to be–1,421,000 won (i.e. earnings of 1,421,000 won).

Table 4-15. MAC of renewable energy technology (estimate)

Unit: ton, 1000 won

	Target abatement of CO_2	MAC	Additional fixed cost	Additional management cost	Additional earnings	Cost reduced
Geothermal heat pump	22,065	-504	1,422	698	1,238	1,386
Biogas plant	15,000	-379	572	608	1,560	-
LED	1,508	-142	204	-	306	40

Note: The numbers for geothermal heat pumps are based on estimates by KREI, those for biogas plants on EASY bio estimates, and those for LED on estimates by the RDA. MAC is represented in abatements per ton of CO_2, MAC refers to reduction of CO_2 per ton. Additional fixed cost, additional management cost, additional earnings and reduced cost are represented per 10a for geothermal heat pumps and LED, and per plant for biogas plants.

2.4. Suggestions from MAC Analysis

A MAC analysis represents the relationship between cost and reduction potential. It allows the identification of cost-effective measures for achieving emissions targets in each sector. It can therefore be used to provide the basic data for determining policies by determining the level of economically efficient emissions. It also makes it possible to compare the MAC in other sectors, if any, to check relative cost-effectiveness of the agricultural sector.

MAC was derived by subtracting the energy cost associated with employing GHGs reduction technology per ton of carbon from the additional cost required to eliminate one ton of CO_2 for each reduction technology in the agricultural sector of Korea. It is necessary to analyze MAC in advance for the 50 previously mentioned practical tasks and detailed tasks, as well as the renewable energy sector. To this end, the economic efficiency of each technology should be analyzed and the level of GHG abatement derived. The level of GHG abatement was based on the national targets for policies, but a more accurate abatement can be obtained if the level at which farmers apply the technology is examined.

3. Green productivity analysis

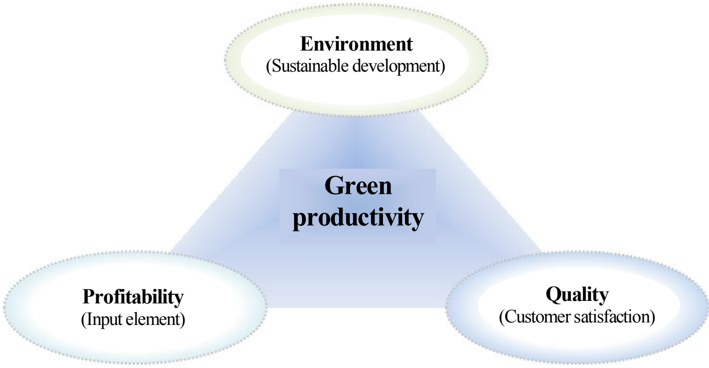
3.1. Concept of green productivity

Green productivity was established as a strategy for actualizing both productivity improvement and environmental conservation (APO, 2002). The APO concept of green productivity of APO emphasizes 3 aspects: profitability, the environment and the quality of products and services for sustainable growth.[23] In terms of the management of enterprises, green productivity contributes to improving competitive power through improved productivity as well as reduced cost but considering

[23] APO started to handle green productivity from 1994 to embody both of productivity improvement and environmental conservation. At the beginning of introducing green productivity, the efficiency thereof was questioned. However, with ever increasing interest in climate change, more approaches are being made to supply chains to persuade them as to validity of green productivity, efficiency in environment and energy, and waste management.

environment from the initial process of a project. While measures for abating GHG to cope with climate change do incur environmental cost, they also create the green market by boosting both production and the consumption of environment-friendly products. Green productivity is thus considered to be closely related to green growth.

Figure 4–4. Components of green productivity



Source: APO (2002).

3.2. Methodology of measuring green productivity

An exemplary method of measuring green productivity is Green Total Factor Productivity which uses green growth models. Green Total Factor Productivity is described with measurable input factors, e.g., labor, material capital, human capital, etc., among input factors. However, the productivity of each input factor and the rest all parts (the Solow residual) not included in growth accounting are defined as technological progress factors.

CO_2 generated by inputting existing production factors brought about negative externalities such as global warming, and increasing cost burdens to solve the externalities. In this the environment is considered to be a kind of social capital, with CO_2 emissions acting as a factor which acts to reduce capital. Therefore, CO_2 emission may be replaced by a kind of instrumental variable called social capital input in agricultural production.[24]

[24] Tzouvelekas, Vouvaki and Xepapadeas (2007) presented a green growth pattern for measuring the relative importance of environment in gross production, considering the contribution of environment

Measuring total factor productivity based on green growth models requires the division of the Solow Residual, analyzed conventionally as a technological progress factor, into environmental factors and new productivity factors, drawn from the technological progress factors. This will allow for systematic description. However, measuring total factor productivity by means of the green growth model may result in an overassessment because everything not included in growth accounting are considered. This and requires a complicated indexing process, detailed unit prices and input data for each agricultural sector, so that it is difficult to perform the tual measurement.[25]

A simplified method of measuring green productivity is carbon productivity, which is calculated by means of GDP (or added value) and the ratios of CO_2 emissions (McKinsey, 2008). This method is conceptually similar to eco-efficiency which is explained with the primary factor actually for offsetting the assumed GDP reduction, or an assumed GDP increase, although GDP is assumed to be reduced due to the payment of GHG abatement costs.

The agricultural production function in the paradigm of green growth has a production factor of GHG emissions in addition to existing labor and capital. Here GHG emissions are a cost levied relative to emissions when a carbon tax or the Emission Trading scheme is enforced.

$$Y = f(L, K, CO_2) \tag{7}$$

Y: GDP or value added L: Labor
K: Capital CO_2: CO_2 emissions

Since the production factor and output is represented as productivity, GDP/L is labor productivity, GDP/K is capital productivity, and GDP/CO_2 is carbon productivity. Carbon productivity is similar to the concept of green productivity and

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measured with CO_2 emissions as one input factor of growth accounting.

[25] Hakgil Pyo (2009) analyzed, in measuring the gross green factor productivity using the hybrid input-output table, that development by environmental factors was, during the period of 1995 to 2000, -0.4% for the agriculture, fishery and mining industries and 1.7% for the manufacturing industry, and during the period of 2000 to 2005, 0.3% for the agriculture, fishery and mining industries and 0.5% for the manufacturing industry. This is the integrated result of research for agriculture, fisheries and mining, and is not considered as analysis only of the agricultural sector. During the period of 1995 to 2000, the ratio of annual average value added growth per capita of agriculture, fishery and mining industries was lowered by 26.7% due to the environmental factor, but it is unreasonable to accept it as the environmental factor.

eco-efficiency given that carbon productivity is a ratio of productivity and factors of environmental loads, and can be applied to the entire industry. It can be calculated using only GDP and CO_2 without measuring energy productivity.

Carbon productivity is calculated by multiplying energy productivity (GDP/E) by the inverse number of carbon intensity (CO_2/E).

$$\frac{GDP}{CO_2} = \frac{GDP}{E} \times \frac{E}{CO_2} \tag{8}$$

To enhance carbon productivity, it is necessary to enhance energy productivity or to lower the carbon intensity; carbon intensity being the inverse value of GHG emissions with respect to energy consumption. Exemplary feasible methods include using alternative energies which are low carbon and high calorie, developing technologies for enhancing energy efficiency, expanding GDP with application of green technologies and lowering energy input.

3.3. Measuring green productivity in each sector

An empirical analysis of green productivity was carried out by applying the methodology of McKinsey (2008) for analyzing carbon productivity with GHG emissions and GDP. In addition the methodology of IEA (2009) was applied to predict GHG emissions utilizing the inverse value of carbon productivity in OECD member countries and non-member countries.

Sectors analyzed included the entire agricultural sectors, tillage and livestock farming, and it was also set to compare this data with that from the manufacturing industry and the construction industry. Carbon emissions were based on CO_2 equivalent GHG emissions during the period of 1990-2007 in the IPCC guidelines and GDP was based on the standard real price data in 2005 published by the Bank of Korea.

For assessing green productivity in each industry, carbon productivity was first analyzed by dividing GDP (an economic growth factor) by GHG emissions (an environmental factor) in order to assess the level of green productivity in each industry. The average carbon productivity in manufacturing and construction sectors was 1.5, somewhat higher than the 1.2 which is the average for the agricultural sector (Table 4-16).

Table 4-16. Changes in carbon productivity in manufacturing, construction and agricultural sectors (based on GDP in 2005)

Unit: million tCO_2eq, billion won

Category	Manufacturing and construction sectors			Agriculture			Cultivation			Livestock farming		
	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity
1990	112.2	82.0	1.4	20.6	15.2	1.4	13.7	10.3	1.3	2.6	4.8	0.5
1995	159.8	124.2	1.3	23.4	22.4	1.0	15.4	15.6	1.0	4.7	6.8	0.7
2000	205.0	141.8	1.4	24.9	20.6	1.2	16.8	15.0	1.1	4.9	5.6	0.9
2005	272.9	148.2	1.8	25.9	19.9	1.3	16.8	14.0	1.2	5.5	5.9	0.9
2006	291.5	149.9	1.9	26.2	19.9	1.3	16.7	13.8	1.2	5.7	6.1	0.9
2007	309.5	159.9	1.9	27.3	20.0	1.4	16.9	13.6	1.2	6.2	6.4	1.0

The carbon productivity of the manufacturing and construction sectors was 1.4 in 1990 and 1.2 to 1.4 in 2000 due to increase in both GHG emissions and GDP, but rose continuously after 2001 to 1.9 in 2007.

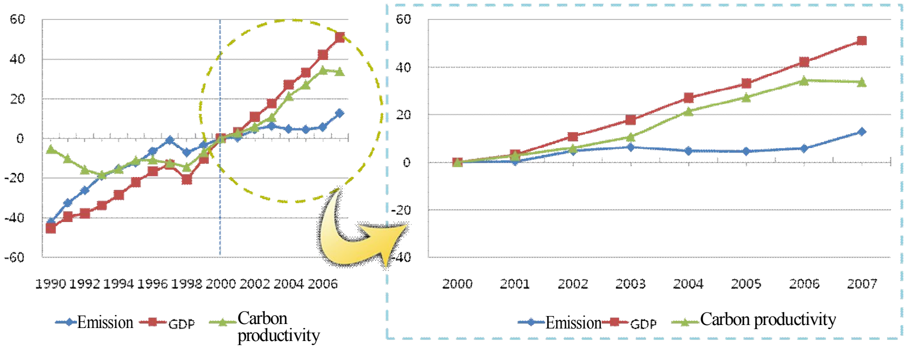
The carbon productivity of the agricultural sector was 1.4 in 1990, falling to 1.0 during the period of 1991 to 1999 but then rose continuously to 1.2 in 2000 and 1.4 in 2007. The carbon productivity of the crop farming sector was 0.9 in 1991, but rose slowly but continuously to 1.1 in 2000 and 1.2 in 2007. The carbon productivity of the livestock farming sector was 0.5 in 1990, 0.9 in 2000 and 1.0 in 2007.

Table 4-17. Changes in carbon productivity of manufacturing and construction sectors (on the basis of 2000)

Unit: %

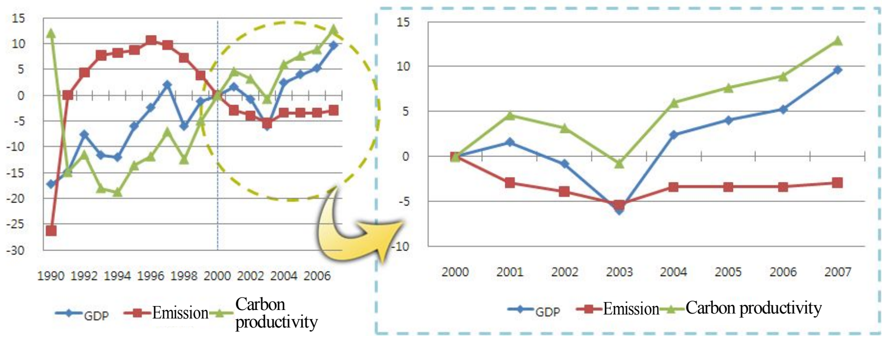
Category	Manufacturing and construction sectors			Agriculture			Cultivation			Livestock farming		
	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity	GDP	Emissions	Carbon productivity
1990	-45.3	-42.2	-5.4	-17.3	-26.2	12.1	-18.5	-31.3	18.8	-46.9	-14.3	-38.1
1995	-22.0	-12.4	-11.0	-6.0	8.7	-13.6	-8.3	4.0	-11.9	-4.1	21.4	-21.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	33.1	4.5	27.4	4.0	-3.4	7.7	0.0	-6.7	7.1	12.2	5.4	6.5
2006	42.2	5.7	34.5	5.2	-3.4	8.9	-0.6	-8.0	8.0	16.3	8.9	6.8
2007	51.0	12.8	33.9	9.6	-2.9	12.9	0.6	-9.3	11.0	26.5	14.3	10.7

Figure 4-5. Changes in carbon productivity of manufacturing and construction sectors



A comparison of the changes in carbon productivity of each sector with the year 2000 being the base year revealed the following picture. For the manufacturing and the construction sectors emissions, GDP and carbon productivity rose continuously from the year 2000. GDP in the manufacturing and the construction sectors showed an increase of 51% in 2007 with respect to figure in the year 2000. During the same period GHG emissions rose by 12.8% resulting in an increase of 33.9% in carbon productivity. The increase in carbon productivity of this case results from GDP having a relatively higher rate of growth than GHG emissions. It is worth noting that the increase in carbon productivity cannot surpass the increase in GDP while GHG emissions increase. Therefore, the manufacturing and the construction sectors are not considered to be following a pattern of green growth due to a lack of an accompanying reduction of GHG emissions.

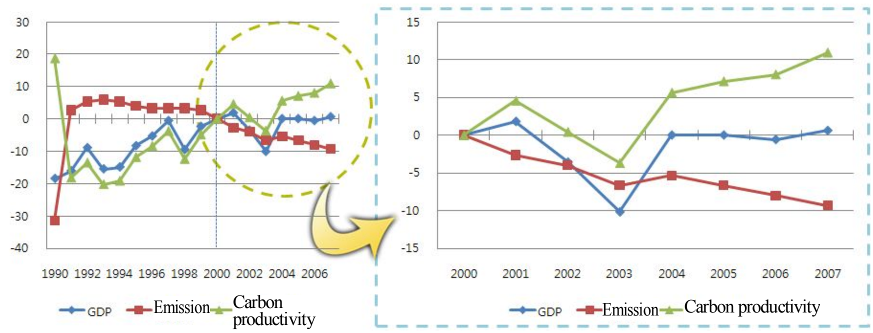
Figure 4-6. Changes in carbon productivity of the agricultural sector



Likewise, carbon productivity in the agricultural sector continues to increase, the result of continuous reductions in GHG emissions in combination with GDP growth in the livestock farming sector since 2000. In the agricultural sector, GDP increased by 9.6%, GHG emissions were reduced by 2.9%, leading to an increase in carbon productivity of 12.9% in 2007 with respect to 2000. The GHG reduction in the agricultural sector is considered to be the result of the reduction in cultivated land areas in combination with a reduction in the application of chemical fertilizers. This is despite the fact that GDP has steadily increased. Reduced GHG emissions coupled with simultaneous increase in value added is considered to comply with the concept of green growth.

The crop farming sector did not show any significant change in GDP, but did show a reduction in emissions, therefore the analysis showed that carbon productivity had increased since 2000. The crop farming sector showed a 0.6% of increase in GDP, a 9.3% reduction in GHG emissions, and thus an overall 11.0% increase in carbon productivity. The GHG emissions reduction in the crop farming sector result from the reduced in the area cultivated paddy land which in turn generated less methane (a potent GHG gas) as well as a reduction in the application of chemical fertilizers. However, given that there has been a reduction in emissions and no significant change in GDP despite a reduced cultivation area the crop farming sector complies with the concept of green growth.

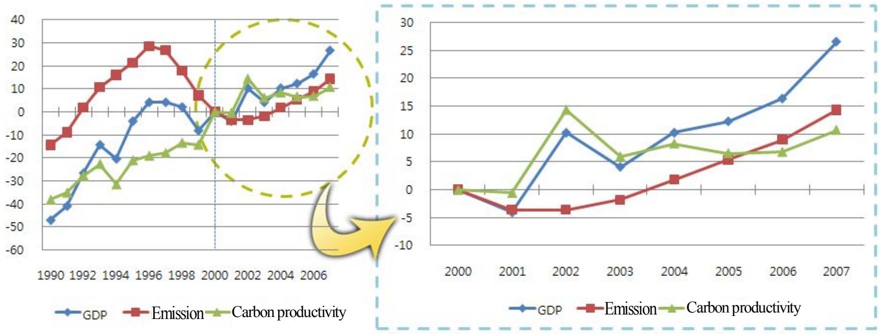
Figure 4-7. Changes in carbon productivity in the crop farming sector



The livestock farming sector shows continuous increase in emissions since 2000 accompanied by increasing GDP. The change in carbon productivity is approximately 6 to 10%; steadily increasing since 2003. The livestock farming sector shows a 26.5% increase in GDP coupled with a 14.3% increase in GHG emissions.

This results in a 10.7% increase in carbon productivity in 2007, with respect to 2000. Increasing carbon productivity in the livestock farming sector is therefore the result of GDP increasing faster than GHG emissions. The increasing number of raised beef cattle in the livestock farming sector contributes to increasing both GDP and GHG emissions. It is thus necessary to develop GHG reduction technology, e.g., improvement of enteric fermentation and livestock manure management for green growth to occur in the livestock farming sector.

Figure 4-8. Changes in carbon productivity in the livestock farming sector (on the basis of 2000)



Carbon productivity is fundamentally related to economy (GDP) and environment (CO_2). Considering that both GDP and CO_2 are the output of agricultural activities, carbon productivity is a modified form of output. Therefore, carbon productivity is represented as a linear combination of variables related to agricultural activities, allowing a regression analysis. According to the IPCC guideline, related key items of GHG emission from the agricultural sector include cultivated areas, use of nitrogenous fertilizers, input of livestock manures in crop farming, and emissions from the livestock farming sector, include stocking density and methods of night soil treatment, etc. Here, since the cultivated land area, use of nitrogenous fertilizers and stocking density (SD) are the variables affecting both GHG emissions and GDP, carbon productivity of the agricultural sector is thus represented as follows:

$$CP_{agri} = f(A, F, L_i) \tag{9}$$

CP_{agri}: Carbon productivity of the agricultural sector

F: Use of nitrogenous chemical fertilizers in paddies

A: Rice cultivation area L_i: Livestock, I: SD

On the basis of the above equation 9, a regression analysis was performed by setting the agricultural activity variables as independent variables, and the carbon productivity of the agricultural sector as a dependent variable to be converted to an equation of full log.

The contribution by independent variables to the carbon productivity of the agricultural sector was analyzed by means of coefficients (assuming that the other variables did not change). The result of analysis is shown as follows: The carbon productivity of the agricultural sector decreases by 4.51% if the rice cultivation land area decreases by 1%. If the application of chemical fertilizers is decreased by 1%, the carbon productivity of the agricultural sector shows a 4.57% increase. If the density of milking cows increases by 1%, the carbon productivity of the agricultural sector shows a decrease of 0.51%. If the stocking density of pigs increases by 1%, the carbon productivity of the agricultural sector increases by 0.23% (Table 4-18).

Table 4-18. Result of regression analysis of factors which influence the carbon productivity of the agricultural sector

	Coefficient	Standard deviation	t-value
Constant	25.950	4.210	6.164***
ln rice cultivation area	4.508	0.451	9.992***
ln chemical fertilizers applied to paddies	-4.565	0.535	-8.531***
ln density of milking cows	-0.515	0.131	-3.920***
ln density of pigs	0.225	0.071	3.158***
Adj-R^2: 0.93			

Note: *** means significance at the significant level of 99%.

Table 4-19. Changes in variables of agricultural activities

Year	Rice cultivation land area (1000 ha)	Nitrogenous fertilizer applied to paddies (ton)	Nitrogenous fertilizer applied to paddies per unit area (ton/1000 ha)	Density of cattle (head)	Density of pigs (head)
1991	1,208 (0.0)	157,200 (0.0)	130 (0.0)	495,772 (0.0)	4,809,674 (0.0)
1992	1,157 (-4.3)	150,557 (-4.2)	130 (0.0)	508,241 (2.5)	5,365,712 (11.6)

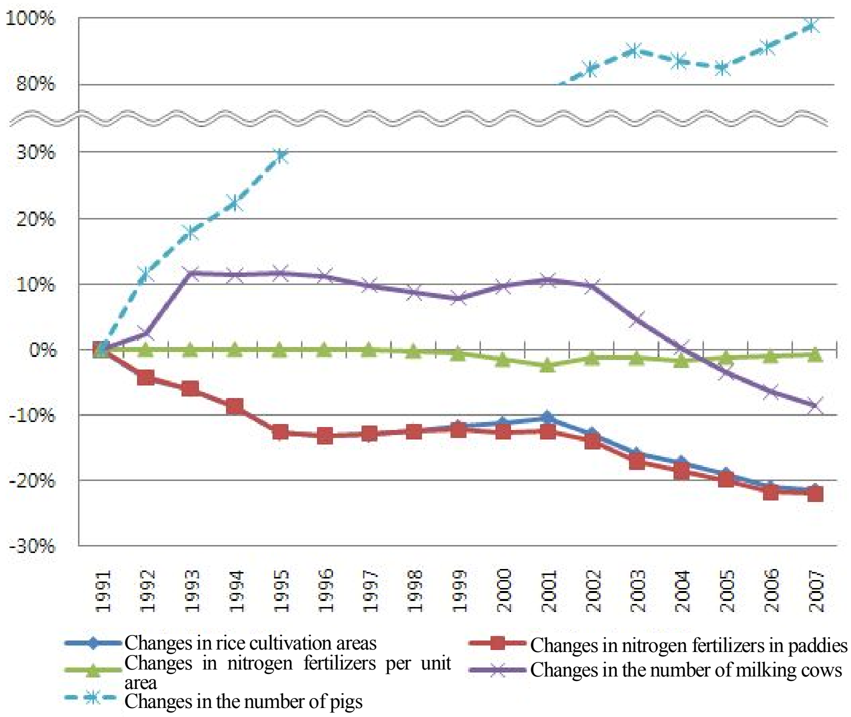
Year	Rice cultivation land area (1000 ha)	Nitrogenous fertilizer applied to paddies (ton)	Nitrogenous fertilizer applied to paddies per unit area (ton/1000 ha)	Density of cattle (head)	Density of pigs (head)
1993	1,136 (-6.0)	147,822 (-6.0)	130 (0.0)	553,343 (11.6)	5,670,198 (17.9)
1994	1,103 (-8.8)	143,524 (-8.7)	130 (0.1)	552,139 (11.4)	5,883,876 (22.3)
1995	1,056 (-12.6)	137,403 (-12.6)	130 (0.0)	553,467 (11.6)	6,225,991 (29.4)
1996	1,050 (-13.1)	136,622 (-13.1)	130 (0.1)	551,493 (11.2)	6,479,228 (34.7)
1997	1,052 (-12.9)	137,012 (-12.8)	130 (0.1)	544,417 (9.8)	6,799,162 (41.4)
1998	1,059 (-12.4)	137,533 (-12.5)	130 (-0.2)	538,913 (8.7)	7,557,722 (57.1)
1999	1,066 (-11.8)	137,924 (-12.3)	129 (-0.6)	534,506 (7.8)	7,599,355 (58.0)
2000	1,072 (-11.3)	137,403 (-12.6)	128 (-1.5)	543,708 (9.7)	8,149,776 (69.4)
2001	1,083 (-10.4)	137,533 (-12.5)	127 (-2.4)	548,176 (10.6)	8,520,085 (77.1)
2002	1,053 (-12.9)	135,319 (-13.9)	128 (-1.2)	543,587 (9.6)	8,879,564 (84.6)
2003	1,016 (-15.9)	130,500 (-17.0)	128 (-1.3)	518,645 (4.6)	9,148,704 (90.2)
2004	1,001 (-17.2)	128,156 (-18.5)	128 (-1.6)	497,261 (0.3)	8,994,161 (87.0)
2005	980 (-18.9)	125,942 (-19.9)	129 (-1.2)	478,865 (-3.4)	8,894,836 (84.9)
2006	955 (-21.0)	123,077 (-21.7)	129 (-1.0)	464,056 (-6.4)	9,198,143 (91.2)
2007	950 (-21.4)	122,715 (-21.9)	129 (-0.7)	453,403 (-8.5)	9,517,988 (97.9)

Note: ( ) represents changes in variables of agricultural activities in % on the basis of 1991.

However, since 4 variables actually applied to the analysis change at the same time as shown in Table 4-19, it is essential to consider changes in all parts in analysis. Therefore, it is desirable to find the various rates of change of carbon productivity by finding the sum of the partial rates of changes for each independent variable. Of the variables of agricultural activities the most noteworthy are the continuously decreasing paddy areas and the continuously decreasing use of nitrogenous fertilizer applied to the paddy fields. The rice cultivation area is related to both agricultural

GDP and methane emissions in the crop farming sector, while the use of nitrogenous fertilizers is related to agricultural GDP and nitrous oxide emissions in the crop farming sector. However, there has been no significant change in the use of nitrogenous fertilizers per unit area so far (Figure 4-9).

Figure 4-9. Rate of changes in variables of agricultural activities

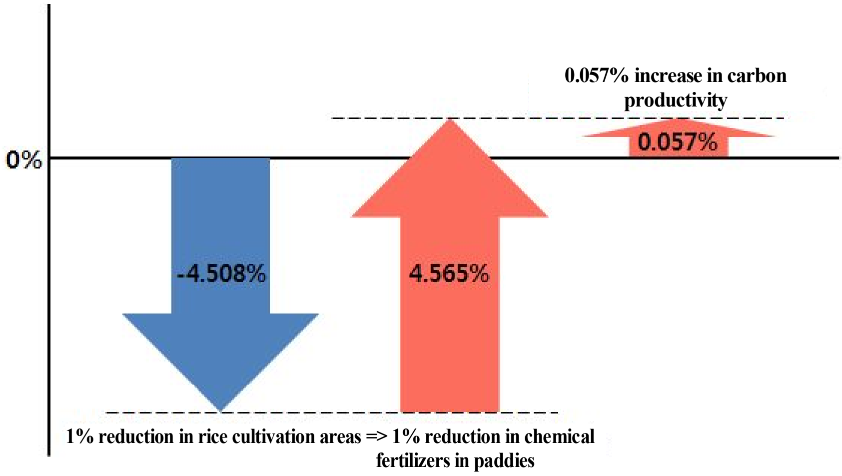


Note: The rate of changes in the density of pigs has steadily increased to be 69.4% in 2000 and 97.9% in 2007 with respect to 1991, but the rate during the period of 1996 to 2002 is omitted in the figure because of too much increase.

Therefore, the data indicates that the reduction of applied nitrogenous fertilizers in the agricultural sector results from an actual reduction of rice cultivation areas and by changes in the use of nitrogenous fertilizers by rice growing farmers (Figure 4-10). The coefficient of rice cultivation areas is 4.508 and has a greater influence on GDP, which is an economic division of carbon productivity. The coefficient of nitrogenous fertilizers is -4.565 and has a greater influence on CO_2, which is an environmental part of carbon productivity.

If the rice cultivation area is reduced by 1%, the carbon productivity of the agricultural sector will decrease by 4.508%. However, there is a simultaneous 4.565% increase in the carbon productivity of the agricultural sector due to the drop in the use of nitrogenous fertilizers. Subtracting one from the other results in a net 0.057% increase in carbon productivity of the agricultural sector for every 1% reduction in the rice cultivation area.

Figure 4-10. Changes in carbon productivity resulting from 1% of reduction in rice cultivation areas



Two variables which affect the carbon productivity of the agricultural sector are the density of milking cows and the density of pigs in the livestock farming sector. The regression coefficient of the density of milking cows is -0.515 and is seen to have a strong relationship with GHG emissions. Milking cows are ruminants which generate methane in the process of enteric fermentation and the IPCC guideline specifies an emission coefficient of 118kg, the greatest among farming livestock.[26] Therefore, changes in the density of milking cows may be acting as a primary cause of increasing GHG emissions in the livestock farming sector, rather than GDP increase, and reducing the carbon productivity of the agricultural sector.

[26] The emission coefficient which represents the annual methane emission per head is set at 118kg for cattle, 47kg for Korean beef cattle, and 1.5kg for pigs (IPCC, 1997).

The rearing density of pigs significantly increases with increasing meat consumption. Meat consumption increases as people's incomes rise. The coefficient of GHG emissions by pigs is 1.5kg which is greatly lower than that of milking cows. Pork is in high demand however, so the resulting increase in the density of pigs contributes to GDP increase in the livestock farming sector. Therefore, the regression coefficient of the density of pigs is 0.225. It is noted that this is a factor increasing the carbon productivity of the agricultural sector.

The improvement of carbon productivity presented in the analysis of carbon productivity of the agricultural sector may be enhanced by a reduction in the use of chemical fertilizers, a reduction led by practitioners of environment-friendly agriculture. However, the analysis shows that a major contribution is made by the reduction of the rice cultivation areas. Therefore, to ensure strong, steady green growth in the agricultural sector, an effective approach, supported by policies, to reduce the application of chemical fertilizers per unit area is essential.[27]

To advance green productivity in the livestock farming sector, it is essential to apply green technology to ruminants. In the livestock farming sector, both GDP and GHG emissions are directly related to the density of livestock. It is thus necessary to develop technology for increasing the density of livestock while acting to reduce GHG emissions. For example, if generated methane gas per ruminant is reduced by as little as 1% with feed additive technology to the process of a ruminant's enteric fermentation, it is possible to increase carbon productivity by 0.51%. Another method of improving carbon productivity in the livestock farming sector is to increase the density of pigs as so generate less GHG emissions and higher GDP. A1% increase in the density of swine contributes to a 0.23% increase in carbon productivity.

[27] A 1% reduction in the use of nitrogenous fertilizers per unit area in 2007, a reduction fromfrom roughly 129 tons/1000 ha to roughly 127.8 tons/1000 ha, would bring about a carbon productivity increase, from 1.34 to roughly 1.40, an increase of 4.57% If 1% of farmland is switched to environment-friendly agriculture, it will decrease the area of conventional paddy cultivation and the volume of applied nitrous fertilizers per unit paddy area, resulting in roughly 4.58% of carbon productivity increase.

Figure 4-11. Changes in carbon productivity in reducing 1% of rice cultivation areas

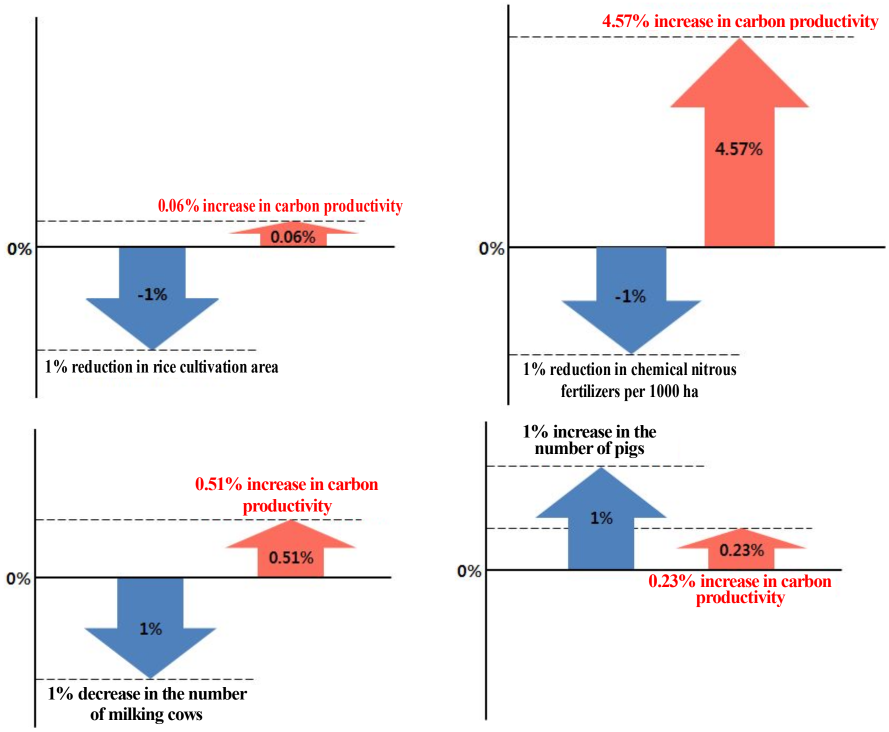


Table 4-20. Changes in carbon productivity depending on changes in variables of agricultural activities in 2007

Category	Cultivation areas (1000 ha)	Nitrogenous fertilizers (ton/1000ha)	Density of milking cows (1000 heads)	Density of pigs (1000 heads)	Carbon productivity	
	Value (rate of changes)	Value (rate of changes)	Value (rate of changes)	Value (rate of changes)	Value	Rate of changes
2007	950	129	453	9,518	1.34	-
	941(-1)	-	-	-	1.34	0.06
	-	128(-1)	-	-	1.40	4.57
	-	-	448(-1)	-	1.35	0.51
	-	-	-	9,613(1)	1.34	0.23

Note: This is the case of a –1% of abatement in the cultivation areas, unit input and the density of milking cows, and 1% of increase in the density of pigs.

3.4. Suggestions from green productivity analysis

Green productivity is an important concept necessary for achieving the twin objectives of abatement of GHG and economic growth, the fulfillment of which will usher in an era of green growth.. In the agricultural sector, the rate of increase in carbon productivity is greater than the rate of GDP increase in the agricultural sector. This means that the sector is to be considered a green growth industry, showing higher levels of green productivity relative to non-agricultural sectors. However, since both the factor of a reduction of the cultivation area and the factor of the development of green technology are applied to the agricultural sector, an in-depth analysis is required for these factors. The results of analyzing carbon productivity, GDP and the rate of changes in $CO_{2,}$ shows that green growth is greatly affected by the reduction of rice cultivation area and thus appropriate measures in each sector are needed for steady green growth.

To obtain steady green growth in the crop farming sector, what is required is to reduce the applied nitrogenous fertilizer per unit area, to create value added farm products by means of a conversion to environment-friendly farming and to improve energy efficiency, e.g., using low carbon energy sources and highly efficient energy. Another requirement is GDP increase, both by improving the value added in the market as well as a scheme for improving carbon productivity to which low carbon technology is applied. For green growth in the livestock farming sector, the requirement is to develop green technology that can achieve both a GDP increase and a reduction in GHG emissions. In particular, since the factor of stocking density in the livestock farming sector is closely related to both GDP growth and a reduction in GHG emissions, what is required is a technology which inhibits the generation of methane in a ruminant’s enteric fermentation process.

4. Analysis of green growth potential in rural districts

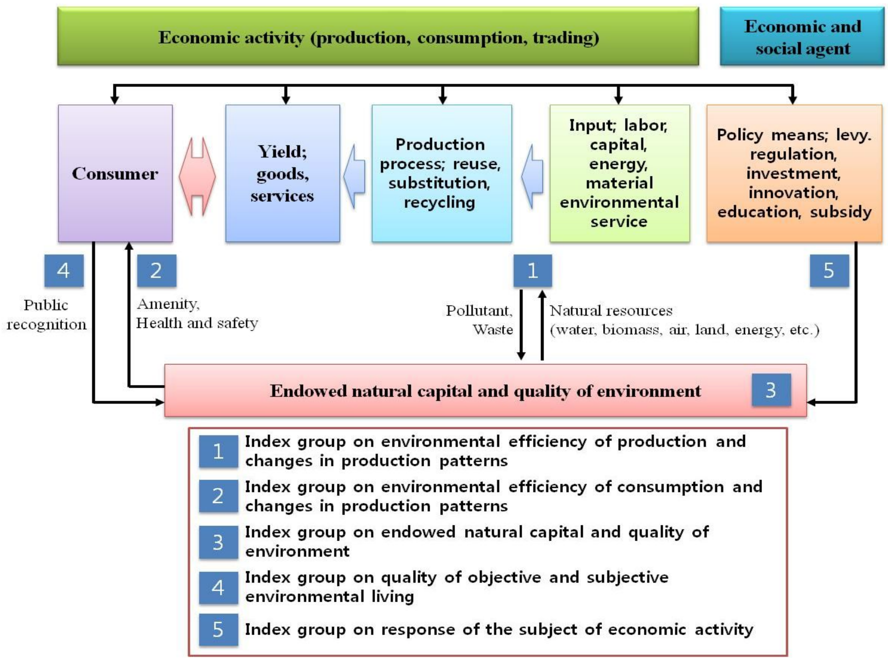
An important task, when developing green growth strategies for rural districts, is to develop a tool that can capture all the states of rural districts and monitor any changes from a green growth perspective. In other words, develop an index that will indicate the green growth potential in rural districts. To this end, the logic of constructing a potential index and the indices for each district is estimated and presented.

4.1. Logic of constructing a potential index of green growth

It is not easy to apply the national level index framework showing green growth potential to Korean rural districts without modification. This is because there is a measurement possibility problem as well as the fact that policies related to green growth are not fully implemented yet.

However, in this chapter, an attempt is made to calculate the potential index of green growth at the level of cities and counties, using the index framework of green growth from the OECD (2010) (Figure 4-12). The potential indices of green growth in rural districts were constructed using the four types of index groups, but excluding the 'index group about the subject response to economic activities' among five index groups presented by the OECD. The indices for four categories were set as 'green production', 'green consumption', 'green resource basis', and 'environmental quality of people's lifestyle', so as to include variables related to each category. Items were selected related to each category which could provide statistics data at the level of cities and counties. Finally, 18 detailed variables were selected (Table 4-21).

Figure 4-12. Index frame of green growth by OECD



The process of selecting detailed variables is described below. The first step was to specify 25 candidate variables drawn from the data at the basic level of local government for rural districts. The next step was to examine the appropriateness of the index system and avoid possible repetition among variables by means of expert discussion. After that, to specify 18 variables excluding seven candidate variables. Lastly, it was decided to assign a weight to each variable through expert discussion. However, the index in each category was assigned the same values, in terms of importance, as in the composite index, and the variable weight was taken to be the arithmetic mean, because there are no logical grounds for assigning a difference in the weight for detailed variables.

Table 4-21. Variables for constructing green growth potential indices for rural districts

Index category	Detailed variables	Sign	Weight in the sector
Green production	Area for environment-friendly agriculture	+	1/7
	Number of employees in environmental industry	+	1/7
	Increase/decrease in the number of pollutant dischargers	-	1/7
	Construction waste per resident	-	1/7
	Rate of recycling construction wastes	+	1/7
	Discharged waste water	-	1/7
	Discharged organic matters	-	1/7
Green consumption	Motor fuel tax levy	-	1/3
	Rate of recycling general wastes	+	1/3
	Municipal solid waste per capita	-	1/3
Basis of green resources	Forest area	+	1/4
	Farmland area	+	1/4
	Ratio of green	+	1/4
	River area	+	1/4
Environmental quality of people's living	Ratio of sewage line supply	+	1/4
	Increase/decrease of bike lanes	+	1/4
	Number of facilities of environmental pollutant discharge	-	1/4
	Natural park area per resident	+	1/4

Note: No difference in weight is applied to categories by reflecting experts' opinion in the related sector.

4.2. Rural districts and green growth potential index

Indexing each category for the analysis of the green growth potential of rural districts was carried out in a four step process.

First, normal scaling was applied to standardize detailed variables.

Second, it was decided that a positive sign (+) for individual variables would indicate a positive state related to green growth in the relevant area and that a negative sign (-) would indicate a negative state.

Third, the individual variables used for constructing one sector were averaged to calculate indices in each category.

Fourth, indices in each category were averaged to calculate a 'green growth potential index' in rural districts.

4.2.1. General green growth potential in cities and counties of rural districts

The 'green growth potential index', which generalizes indices in four categories of 'green production', 'green consumption', 'basis of green resources' and 'environmental quality of people's living', was analyzed for the 140 local autonomies, some being cities and some being counties, based on rural districts.

As shown in Figure 4-13, the indices of green growth potential for each city and county based on rural districts were divided into four categories so that they could be visually represented by means of GIS. Cities and counties of darker shading represent those with comprehensively higher green growth potential.[28] Cities and counties of comprehensively higher indices for green growth potential are located in the less urbanized areas, e.g., remote and secluded mountainous locations in Gangwondo and Gyeongsangbukdo, and some of plains in Jeollanamdo and Jeollabukdo.

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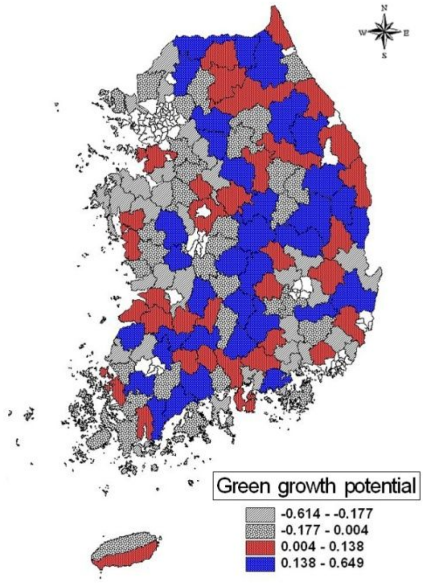
[28] The area not shaded is cities not included in this study.

Figure 4-13. Distribution of general indices for green growth potential of cities and counties based on rural districts



A comparison of the 140 local autonomies, whether cities or counties, both being based on rural districts, revealed no significant difference in green growth potential between the cities and counties in their general aspects. The indices of the two categories 'green production' and 'basis of green resource' were shown to be similar in the cities and the counties. Meanwhile, the indices of 'green consumption' were higher in the counties while those of 'environmental quality of people's living' were higher in cities (Figure 4-14 and Table 4-22).

The average index of cities was -0.3075 but that of counties was 0.1900. However, on the index for 'environmental quality of people's living' cities scored higher than counties. With regards this particular variable, the average for cities was 0.1591 while the average for counties was -0.0887. People may expect that the green growth potential of the less urbanized counties to be higher than that of cities, but the research revealed no significant difference in general aspects. However, the green growth potential of counties is greater than that of cities in terms of 'local people's consumption'. Cities fared better with respect to the 'environmental quality of people's living' which measures the possibility that people can experience a pleasant and well-conserved environment.

Figure 4−14. Distribution of indices for green growth of each category

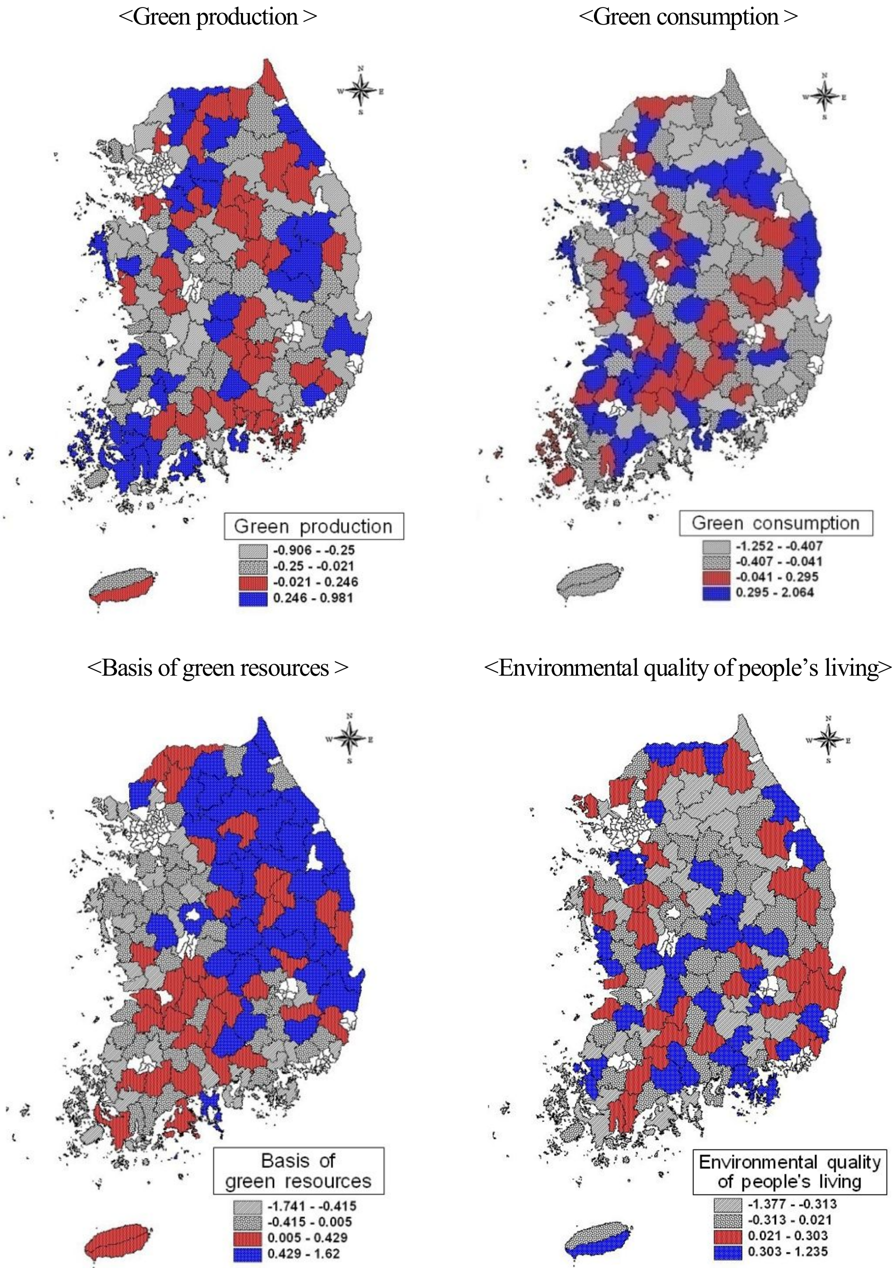


Table 4-23 shows the comprehensive indices of green growth as well as the indices in each category for both cities and counties based on rural districts under each local autonomy.

Table 4-22. Comparison of green growth potential and indices of each category in cities and counties based on rural districts

Index	Category	Average	t-stastic	Significance
Green growth potential (comprehensive)	City	-0.0402	-1.552	0.123
	County	0.0269		
Green production	City	0.0041	0.126	0.900
	County	-0.0039		
Green consumption	City	-0.3075	-5.492	0.000
	County	0.1900		
Basis of green resources	City	-0.0164	-0.241	0.810
	County	0.0103		
Environmental quality of people's living	City	0.1591	3.036	0.003
	County	-0.0887		

Table 4-23. Green growth potential and indices of each category for local autonomies

Category	Local autonomy	Comprehensive index	Green production	Green consumption	Basis of green resources	Environmental quality of people's living
Region	Gangwon	0.1392	0.0418	-0.1306	0.6920	-0.0465
	Gyeongbuk	0.0999	-0.0673	0.0714	0.4136	-0.0179
	Jeonbook	0.0380	-0.0538	0.2133	-0.0476	0.0402
	Choongbuk	0.0120	-0.1391	0.1326	0.0441	0.0102
	Jejoo	0.0093	-0.0108	-0.3068	0.1154	0.2392
	Jeonnam	-0.0230	0.1207	0.0875	-0.2407	-0.0595
	Gyoungnam	-0.0554	0.0661	-0.1979	-0.2573	0.1675
	Gyeonggi	-0.0791	0.1098	-0.1236	-0.1385	-0.1640
	Choongnam	-0.0818	-0.0933	-0.0278	-0.3027	0.0965
Metropolitan city	Woolsan	0.0316	-0.3791	-0.2611	0.2400	0.5266
	Daegu	-0.0009	-0.2615	-0.1273	-0.1996	0.5849
	Busan	-0.2632	-0.1190	-0.0452	-1.0504	0.1617
	Incheon	-0.3120	-0.0662	0.5428	-1.0586	-0.6660

4.2.2. Potential for ‘green production’

The indices for ‘green production’ were higher in some parts of the country than in others. Some areas where the indices were high included Gangwondo, Gyeongbuk, the capital area, exemplary areas of Jeonnam with ‘green production’ including those with abundant forestry resources, areas with a small number of secondary and tertiary industry enterprises and thus bearing a low environmental load. Additionally, other areas included those of small and medium sized local cities but based on clean industry and/or with wide rural and forestry districts as their setting. Table 4-24 shows the test results which identify the significance between the average values of cities and counties for detailed variables.

Areas of environment-friendly agriculture show great difference among local autonomies based on rural districts. The largest area of environment friendly agriculture, at 5,074ha, is located in Cheolwon-goon, Gangwondo. A level of significance of correlation between the farm land area and the environment-friendly agricultural area was 0.164 which is considered low. This suggest that one strategy to promote green growth is to reorganize local agriculture into environment-friendly agriculture in cities and counties where there is large areas of farm land but where environment-friendly agriculture is not widely diffused as yet.

Table 4-24. Comparison of detailed categories for ‘green production’ in cities and counties based on rural districts

Detailed category	Type of area	Average	t-statistic	Significance
Area for environment-friendly agriculture	City	0.0383	0.361	0.718
	County	-0.0241		
Number of employees working for environmental industry	City	0.6524	7.211	0.000
	County	-0.4096		
Rate of increase/decrease in pollutant dischargers	City	-0.0064	-0.061	0.952
	County	0.0041		
Construction waste discharge per capita	City	0.5300	6.014	0.000
	County	-0.3368		
Rate of recycling construction waste	City	-0.0514	-0.377	0.707
	County	0.0049		
Waste water discharge	City	-0.6658	-7.055	0.000
	County	0.3947		
Organic matter discharge	City	-0.5932	-6.058	0.000
	County	0.3517		

The number of workers employed in the environmental industry is an index for representing how much of the industrial activity in the relevant area is related to green growth, in terms of employment. Enterprises in the environmental sector are generally located in counties close to cities. The possibility that a new environmental industry business will appear as well as the distribution of employees working in the environmental industry in rural districts varies with the development of green technology and the expansion of the green product market in the future. What is needed is a green growth strategy for rural districts that can respond to this possibility.

The increase and decrease in the number of pollutant dischargers in a specific area is measured on a scale which represents to what degree the area follows the path of green growth. Seventy-seven (77) cities and counties based on rural and fishery districts showed an increase in the number of pollutant dischargers and fifty-three (53) showed a decrease during the period from 2008 to 2009. It is decided that movement of pollutant dischargers from the city hinterland to the city itself and to counties based on rural districts negatively affects green growth in rural districts.

Waste water discharged from all sorts of economic and domestic activities is a primary factor in causing local environmental pollution. The average waste water discharge per day in cities and counties based on rural districts in Korea is 9,912 m^3/day as of 2007. Mountainous areas, excluding mountains within city boundaries, and counties based on rural districts with a much lower waste water discharge amount are generally located close to the origin of a water system. The protection of water quality is an important task, both for the local environment and for the country’s green resources.

The average amount of organic matter discharged from cities and counties based on rural districts in Korea is 352.0kg/day. The minimum number is 1.1kg/day and the maximum number is 3,393.6kg/day, which indicates a wide spread. Cities, and counties based on islands or mountains, belong to the upper level with regards to waste water discharge, as described above. Areas with a higher population and a greater number of waste discharging firms, discharge more organic matter.

4.2.3. Potential in ‘green consumption’

The areas exhibiting a high index value in ‘green consumption’ are evenly distributed in each region, but rural, forestry and fishing districts of small population tend to belong to the higher index groups. Table 4-25 shows the result of t-examination as to whether there is a significant difference between cities and counties in the average numbers for detailed variables.

Table 4-25. Comparison of detailed variables for 'green consumption' in cities and counties based on rural districts

Detailed variables	Category	Average	t-statistic	Significance
Motor fuel tax	City	-0.7543	-8.922	0.000
	County	0.4736		
Ratio of recycling general waste	City	0.1967	1.936	0.055
	County	-0.1300		
Municipal waste per capita	City	-0.3650	-3.596	0.000
	County	0.2262		

The local tax, motor fuel tax, levied on transport fuels sold in basic local autonomies is a proxy indicator which shows fossil fuel consumption in the relevant area. This data reveals that the annual average motor fuel tax levied in the cities based on rural districts was higher than the tax levied on islands, and in mountainous areas with low levels of traffic. For the green growth strategy in cities, a key task is to reduce GHG generated by transportation and to reduce petroleum consumption, but this task may be relatively less important in the rural districts.

The average ratio of recycling general waste in cities and counties based on rural districts is 42.3% in 2009.

An easily approachable and practical task among those tasks required for green growth of rural districts is to construct facilities and organizations for promoting recycling general waste in basic local autonomies.

As of 2009, average municipal waste per capita discharged in cities and counties based on rural districts in Korea is 0.88kg/person·per day. The minimum value is 0kg/person·per day and the maximum value is 1.98kg/person·per day. The basic local autonomies of rural districts should first expend effort to create recycling facilities so as to reduce the amount of discharged municipal waste. It is necessary for urban-rural integration that cities rather than counties should make more effort to reduce municipal waste. It is also necessary that provinces such as Gangwondo and Gyeongnam, which play host to large numbers of tourists should make still more effort.

4.2.4. Potential of ‘basis of green resources’

Detailed variables making up the green growth potential index on the basis of green resources consists of four factors, being ‘forest areas’, ‘farm land areas’, ‘green ratios’ and ‘river areas’. Most of the areas scoring exceptionally highly on the ‘basis of green resources’ index are located in mountainous areas in Gangwondo and Gyeongbuk. Table 4-26 shows the result of test showing the significant differences in each city and county based on the average of detailed variables.

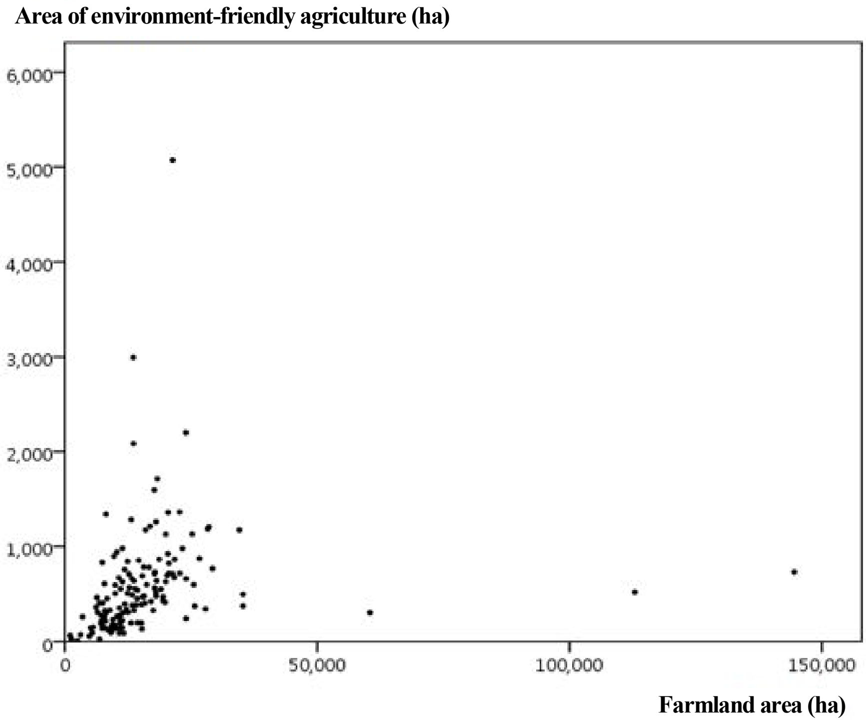
Table 4–26. Comparison of detailed variables of ‘basis of green resources’ in cities and counties based on rural districts

Detailed variable	Category	Average	t-statistic	Significance
Forest area	City Country	-0.1605 0.0668	-1.007	0.316
Farm land area	City Country	0.2091 -0.1314	1.999	0.048
Green ratio	City Country	-0.3482 0.2187	-3.416	0.001
River area	City Country	0.1800 -0.1130	1.714	0.089

As of 2009, the average forest area in cities and counties based on rural districts is 399.2 ㎢, with the total forest area being 1,554.0 ㎢. The region based on rural districts with the largest forested area is Bonghwa-goon with a total of 9,930.4 ㎢. Forests are the most important resource for green growth in rural districts. The forest itself serves as an enormous carbon absorption source, a site for producing biomass, and an eco-tourism resource. Finding a method for realizing economic values at an acceptable level while also conserving forests is the most important task of green growth in cities and counties based on rural districts around the Baekdoo Great Chain.

As of 2009, the nationwide average farm land area in cities and counties based on rural districts is 116.4 ㎢. Bonghwa-goon has the largest farm land area of 1,445.2 ㎢. There is no correlation between the farm land area in cities and counties based on rural districts and the area of environment-friendly agriculture (Figure 4-15) given that the correlation coefficient is only 0.164. Thus, an important task is to revitalize environment-friendly agriculture in basic local autonomies with a large farm land area where environment-friendly agriculture is little practiced at present.

Figure 4-15. Distribution of farm land areas and environment-friendly agriculture areas in cities and counties based on rural districts



The ratio of green space represents of greens with respect to the entire area for urban planning with respect to the entire area for urban planning. In this case, the definition of green space is set out according to the National Land Planning Act. In the current act, the principle is that the ratio of green space with respect to the entire area for planning should wherever possible be greater than 30%. In this study, the ratio of green space to entire area in cities and counties based on rural districts is the ratio of green areas with respect to the entire area of the relevant region. It is deemed highly probable that a high ratio of greens represents benefits in conserving soil and improving scenery. As of 2005, the nationwide average ratio of greens in cities and counties (based on rural districts) is 71.5%. The average ratio of green spaces to total area in cities is 64.8%, with the corresponding ration in counties being 72.0%. It is necessary that cities and counties based on rural districts for which urbanization has been completed or is underway should seriously reexamine the ratio of green space to total space when establishing their urbanization plan.

As of 2005, the nationwide average river area in cities and counties based on rural districts is 13.6 ㎢. However, cities and counties with extensive river areas are located around the Namhan River, the Bookhan River, the Nakdong River, the Geum River, and the Imjin River. While, it is not reasonable to state that the volume of green growth resources is directly proportional to the river area, the river areas remain very important green resources by virtue of the various special functions and roles they play in rural districts. Therefore, in order to conserve the basis of green growth it is important to manage river water quality.

4.2.5. Potential of 'environmental quality of people's living'

The detailed variables, consisting of the green growth potential index in this category, are four (4) in number, being the 'installation of sewage pile lines', 'increase/decrease in bike lanes', 'the number of environmental pollutant dischargers' and 'park area per capita'. Table 4-27 shows comparison of cities and counties for these detailed variables. For two variables, namely the 'installation of sewage pipe lines' and 'increase/decrease in bike lanes', cities revealed higher standard values than counties. The other two variables, namely 'the number of environmental pollutant dischargers' and the 'park area per capita' are usually dependant on industrial structure and the geographical conditions of each area, but are also determined by the finances of the basic local autonomy.

As of 2009, the nationwide average installation of sewage pipe lines in cities and counties based on rural districts was 67.8%. The highest installation ratio of sewage

Table 4-27. Comparison of detailed variable of 'environmental quality of people's living' in cities and counties based on rural districts

Detailed variable	Category	Average	t-statistic	Significance
Installation of sewage pipe lines	city	0.3163	3.000	0.003
	county	-0.1915		
Increase/Decrease in bike lanes	city	0.2325	2.068	0.041
	county	-0.1066		
Number of environmental pollutant dischargers	city	0.0941	0.889	0.376
	county	-0.0591		
Park area per capita	city	-0.0038	-0.036	0.971
	county	0.0024		

pipe lines was for Seocheon-goon at 164.0%. The average installation of sewage pipe lines in cities was 71.9%, slightly higher than the 62.2% for counties. Such a difference is significant within the 5% of statistical significance level. The lower ratio of installation of sewage pipe lines in counties based on rural districts, as compared to cities, suggests that the central government should provide more support to the basic local autonomies which have fewer financial resources so as to improve the environmental quality of people's living in these areas.

For one year from 2008 to 2009, the nationwide extension of bike lanes showed an average 78.1% increase in cities and counties based on rural districts. The average increase and decrease in bike lanes in cities was 87.7%, and 73.2% in counties. A primary factor in deciding the value of this variable is the financial capacity of a basic local autonomy, as it is in the installation of sewage pipe lines.

As of 2005, there were 85,592 environmental pollutant dischargers located in cities and counties based on rural districts all over the country. Which means that on average each city and county had approximately 576 environmental pollutant dischargers. The data revealed that Gangwondo and Chungnam had relatively more environmental pollutant dischargers. However, it was not the case that counties and cities with many manufacturing companies had many environmental pollutant dischargers. It was shown that many environmental pollutant dischargers were located in Gangwondo and Taean-goon. Choongnam, where Taean-goon is located, has a national park, thus environmental regulations specified for prescribing environmental pollutant dischargers are highly detailed and strongly enforced. In other words in this area environmental pollutant dischargers must be recorded in great detail for the purpose of environmental protection.

As of 2005, the average park area per capita in cities and counties based on rural districts is 30.1 ㎡. Gyeryong city has the largest per capita park area of 225.5 ㎡. One thing areas with a large parkland area per capita have in common is that they are close to metropolitan cities or urban-rural integration cities. Both are local autonomies with a need to secure large parkland areas while having the financial capacity to do so.

Green Growth in Agriculture and Rural Districts by International Organizations and Major Countries

Chapter 5

International society has recently taken to discussing green growth but in fact green growth policies of various kinds have been promoted for some years now. Chapter five will describe the details of discussions on green growth carried out by international organizations, e.g., OECD and UNESCAP. It will also explore the green growth policies for the agricultural sector as promoted by major countries including the USA, UK, Australia and Japan. The case of EU Natura 2000 will be described, which is a case of exemplary green growth in rural districts.

1. Trend of discussion on green growth of the agricultural sector by international organizations

1.1. Green growth of the agricultural sector of OECD

The OECD has organized joint working parties for each sector since early 1990s. These joint working parties were tasked with finding policy approaches for a paradigm conversion to sustainable growth and to act as forums for member countries to discuss green growth.

From around 2004 onwards the Environment Directorate and the Agriculture Directorate have been discussing measures in connection with discussions on environmental issues, including coping with climate change and global warming as well as measures for abating GHG.

In particular, the Joint Working Party of Agriculture and the Environmental Policy Committee prepared consultation reports on the mitigation of, and adaptation to, climate change of the agricultural sector in 2007. A related report, an in-depth review by member countries, was announced in 2009.

Full scale discussion on green growth in the OECD can be dated back to the Ministerial Council Meeting in June, 2009 when Korea put forth a proposal on a "Declaration on green growth". The proposal was unanimously approved. The OECD selected green growth as a core task for both alleviating GHG and achieving economic growth; both of which are the subject of lively discussions in the environmental agricultural sectors. In particular, the OECD announced the 'Interim Report for Green Growth Strategies' (OECD, 2010) as a follow-up measure to the Declaration on green growth voiced in the OECD ministerial meeting of May 27 to 28, 2010. The Interim Report for Green Growth Strategies describes the background for promoting green growth with the accompanying framework, key program factors, measurement methods and dissemination strategies.

The OECD selected green growth as a key task for the agricultural sector if it is to efficiently handle climate change, move towards a sustainable society and meet the accompanying economic system requirements in the Agricultural Ministerial Conference in February, 2010. The necessary follow-up measures were designated as a core task by the Agricultural Committee in 2011/12.

The Joint Working Party of the OECD Agricultural & Environmental Policy Committee included the green growth of the agricultural sector as a primary agenda topic in the 30th JWP meeting (June 28 to 30, 2010 Paris, France). This Joint Working Party discussed how best to systematically handle in-depth green growth of the agricultural sector. From the discussion arose the decision to explore and further discuss issues related to green growth. This was deemed necessary as a response to the Synthesis Report on Green Growth by the Ministerial Council in 2011. It was then proposed to hold an OECD expert meeting on the green growth of the agricultural sector in Korea, April, 2011, in Korea order to comprehensively and systematically handle green growth of the agricultural sector, which had already been fixed at the 31st JWP meeting in December, 2010. More than 20 countries, from among the 30 OECD member countries, participated in the OECD green growth expert meeting of the agricultural and food sectors.

1.2. Trend of discussion on green growth of UN ESCAP

UNESCAP (The United Nations Economic and Social Commission for Asia and Pacific) an organization of the Regional Economic Committee, is dedicated to working for economic development and ending poverty in developing and underdeveloped countries. UNESCAP introduced the term Green Growth in the 5th Ministerial Conference on Environment and Development in 2005 as a label for a means of rapid economic growth that systematically manages the associated environmental burdens, and applies diversified ways of approaching the concept and its dissemination. UNESCAP established a strategy by which economic growth in underdeveloped countries in the Asia/Pacific region can be harmonized with environment by allowing them to forego the process of industrialization. This strategy is entitled the green growth strategy. The keynote of green growth in this instance is characterized by underdeveloped countries in the Asia and Pacific region moving rapidly away from the traditional paradigm of "grow rich, clean up later" to the new paradigm of environmentally sustainable economic growth called "green growth".

Recently, UNESCAP established this paradigm as one focused on green growth, i.e. so that economic growth contributes to ending poverty in the current generation while conserving environmental capacity for future generations. It attempts to do this by adopting a diverse pool of approaches to reducing the seemingly inevitable environmental pressures which result from economic growth. UNESCAP attempts to achieve this by creating synergy effects and win-win solutions between the economy and the environment. It attempts to reduce the environmental pressures of economic growth by several means: improving the eco-efficiency of production and consumption patterns, promoting changes in the concept and the system for integration and finally producing a synergy effect that will enhance both environmental and economic policies. By doing so UNESCAP hopes to successfully achieve green growth.

To achieve the successful promotion of green growth UNESCAP emphasizes a governance approach based on appropriate role sharing between government, the private sector and citizens. UNESCAP recommends that the government should play the leadership role in converting the prevailing system to one that is low carbon and green. The role of the private sector should be to provide the necessary technical innovation to allow the integration of the environment and economy. Additionally, the private sector should create the synergy effect for both the government and citizens. Citizens, for their part should accept the new paradigm of eco-efficiency and the new lifestyle which accompanies it. The emphasis for achieving green growth is laid on policy tools. These tools include including market-oriented policy measures, e.g., existing commands and control, environmental levies, an emission trading system, and policy mixing, e.g., voluntary agreements. In the private sector, it is recommend innovators be nurtured that will induce people to accept environment-friendly production and consumption. Such innovators would include caretakers responsible for environmental conservation, and promoters for environmental marketing. Each country should pay attention to the aforementioned recommendations and details for promoting green growth.

In UNESCAP, the topic of green growth of the agricultural and rural districts has been under full discussion since 2008. This discussion has been by means of international symposiums and seminars that allowed information exchanges between member countries to take place. In particular, for green growth of the agricultural sector, one approach is to focus on the general and multi-dimensional aspects, e.g., management of environment-friendly agricultural resources and food security that will allow for the mitigation of, and adaptation to, climate change.

An international symposium was held in Bali, Indonesia (October 13 to 14, 2010) with the subject of “Low carbon economy: trade, investment and climate change”. The symposium was a forum for in-depth discussion on green growth, including measures for climate change in the agricultural sector and a low-carbon agricultural production system.

The symposium recommended a scheme whereby governments provide incentives to the private sector to persuade it to act as an efficient means of mitigation, while not overlooking the fact that market organization has an important role to play in alleviating GHG. It also laid emphasis on the importance of scientific and reliable approach to carbon footprinting, despite the carbon footprint system being important in trade.

The symposium proposed the necessity for appropriate measures for open trade in the multiparty trading system plus inter-region and bilateral trade in order to promote trading and investment of climate smart goods and services. The symposium laid emphasis on using more definite terms and establishing the concept (although similar concepts including green growth, low carbon and the like have been presented), and on the promotion of green growth in connection with food security as an important task of the agricultural sector. In particular, the symposium recommended step-by-step interim and long-term approaches on the understanding that green growth is not a special scheme promoted by specific countries, but by many countries, and that it takes a lot of time to achieve the objectives.

2. Cases of promoting green growth of the agricultural sector in major countries

2.1. USA[29]

2.1.1. GHG emission and sinks in agricultural sector

As of 2007, 7,150 million tons of CO_2 were emitted as GHG in the USA. From 1990 to 2007, US emissions increased by 17%. The volume of GHG emitted by the US agricultural sector alone is 413 million tons of CO_2, or 5.8% of the entire volume. The primary GHGs emitted by the agricultural sector are methane and nitrous oxide, which comprise 46% and 53% respectively of the agricultural sector's total GHG emissions. The trend in these emissions is to increase by 0.6% and 0.3% per annum, respectively. Meanwhile, as shown in Table 5-1, the primary carbon sinks in the American agricultural sector were conservation of farm land and the conversion to green spaces. As of 2007, conservation of farm land contributed to absorption of 19.7 million tons of CO_2 while the conversion to green spaces contributed another 26.7 million tons of CO_2 absorption.

Table 5–1. Carbon sinks in agricultural sector (million tons of CO_2)

Sinks	2004	2005	2006	2007
Conservation of farm land	18.1	18.3	19.1	19.7
Conservation of greens	4.5	4.6	4.6	4.7
Conversion to greens	26.7	26.7	26.7	26.7
Total	43.4	43.7	44.5	45.2

Source: Excerpted from EPA (2009).

29 The details of strategies for promoting green growth of the agricultural sector in America are excerpted from the report prepared by Professor Susan Capalbo, Oregon State University.

2.1.2. GHG Reduction Technology and Carbon Mitigation Potential for the Agricultural Sector

A. GHG Reduction Technology

Agriculture can play an important role in reducing GHG by means of conversion of agricultural techniques and the reduction of methane and nitrous oxide emitted from soil. Exemplary agricultural techniques and technologies that can reduce GHG emissions include a conversion to conservation tillage, a conversion to grassland, improved grazing land management, buffer forests, alternative bio-fuel crops, improved fertilizer management, livestock feces and urine, etc. Of these techniques and technologies, conservation tillage plays the most important role in fixing carbon (Table 5-2). Such technologies for reducing GHG are categorized as follows: technology for carbon sequestration in soil, technology for reducing GHG generated by agro-dairy farming and technology for producing bio-energy. Technology for soil sequestration of carbon includes technologies for abating GHG generated in soil using feasible technology. The details of the agricultural techniques and technologies are described below in Table 5-2.

Table 5-2. Technologies for soil carbon sequestration

Farm land	Grazing land	Agricultural technique
- Conversion to perennial grass - Recovery of swamps - Conservation of buffer forests - Bio-energy crops	- Management of grazing land - Management of grass land	- Conservation tillage[30] - Precision agriculture techniques - Crop rotation and winter cover crops - Maintenance of irrigation facilities

Source: See some details of EPA (2005) and CCTP (2006).

Apart from technologies for soil carbon sequestration, there are some technologies for directly abating GHG generated in agro-dairy farming (Table 5-3). Nitrous oxide is generated in tillage due to the excessive use of nitrogen fertilizers and so there is a need for technologies for enhancing efficiency of used nitrogen fertilizers while maintaining productivity. An exemplary technology is precision agriculture, which is

[30] Conservation tillage is for minimizing surface derangement in managing crops and other crop residuals on the ground surface and is represented by no-till and strip-till, and includes methods such as the use of air-seeders and manure injectors.

using agricultural information to input only those agricultural elements most suitable for the condition of the growing crop. Exemplary technologies for eliminating methane generated from livestock manures include anaerobic digesters, anaerobic manure composting, physical immersion, etc. Meanwhile, an exemplary technology for reducing methane emissions from livestock enteric fermentation would be the improvement of feed absorption rates using growth hormones, etc. The production of bio-fuel crops contributes to reducing GHG by replacing typical fossil fuels, with related technologies include the utilization of food residuals as well as bio-fuel production, using switch grass, poplars, etc.

Table 5-3. Technologies for reducing GHG in the agricultural sector

Abate nitrous oxide, by managing soil and fertilizers	Abate methane and nitrous oxide by managing livestock manures	Abate methane from livestock enteric fermentation	Bio crop production
- Precision agriculture - Management of fertilizers and agricultural chemicals - Biochemical method (lime treatment) - Utilization of livestock manures - Breeding new varieties	- Anaerobic digesters - Anaerobic livestock manure compost - Physical immersion - Reduce the use of nitrogenous fertilizers	- Improve feed absorption rates (growth hormone). - Use intensive grassland. - Improve management of animal feed.	- Use biomass residuals. - Bio-crops, e.g., switch grass, poplars, etc.

Source: See some of EPA (2005) and CCTP (2006).

B. Carbon mitigation potential

Carbon mitigation potential means the volume of abatable GHG with respect to the volume of baseline GHG when applying feasible agricultural technologies and techniques. As shown in Table 5-4, by converting to conservation tillage it is possible to reduce soil CO_2 emissions by 95.5 million tons the reduction for no-till farming is 107.3 million tons of CO_2. A 15% reduction in the use of nitrogen fertilizers would reduce CO_2emissions by 62.8 million tons. Meanwhile if the raw material of nitrogen fertilizers were converted from ammonia to urea this would reduce CO_2 emission by another 53.3 million tons. The abatable CO_2 volume by agroforestry for example by the use of windbreaks, alley cropping, alley livestock farming (silvopasture), etc. is presumed to be 281.4 million tons. . It was calculated that short-rotation woody crops[31] could abate 274.2 million tons of CO_2.

Table 5-4. Carbon mitigation potential in American agriculture

Unit: million tons of CO_2/year

Conservation tillage	No-till farming	Reduction of nitrogenous fertilizers	Change raw material of nitrogenous fertilizers	Diversified crop rotation	Perennial crop rotation	Winter cover crop	Forest agriculture	Short-rotation woody crops
95.5	107.3	62.8	53.3	79.7	57.7	113.6	281.4	274.2

2.1.3. Low carbon, green growth policies in the agricultural sector

A. Carbon abatement policies in agricultural sector

The carbon abatement policies in the agricultural sector currently carried out by the federal government are divided into two classifications: programs for fallow land and programs for cultivated land.

Fallow programs are for converting existing farmland to grassland, wetland and forest, some examples being the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP), and Grasslands Reserve Program (GRP) (Table 5-5).

The programs for cultivated land aim to improve land management by converting agricultural techniques or methods of tillage. Exemplary programs include the Environmental Quality Incentives Program, the Conservation Stewardship Program, etc. CSP is a policy for paying a given amount of money to farmers who produce environmentally sensitive crops, to encourage them to cultivate cover crops for the contract period of 10 to 15 years. Farmers who participate in CRP can sell carbon credit in the carbon market to create earnings.

As of 2007, it is estimated that CRP had abated 59.6 million CO_2 tons of GHG. As of 2007, the Wetlands Reserve Program (WRP), a program to encourage land owners to protect or recover wetland, is estimated to have abated 0.18 million CO_2 tons of GHG. The Grasslands Reserve Program (GRP) aims to prevent grassland from being used for producing other crops so as to improve biological diversity, and

[31] The short term woody crop system is to plant fast-growing trees in farmland and grassland then to harvest them in a period of 3 to 5 years to produce fuel and bio-oil.

is estimated to have abated 0.007 million CO_2 tons of GHG. EQIP, meanwhile, is a program for supplying subsidies to farmers who make efforts to conserve the environment by adopting residual management and fertilizer management practices and by using covering crops, in the process of farm operation. This was estimated to have abated 3.9 million CO_2 tons of GHG. The US Department Of Energy (DOE) is carrying out a number of programs for producing bio-fuel from bio-crops, woodchips and crop residuals, and it is presumed that this bio-energy technology has the potential to abate 55.2 million CO_2 tons of GHG in 2020.

Table 5-5. Potential for carbon mitigation by agricultural policies of USA

Policies	Related greenhouse gases	Performance authority	Abatement effect	
			2007	2020
CRP	CO_2 ,N_2O	USDA	59.6	53
WRP	CO_2 ,CH_4, N_2O	USDA	0.18	0.25
GRP	CO_2 ,CH_4, N_2O	USDA	0.007	0.03
EQIP	CO_2 ,CH_4, N_2O	USDA/NRCS	3.9	14.2
Biomass Program	CO_2	DOE	0	55.2

B. Carbon emission trading market

Meanwhile, apart from these policies, more and more farmers using conservation tillage practices are voluntarily participating in the carbon trading system through the Chicago Climate Exchange. As of 2009, approximately 10,000 farmers in 35 states were participating in the Chicago Climate Exchange and the off-board market. Table 5-6 shows that the trading volume was approximately 65 million CO_2 tons, that is, 331 million dollars as of 2007.

Table 5-6. Traded CO_2 tons and trading volume in the agricultural sector in the carbon market

Market	Traded CO_2 (million CO_2 tons)		Trading volume (million dollars)	
	2006	2007	2006	2007
Chicago Climate Exchange	10.3	22.9	38.3	72.4
Other off-board market	14.3	42.1	58.5	258.4
Total	24.6	65.0	96.7	330.8

Source: Hamilton *et al* (2008).

2.1.4. Future technologies and strategies to adapt to climate change

A. Future technologies and strategies

The United States is doing research and development on how to cope with climate change with two programs; Climate Change Science Program (CCSP) and Climate Change Technology Program (CCTP). The second of these, CCTP, presents interim and short-term future strategies for developing the technology that promise to reduce soil carbon, reduce GHG emissions (excluding carbon dioxide) in livestock farming, and reduce carbon in bio-energy production (Table 5-7).

Future strategies for abating soil carbon include the quantification of carbon abatement potential depending on land use, the maintenance of management systems for satisfying economic efficiency and environmental conservation, the development of bio-energy and bio-products and the development of biomass related technologies, etc. The short-term strategy pursues carbon abatement by means of agricultural techniques for soil conservation, while the interim strategy is based on soil absorption and land use, which holds out the promise of large scale carbon abatement. To reduce nitrogen oxide emissions generated from the application of fertilizers, the short term strategy focuses on precision agriculture while the interim strategy demands the development of technologies for enhancing the efficiency of nitrous fertilizers.

Meanwhile, to abate methane and nitrous oxide emissions generated from livestock manures, the short term strategy is to improve facilities for manure storage and separation. The intermediate and long-term strategies focus on improving the biological efficiency of, and facilities for, intensive anaerobic treatment. Reducing methane generated from livestock enteric fermentation requires in the short-term the development of technologies for enhancing feed absorption rates. In the intermediate term, the need is to improve the grassland management system for enhancing feed productivity and digestion rates. In-depth understanding is required to correlate the relationships between methane, CO_2, nitrogen, etc., in the agricultural environment. In the bio-energy sector, what is required is to develop technology for reducing the cost of biomass harvesting and storage in the intermediate term. It is predicted that by these means that a nationwide supply of bio-energy will be achieved.

Table 5-7. Plan for future strategy

Strategy	Short-term	Intermediate term	Long term
Abate soil carbon	- Soil conservation	- Soil absorption and use of soil - Relation among GHG - Renewable and bio-products	- Large-scale abatement of carbon
Abate GHG other than CO_2	- Anaerobic digester - Precision agriculture - Improve the efficiency of producing livestock products	- Relation among GHG - Improve digestion rates by genetic manipulation	- Pollution-free agriculture
Bio-energy production	- Early bio-chemical industry - Bio-diesel - Early lignocellulosic bio-fuel production	- Advanced bio-chemical industry - Lignocellulosic bio-fuel production - Reduce cost for biomass harvesting and storage	- Nationwide supply of renewable energy

Source: CCTP (2006).

B. Strategy for adapting to climate change

Global warming is the phenomenon in which worldwide temperatures have increased over the last 50 years. The resulting climate change will affect entire industries, including agriculture. Therefore, there is a need to adapt to these changes, which are seen as inevitable despite abatement efforts, and so avoid the worst effects. Adaptation will require the development of appropriate strategies.

There has been a great deal of research done on the impact of climate change on agriculture, and from that research the following four major impacts can be derived. Firstly, localized heavy rain and drought will reduce crop yields. Secondly, the incidence of weeds, diseases and harmful insects will increase due to global warming, which will also reduce crop yields. Thirdly, the quality of livestock feed will be reduced with the increasing carbon concentration. This is due to the fact that increasing CO_2 concentration will have a negative influence on the nitrogen and protein contents of crops. Fourthly, the increasing temperature and climate deviations will have a negative influence on the production of livestock products.

To cope with dangerous climate change, it is necessary that farmers use sustainable agricultural techniques. Well and Smit (2005) presented four strategies for managing dangerous climate changes, which are described below.

Firstly, farmers can cope with dangerous climate changes, e.g., drought, by cultivating perennial crops and a variety of new crops with greater tolerance for drought.

Secondly, conservation tillage both reduces soil erosion and increases soil moisture, both of which will reduce the influence of climate change on the soil.

Thirdly, it is necessary to improve the efficiency of irrigation facilities and more effectively manage water resources.

Fourthly, individual farmers can reduce earnings deviations brought on by climate change by business diversification under a modified agricultural production system that would allow this.

The state governments, for their part, are also putting forward a variety of strategies to adapt to climate change. The California State government's intermediate and short-term plans for each strategy are listed below (Table 5-8).

Table 5-8. Plan to adapt to climate change (California)

Strategy	Short term	Long term
Supply and conservation of water resources	- Conserve water resources - Manage inundation sources	- Develop winter-hardy crops - Improve the reliability of high quality water provision- Take measures to reduce flood damage - Increase the moisture content in soil
Prevention of diseases and harmful insects	- Quarantine - Nationwide control	- Continuous research and development
Plan for using land	- Policy integration	- Abatement of carbon by farmers
Increase biological diversity in agriculture	- Technology support and penetration - Bio-energy	- Climate-adapted crops and mixed cultivation of crops - Diversify crops - Economy assessment system for improving eco-service

Source: California Natural Resource Agency (2009).

2.1.5. Eco-efficiency analysis for the agricultural Sector[32]

As of 2007, the eco-efficiency index of USA stands at $1,930/million CO_2 tons, or

[32] An eco-efficiency is a value found by dividing actual GDP in each sector by the amount of carbon emissions in each sector shown in carbon emissions. Inventory of the U.S. GHG emission and sinks, and GDP data was sourced from the U.S Census Bureau.

in 32nd place among the top 40 countries (including OECD countries), and its eco efficiency is increasing at a rate of 2.1% of per annum. The eco-efficiency in the agricultural sector is $225.5/million CO_2 tons. This is more than the transportation sector ($161/million CO_2 TONS) but less than the industrial sector ($2,532/million CO_2 TONS).

The eco-efficiency index of each economic sector in USA shows a positive increase, which means that the American economy is being converted to green growth. However, the increase of the agricultural eco-efficiency index at 2% is considered low. This is because the annual increase in GHG emissions in the agricultural sector is 0.42%. This is higher than the industrial sector (0.08%), but lower than both the transportation sector (1.41%) and the national average (0.86%). The GDP growth rate of the agricultural sector is 2.5%, which is lower than the industrial sector (2.9%), the transportation sector (4.1%) and the national average (2.9%). Therefore, considering the slow increase in the rate of GHG emissions in the agricultural sector, analysis shows that the low GDP increase rate is the primary cause of the low rate of increase rate in the agricultural eco-efficiency index. The eco-efficiency index increase rate in the industrial sector is 2.9%, which is a GDP growth rate lower than the transportation sector. However, the sector still shows the highest rate of increase on the eco-efficiency index due to insignificant changes in GHG emissions. In contrast, the transportation sector, which shows the highest GDP increase rate, has a smaller increase rate, at 2.7%, on the eco-efficiency index because of the high rate of increase in GHG emissions.

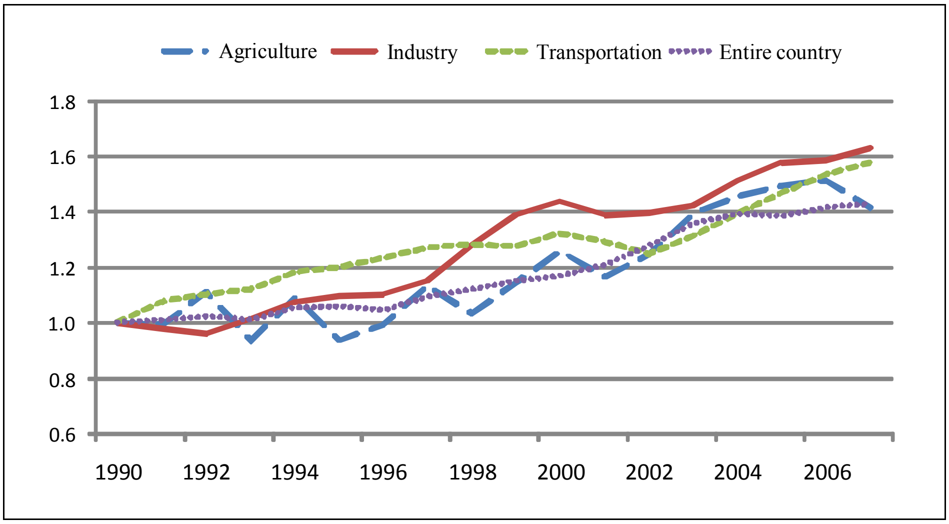
Table 5-9. Eco-efficiency index of USA (1990 to 2007)

Year	Eco-efficiency index ($/million CO_2 TONS)			
	Agriculture	Industry	Transportation	National average
1990	190.6	1,551.5	126.5	1,352.9
1991	188.9	1,522.5	136.0	1,367.0
1992	211.7	1,493.2	139.6	1,381.6
1993	177.9	1,574.5	141.9	1,369.4
1994	207.6	1,668.6	149.5	1,429.2
1995	178.2	1,706.3	151.8	1,431.1
1996	189.2	1,708.6	156.2	1,410.6
1997	215.7	1,789.7	160.9	1,479.4
1998	196.5	1,981.8	162.3	1,512.2
1999	217.7	2,151.4	161.5	1,559.7

Year	Eco-efficiency index ($/million CO_2 TONS)			
	Agriculture	Industry	Transportation	National average
2000	239.3	2,229.4	167.4	1,581.9
2001	221.8	2,153.7	163.5	1,635.5
2002	237.9	2,167.1	158.0	1,731.8
2003	265.7	2,210.1	166.2	1,836.4
2004	277.4	2,345.4	176.5	1,884.0
2005	285.1	2,446.8	186.1	1,871.7
2006	287.7	2,466.2	194.4	1,917.0
2007	269.5	2,532.0	199.6	1,930.1
Average	225.5	1,983.3	161.0	1,593.4
Increase rate	2.0%	2.9%	2.7%	2.1%

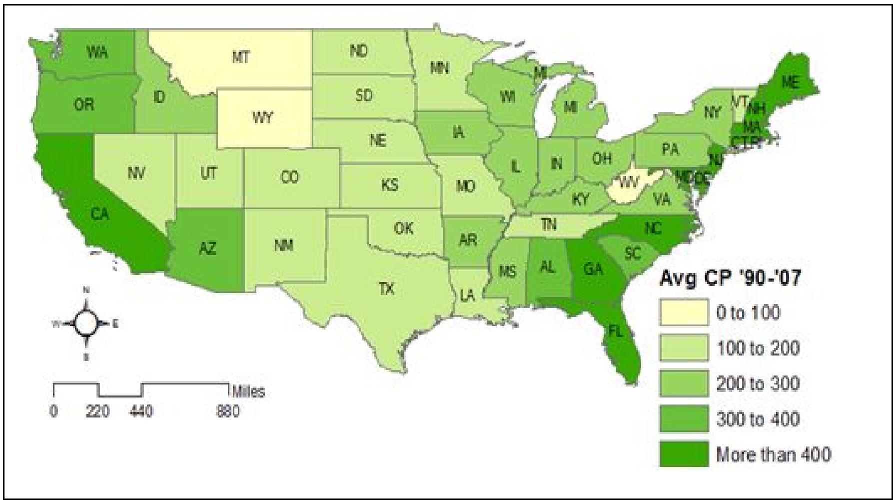
As shown in Figure 5-1, the eco-efficiency in the agricultural sector continues to increase, however this increase has greater annual variation than in other sectors. The primary cause of this is wide variations in agricultural sector GDP due to climate variations, government intervention in the sector and other economic situations, taking into consideration the slow increase rate of GHG in the agricultural sector.

Figure 5-1. Eco-efficiency index (1990 to 2007) (1990=1.0)



With respect to the agricultural eco-efficiency index in each state, the average eco-efficiency index of 13 states (including Maryland, New Hampshire and Georgia) is \$400/million CO_2 TONS or two times the average agricultural eco-efficiency index of the USA. In contrast the states of West Virginia, Montana, and Wyoming showed an eco-efficiency index lower than \$100/million CO_2 tons (Figure 5-2).

Figure 5-2. Average agricultural eco-efficiency index in each state (1990 to 2007)



Since the eco-efficiency index does not include GHG generated as a by-product in the process of production, efficiency may be over evaluated. The Malmquist-Luenberger (ML) productivity index[33] is a method employed to complement a disadvantage of this nature. When ML is employed the increase rate of the agricultural eco-efficiency index was shown to be 1.3%. This means that American agriculture is changing rather slowly towards a green growth economy. Additionally, it was shown that technical changes were the most important factor for changes in the ML productivity index. Great deviations were apparently in the annual average ML productivity for each state, e.g. Alaska showed a 2% decrease while Arizona showed a 7% increase.

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[33] Malmquist-Luenberger (ML) productivity index = MLTECH (technology change) x MLEFFCH (efficiency change).

2.2. United Kingdom

2.2.1. Greenhouse gas emissions and the target for abatement

The land area of UK (as of 2008) is 24 million ha, of which grassland makes up 43% at 10.4 million ha, farmland is 25% of 6.1 million ha and forests are approximately 12% at 2.8 million ha. The economically active population related to the agricultural sector is approximately 200,000, which is 2.2% of the entire economically active population and showed a 15% decrease over a ten year period. Primary agricultural products of UK are livestock (lambs and cattle largely) products, grains, dairy products, etc.

As of 2008, UK GHG emissions generated from agriculture and other land uses stands at 46.4 million CO_2 tons, which is 7.4% of total GHG emissions.

Analysis suggests that GHG from the agricultural sector is emitted mainly from livestock and chemical fertilizers in the crop farming sector, with the remainder arising from natural changes in carbon balance due to changes in the methods of using and managing land.

The UK established a target abatement of 12.5% (with respect to 1990) for GHG emissions during the first commitment period (2008 to 2012). This was in accordance with a burden sharing agreement between EU members. In addition to this international commitment, the UK government has adopted a 20% national abatement target with respect to the reference by 2010 and has declared an ambitious target abatement target of 60% by 2020 based on 1990.

2.2.2. Strategies for promoting green growth[34]

The UK government is positively promoting policy programs to make farmers' and UK citizens more aware of global environmental issues. The UK government has established and operates the Rural Climate Change Forum (RCCF). The RCCF acts as a venue where workers in charge of policies, farmers and other parties concerned about global warming can meet to share common experience as a part of

[34] The strategy for promoting green growth of the agricultural sector in UK was prepared by a researcher who visited the department of Future Strategy of Defra to collect data and interviewed staffs in charge in the related fields from Sep.12 to 18, 2010.

the related programs.[35] It is known that this forum contributes significantly to policy making (e.g., practical measures and the development of communication strategies, the effective penetration of climate change programs, etc.) for reducing GHG emissions.

With enforcement of the Climate Change Act in 2009 and the Low Carbon Transition Plan in 2009, national policies have been refocused on the abatement of GHG. According to UK government's Low Carbon Transition Plan (UK LCTP), emissions in the agricultural sector will be reduced by 3 million CO_2 tons per annum, a figure which corresponds to 11% of the UK agricultural sector's emissions in 2007. The UK LCTP was requested to establish an action program at which level the mandatory emission reduction goal of farmers in Britain will be achieved. The government believes that that this kind of approach is the most effective method for achieving GHG reduction. Farmers actively take measures to combat climate change, e.g. livestock emissions reduction, modifications in the use of fertilizers and other factors. Farmers are also making an effort on technical aspect for GHG mitigation. Farmers are attempting to lower the carbon intensity in the energy sector by developing renewable energy and, enhancing energy efficiency. They are producing the raw material for producing low carbon materials. They are also storing carbon in the soil and in forested areas. UK government prioritized three tasks to promote the green growth of the agricultural sector as a means of coping effectively with climate change and to ensure continuous agricultural economic development. The government then announced the Draft Structural Reform Plan for diversified policy projects in July, 2010.

The first task is to support and develop agriculture in Britain, and encourage the production of sustainable food. In practice, this means supporting and strengthening both the sector's competitive power and the resilience of the entire food chain (including the agricultural and fishery industry) so as to ensure an environmentally sustainable and healthy food supply and improve animal welfare standards.

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[35] Rural Climate Change Forum (RCCF) was first founded in March 2005 and planned to be finished in October, 2008. However, the minister of Defra extended the period of RCCF to March 2011, on October 17, 2008. At the beginning, there were 8 member groups in the Forum but three more joined in October, 2008, totaling 11 members. The original 8 members are National Federation of Farmland Business, the Environmental Protection Agency, the Forest Committee, the Carbon Trust, the National Trust for the National Farmers' Organizations, the Nature UK, and the Royal Society of Protection of Birds and the three added are the Federation of Agricultural Industry, the Soil Association, and the Sustainable Development Commission.

The second task is to promote the environment and bio-diversity for improving the quality of life. In practice, this means reducing pollution, preventing habitat destruction and loss and protecting the natural environment (including bio-diversity and the marine environment).

The third task is to support measures designed to bring about a strong sustainable green economy and combat climate change. In practice, this means recommending businesses, places, people and local societies manage and use natural resources in a sustainable way, and reduce waste. These measures will support Britain's economy and allow it to cope more efficiently with climate change.

The UK Department for Environment, Food and Rural Affairs (DEFRA) announced the Greenhouse Gas Action Plan (GHGAP) in February, 2010. GHGAP is intended to reducing GHG emissions in the agricultural and industrial sectors. GHGAP was prepared by a task force consisting of authorities associated with the agricultural sector and finalized after discussions with the industries concerned.

GHGAP's objective is to enhance the efficiency of use and productivity of resources. It seeks to achieve this by feasible but resolute actions to reduce GHG emissions and to benefit farmers by encouraging the use of renewable energy for agricultural production. To this end, it specifies the measurement, reporting and verification of the contribution of the carbon budget to GHG mitigation during the period of 2018 to 2022. GHGAP aims at realistic studies which can induce changes in policies and the knowledge base and also requests regular modification and innovation. The operation of GHGAP is made up of two steps. The first step is to promote more effective management by the development and dissemination of an efficient management. The second step is detailed implementation planning to achieve the objectives.

The effort for reducing GHG will attempt to penetrate all sectors in rural districts by means of diversified methods and routes. Importantly, it will seek to clarify necessary actions so that people highly interested in improving agricultural efficiency can participate in reducing GHG through continuous communication with experienced people in each sector.

The UK's Agriculture and Horticulture Development Board (AHDB) and industry will jointly work out a method to allow additional government funds to fit existing plans. Through such a process, it is possible to present the differences between planning and implementation through an agricultural consulting service provided by the government. Consulting and information exchange will contribute to reducing

CO_2 emissions by means of energy efficiency and renewable energy, and to reducing nitrous oxide and methane emissions through consulting related to existing agricultural efficiency. For successful GHG action plans, since the quality and quantity of communication is very important, i.e. an advice and information exchange service.

One of Defra's organizational responsibilities is to investigate measures for reducing methane emissions in the agricultural sector. It is therefore promoting a soil management program. This program has three components; handling the issues of proper soil management, the conservation of related soil resources and reversing soil vulnerability to soil carbon loss. Defra encourages action to halt the reduction of organic matter which occurs in degraded soils and establishes a standard and cross compliance program in order to prevent soil erosion and keep organic matter in the soil. Defra, having recognized the contribution of organic farming to reducing GHG under conditions of climate change, is positively promoting policies supporting organic farming. However, there is debate over whether more scientific studies are needed to find out how much organic farming contributes to reducing GHG. Defra, first established in November, 2004, has promoted both the 'Strategy for Non-Food Crops and Uses', and the 'Strategy for Bio-resources' since 2007. Both programs seek to developing sustainable agriculture, rural districts and expand renewable energy production. The key projects for bio-energy measures include the construction of infrastructure, a five year subsidy for farmers who produce bio-energy crops and support for the development of next-generation bio-fuel technology, etc. The 'UK Bio-resource Task Force' was created in order to support the development of sustainable agriculture and rural districts and permit renewable energy targets to be met. The 'UK Bio-Resource Task Force' assists both government and industry in ensuring that bio-resource energy is optimally developed. An individual payment is also provided to farmers who cultivate energy crops on abandoned farmland. In addition, the Task Force supports research and development. For example, a significant amount of funding is provided to national policy projects on how to best improve farmland management which can reduce GHG, as well as the use of organic carbon sinks in soil and the like. Defra is promoting strategic studies which investigate the feasibility of, and possible alternatives to, the market mechanism which enables the GHG trading system to operate in the agricultural sector.

2.3. Australia

2.3.1. GHG emissions in Australia

The national land area of Australia (as of 2007) is 772.5 million ha of which the farmland area (including grasslands) is 417.2 million ha, or approximately 54% of the entire land area. The economically active population associated with the agricultural sector is roughly 370,000, or approximately 3% of the economically active population. Australia's agricultural products include barley, livestock meat (mainly cattle and lambs) products and dairy products, etc.

GHG generated from farming and land use in Australia was 88.1 million CO_2 tons, or 16.3% of the entire volume of GHG emissions, as of 2007. GHG emissions in the agricultural sector are the result of livestock farming and the use of chemical fertilizers on cultivated land.

The Australian government set a GHG reduction target of 25% by 2020 with respect to the year 2000.

2.3.2. Measures for climate change

A. Overview of measures for climate change

Australian measures for climate change is laid out in the 'National Agriculture and Climate Change Action Plan'. This plan provides an important framework for climate change policies both for the government and the agricultural sector. This plan was drawn up by means of cooperation and agreement among the federal, the state and the local governments before being completed in a consultation phase with farmers, climate experts and local communities. The Climate Change Action Plan consists of four elements : an adaptation strategy for agricultural system resilience, a strategy for reducing GHG emissions, research and development for coping with climate change, and awareness and communication. Of the four elements, the key strategies are the adaptation strategy and the reduction strategy.

The adaptation strategy to climate change of Australia includes improving agricultural system resilience, improving the capacity of natural resource managers and systems, minimizing the adverse effects of introduced diseases and harmful insects, and seizing advantageous market opportunities etc.

The reduction strategy includes reducing emissions from the agricultural system, improving energy efficiency, developing cost-effective alternatives to using fossil fuels, expanding opportunities for the biological fixation of GHG, and ensuring the investment efficiency of R&D resources, etc (Table 5-10).

Table 5-10. Measures for climate change in Australia

Adaptation strategy	Reduction strategy
▪ Improve resilience of the agricultural system. ▪ Improve the capacity of natural resource managers and systems. ▪ Minimize adverse effect of introduced diseases and harmful insects. ▪ Seize advantageous market opportunities.	▪ Reduce emissions from the agricultural system. ▪ Improve energy efficiency in agriculture. ▪ Find cost-effective alternatives to using fossil fuels. ▪ Expand opportunities for biological fixation of GHG. ▪ Ensure investment efficiency in R&D resources for reducing GHG.

Source: www.daff.gov.au.

B. Adaptation strategy

The Australian government laid out the climate change countermeasures for the primary industry in 'Australia's Farming Future', the essence of which can be summarized as a four year program of financial support over four years to assist primary producers in adapting themselves to climate change. 'Australia's Farming Future' has three elements; a Climate Change Research Program, a Climate Change Adjustment Program and FarmReady.

The first of these, the Climate Change Research Program funds research projects and farm experiments with the objective of assisting the agricultural sector in adapting to climate change and in coping with whatever the future may hold. The focus of this program is on research that will reduce GHG, improve soil management and help agriculture adapt to climate change. The results of this research will be practical management solution for farmers and agriculture. This program supports large-scale joint projects that include many organizations, e.g., research institutes, industrial groups, universities and state governments. As a result, it promotes the development of individual strategies for enhancing producers' adaptation and resilience to climate change. According to the climate change research program, many adaptation schemes have been studied and developed which are of practical use to farmers (Table 5-11). In the field of crop varieties and R&D, there is a trend towards the increased development of a variety portfolio and cultivation methods, especially in relation to planting times under changing weather conditions. Utilizing and improving weather observation can be applied to weather forecasts, seasonal forecasts, and abnormal weather forecasts (e.g., drought) as well as a series of agricultural activities, including variety selection, seeding for cultivation, control of diseases, weeding, harvesting, inventory liquidation, etc. The field of assessing and studying the impact of climate change includes studying the impact of prolonged dry seasons and high temperatures on the ecosystem of harmful insects and using the result to develop solutions. Other high tech facilities and technologies includes establishing an improved management decision support system for pasturage and crops using satellites, the development of low-cost desalting facilities which use salt water from aquifers etc.

Table 5-11. Diversified adaptation to climate change as applied to farmers

	Adaptation scheme
Develop varieties and cultivation technology	▪ Develop crop variety portfolios fit for weather fluctuations: develop varieties resistant to harmful insects and diseases. ▪ Vary cultivation methods and decisions: technical application of seeding seasons, seeding levels, planting density, and nitrogenous fertilizers.
Improve and use weather observation	▪ Cultivation and seeding of crops, control, weeding and harvesting according to developed weather forecast technology. ▪ Determine cultivation type, selection of varieties, the level of crop application according to developed seasonal forecast technology. ▪ Determine stocks and stock liquidation by means of improved climate forecast systems for more accurately forecasting drought levels and periods.
Use high-tech facilities and technology	▪ System for supporting pasturage and crop management based on consulting services by means of the satellite image technology and specialized systems. ▪ Develop low-cost desalting facilities for using groundwater containing salt in order to supply water to irrigated crops.
Assessment and study of impact	▪ Study the impact of prolonged dry seasons and high temperature on the ecosystem, weeds and harmful insects.

Source: Reorganized data by Changgil Kim, *et. al* (2009).

C. Mitigation strategy

Australia's agricultural sector and use of land has contributed significantly to reducing GHG emissions. Production in the agricultural sector has an impact on the emissions of the 3 major greenhouse gases, namely CO_2, nitrous oxide, and methane.

In order to effectively manage GHG the Australian government announced the modified Carbon Pollution Reduction Schemes (CPRS) in November, 2009, though it was originally planned to come into force from July. One of the key modifications of CPRS was to postpone enforcement of the emission trading system of the agricultural sector until 2013.[36] Because of difficulty of emission calculations and monitoring for the agricultural sector in the emission trading system, it was intended that the sector be excluded from the emission trading system in the early stages of introducing the system. The Australian government decided to introduce both of the carbon offset plan for the agricultural sector and CPRS in order to pursue its nationwide carbon reduction policies. There are two carbon offset options under the modified CRPS. On the one hand, there is the CPRS carbon offset in compliance with the Kyoto Protocol and on the other, a voluntary carbon offset (Table 5-12). The activities for carbon offsetting in compliance with Kyoto Protocol cover livestock farming, manure management, use of fertilizers, savanna burning, burning agricultural by-products, rice cultivation, avoidance of deforestation, etc. Example of specific action options connected with these activities include improving the timing of fertilizer applications, improving fertilizer quality, improving how fertilizers are employed on pasturage, improving nitrogenous fertilizer application methods, etc. Voluntary carbon offset activities include activities related to soil carbon and farm soil (pasturage and crop soil) including bio-sequestration by means of bio-charcoal. Specific action options include the expansion of the practice of no-till farming, avoidance of no-grass fallow and the introduction of deep-rooted pasture grasses, etc.

Table 5–12. Carbon offset options for the agricultural sector of Australia

CPRS carbon offset in compliance with Kyoto Protocol	Voluntary carbon offset, other than CPRS
▪ Improve fertilizer application periods (periodical application). ▪ Improve fertilizer quality. ▪ Improve fertilizer management for pasture. ▪ Improve application of nitrogenous fertilizers. ▪ Water management for rice cultivation. ▪ Use rice varieties for reducing methane.	▪ Encourage the no-till farming practice. ▪ Avoid no-grass fallow/cultivate cover crops/use fertile fallow. ▪ Introduce deep-rooted pasture varieties. ▪ Reduce quality deterioration by overgrazing. ▪ Switch over cultivated crops to perennial plants.

[36] The emission trading system in the Australian carbon market employs a Cap-and-Trade scheme, the same as Europe's emission trading system (EU-ETS). Emission allowances will be dispensed via an auction, not by free allocation. The earnings from this emission auction will be spent on those industries damaged by emissions and also on support for households and the development of clean energy,

CPRS carbon offset in compliance with Kyoto Protocol	Voluntary carbon offset, other than CPRS
▪ Improve management of livestock farming. ▪ Improve feed quality. ▪ Use methane capture systems in managing intensive livestock farming. ▪ Improve savanna burning methods.	

Source: www.abare.gov.au.

2.3.3. Bio-energy

A. Trend and Prospect of Supply and Demand

Australia's bio-ethanol yield in 2005 was 60 million liters, the planned increase of which should yield 350 million liters by 2010. Bio-diesel is still produced on a commercially small scale. Bio-ethanol production mostly uses barley as its feedstock. However, production will increasingly utilize sugar cane. The raw material for biodiesel production is waste cooking oil and resin.

As for bio-ethanol consumption, E10 was sold from 400 gas station tanks (as of 2006). Bio-diesel has been supplied in the form of B5 (i.e. diesel containing 5% bio-diesel) or higher proportions to local governments and/or research institutes.[37] Australia is an agricultural superpower and thus has few problems securing the raw materials for increased bio-fuel production. The production and sale of bio-fuel is set to increase and so the use of fuel containing some proportion of ethanol will continue to grow.

B. Institutions and Policies

Although people insist that it is necessary to legislate the use of bio-fuel as the international oil price increases, there is as yet no bill for its mandatory use. Currently, the government provides a bio-fuel subsidy of 38.1 cents per liter to bio-fuel production companies, and does not levy consumption tax on bio-fuel sales until July, 2011. After August, 2011, a per liter consumption tax of 12.5 cents on bio-ethanol and 19.1 cents on biodiesel will of be levied until July 1, 2015. This subsidy

[37] The Australian government has restricted the maximum ratio of ethanol allowed to be mixed in gasoline to 10% from July 1, 2003 and this mixed fuel is called E10.

is on the basis of production, with the actual amount of subsidy decreasing on the basis of the increasing unit cost of production.

Encouragement subsidies are provided to some bio-fuel producers in the form of the $ 37.6 million bio-fuel capital encouragement program.. The 16 cents per liter subsidy is provided, on the condition of a minimum production amount of 5 million barrels per annum. The Ethanol Distribution Program provides a AUS$ 10,000 subsidy to fueling stations equipped with E10 fuel supply facilities.

C. Cases of Production Facilities

Bio-ethanol production facilities have been expanding following the production facility project in eastern and western areas during the period 2007 to 2008. Representative Australian bio-ethanol producers are Manildra, CSR and Rocky Point/ Bundaberg. Manildra's Bomaderry factory in New South Wales is the nation's leading production facility. Bomaderry can produce 100 million liters per annum and uses barley, by-products, etc., as feedstock. This factory extracts protein and carbon hydrate from industrial wheat powder. The by-product of carbon hydrate is ethanol. Manildra has continued to expand its production facilities since 1992, when it first started to produce ethanol.

2.4. Japan

2.4.1. GHG emissions in Japan

Japan's total GHG emissions (as of 2008) was approximately 1.3 billion CO_2 tons, of which the agricultural sector emitted 37.23 million CO_2 tons, or roughly 2.9%. With regards national total emissions, Japan's agricultural sector contributes 70% of total methane emissions and roughly 50% of the nitrous oxide emissions. The agricultural sector now emits less GHG than it did in 1990, the opening of the period of mandatory GHG reduction. The food processing industry, for its part, emitted GHG 15.62 million CO_2 tons in 2008, or roughly 1.2% of total GHG emissions, though the tendency is for this to decrease.

2.4.2. Measures for green growth of the agricultural sector[38]

A. Organizations promoting green growth in the agricultural sector

The measures for green growth of the agricultural sector in Japan are entirely the responsibility of the Department of Environment & Biomass Policies, which operates under the Cabinet Secretariat.

Comprehensive measures for global warming, environmental conservation agriculture and organic agriculture are the task of the Department of Environmentally friendly Agricultural Production. The task of managing GHG emissions resulting from the livestock sector is handled by the Office of Livestock Farming Environment & Management Stabilization.

The Department of Environment & Biomass Policy has set up and runs the task force for agro-fishery global warming measures with the Department's Earth Environment Committee handling affairs concerned with the emissions trading system, the construction of biomass towns, environment management systems, etc. The Department of Agricultural Environment Measures is tasked with sustainable agriculture, organic agriculture, standards governing agricultural production harmonized with the environment, the improvement of soil fertility, the certification of organic JAS (Japanese Agricultural Standards) and eco-farms, etc. To ensure the efficient promotion of policies, the department is operating a nationwide environment-friendly agriculture organization. The Department of Agricultural Environment Measures is generally tasked with measures connected with agricultural production and global warming. The Department of Production and Distribution is tasked with the comprehensive measure project for expanding plant factories as a project for supporting the introduction of low carbon facilities. For the plant factory support project, the Ministry of Economy, Trade and Industry supports the development of base technologies applied to plant factories as well as public relations for the plant factories. The Ministry of Agriculture, Forestry and Fisheries supports demonstration, training and the introduction of plant factories by farmers, including cultivation technologies. The Department of Livestock Farming is tasked

[38] The research on the measures instituted the for green growth of the agricultural sector of Japan was prepared by the research group who visited the division of Environment and Biomass Policies of MAFF and the National Agriculture Research Center. The research group collected data and interviewed workers in charge of the related authorities.

with comprehensive affairs of livestock manure treatment, resource circulating livestock farming, measures for mitigating GHG in livestock farming, etc.

The Ministry of Agriculture, Forestry and Fisheries of Japan installed in December, 2003 (and continues to operate) a council for constructing circulating societies and taking measures for global warming in order to efficiently promote environmental policies in agriculture, forestry and fisheries.

B. Green innovation for constructing an agriculture, forestry and fishery system for low carbon society

Green technologies have been developed which contribute to reduction of GHG emissions; some of which use biomass to improve GHG absorption and storage. In this regard, Japan is promoting the development of the ‘No.3 Agricultural and Forestry Biomass System’. This system allows for the generation and synthesis of methanol using wood biomass as its feedstock. This allows for the efficient use of biomass not produced in Japan and also the production of bio-fuels as a substitute for fossil fuels.

Japan is also developing technology to reduce paddy field methane emissions which is generated by intermittent drying, irrigation and drainage, so as to reduce GHG emissions in agriculture, forestry and fisheries.

Japan has developed cultivation technologies and crop varieties adapted to high temperature and extended dry seasons in order to adapt to global warming and so allow the production of food material in the agriculture, forestry and fisheries industries to continue. Japan is developing high temperature-resistant, warm-weather adapted rice varieties which meet customer tastes. These high yielding varieties produce fewer unripened grains, in the high temperatures which result from global warming.

Japan is also developing technologies for conserving and improving bio-diversity and the indicators (the scientific basis) thereof, in order to ensure stability in the provision of quality products from agriculture, forestry and fisheries. One way Japan investigates species diversity is to compare the bio-diversity indicators from conventional agriculture and environment conservation-type agriculture. These bio-diversity indicators are useful for agriculture in that they assist in the development of bio-diversity conservation and improvement technologies and the maintenance of rural district environments. They also provide the scientific basis for the effect of agricultural techniques (including environment conservation-type agriculture) on bio-diversity.

C. Measures for global warming in agro-food industry

The measures undertaken by the agro-food industry sector in Japan seek to comply with a Kyoto Protocol GHG emission targeted reduction of by 6% (as compared to 1990). The response of the agro-food industry has been to steadily implement measures for forestry control and the use of biomass to achieve a 25% reduction target by 2020. In addition, new measures employed by the agriculture, forestry, fisheries and food industries to combat global warming have been accelerated. The 2010 budget allocation for this undertaking is 258,066 million yen.

Japan is obliged as a signatory to the Kyoto Protocol commitments to reduce its GHG emissions by 6% with respect to 1990 over the first commitment period (2008 to 2012). In the mid to long term the goal is to reduce emissions by 25% by 2020 (with respect to 1990) However, GHG emissions in 2007 showed a 9.0% increase over 1990 figures as opposed to a 6% decrease. While taking measures to reduce and GHG emissions in the field of agriculture, forestry and fisheries, Japan is also taking measures connected with forest sinks and the use of biomass but will need to enact new measures to combat global warming by using an emission trading system and employing 'CO_2 labeling'. With the next measures for the Kyoto Protocol, Japan's continuous forest maintenance measures are highly regarded by the international community and international negotiation is ongoing to use Japan's agricultural land as a GHG sink. The policy target is to reduce GHG emissions in the agriculture, forest, fisheries and food industries to achieve the 6% reduction commitment as well as the 25% reduction target in the Kyoto Protocol (2020). The details of the four major policies for reducing and absorbing GHG are described below.

First, promote the emission trading system in the agriculture, forest and fisheries sectors. To achieve this the examination and determination of new methodologies for reducing agriculture, forest and fisheries emissions related to GHG, e.g., methane, dinitrogen monoxide, etc., is supported. In addition, to support participation, the emission trading system is to be planned, e.g., by connecting a plurality of farmers (sellers) and enterprises (buyers) in the trading system, so that credits for reducing and absorbing GHG emissions may be sold. The 2010 budget for enforcing the emission trading system is 30 million yen as a part of the comprehensive measures to combat global warming.

Second, promote the 'CO_2 labeling' system in the agriculture, forest and fisheries sectors.. Invest 15 million yen in 2010 to construct the basic database necessary for the 'CO_2 labeling system', e.g., the GHG emission units and the like, related to production resources (and imported raw materials) used in the agriculture, forest and fisheries industries of and also to develop simple tools for calculating GHG emissions. Invest an additional budget of 39 million yen for the model CO_2 labeling project in the agriculture, forest and fisheries sectors of as a part of comprehensive measures to protect the earth's environment.

Third, take measures to utilize farmland soil as GHG sinks, since soil can store carbon if properly managed. In particular, support and demonstrate farm efficient methods for storing carbon, e.g., using organic water, etc. To this end, invest a total of 1,499 million yen in 2010 in the comprehensive production environment measures project.

Fourth, take comprehensive measures for creating the 6th future frontier industry. Support the installation of solar panels in agriculture, forest and fisheries facilities, e.g., cold stores for agro-crops, barns, biomass transition facilities, etc. In other words use renewable energy in the rural, forestry and fishing districts to tackle global warming and reduce energy costs. To this end, invest 7,241 million yen in 2010.

D. Estimating the effect of reducing and absorbing GHG by green growth policies

The Global Warming Task Force, within Japan's Ministry of Agriculture, Forestry and Fisheries, has measured the effect of GHG reduction and absorption in the agricultural sector. The Task Force estimated the result, assuming new reduction technologies and facilities, without regard to current technologies and limitations in budget and institutions, would meet the GHG reduction target of 25% of by 2020 with respect to 1990. In this case, it was estimated that at least roughly 30 trillion yen is required by 2020. For the future values, e.g., crop cultivation areas and configuration of forest by age in 2020, the target values were set according to the plans for the agriculture, forest and fisheries industries contained in the current policies, e.g., the basic plans in the current food, agricultural and rural districts and national forest plans, etc.

It is expected that reductions in the agriculture, forest, fisheries and food industries will amount to roughly 3.95 million CO_2 tons. It is expected that a 10% to 20% reduction in the use of nitrogen in the agricultural sector will reduce CO_2 by between

350 to 710 thousand tons. Should 50% of dairy farmers who use pile fermentation change to using forced fermentation, this would lead to a reduction of approximately 770 thousand CO_2 tons. The introduction of heat pumps and multi-layer covering for 60% of greenhouses would reduce GHG emissions by a further 1.65 million CO_2 tons. The replacement of heaters with highly efficient boilers in 2400 locations in medium sized food companies would bring about a further reduction of roughly 820 thousand CO_2 tons. Meanwhile, it is expected that expanding areas cultivated with green manures from 98.000 ha to 210.6 thousand ha and applying more compost to paddies for the farmland soil as sinks would prevent the emission of another 3.8 million CO_2 tons.

2.5. Natural environment conservation policies for rural districts in EU (Natura 2000)

Natura 2000, the EU's representative territorial environment policy, illustrates the possibility of achieving successful local development plans by creating local value added while also conserving the amenities of rural districts. There are various local plans which should be established by local autonomies in rural districts of Korea, some of which are related directly to the use of land or scenery. However, there is no plan in Korea which aims to use the natural environment of rural districts for economic activities at the optimum level while conserving the environment. In this respect, Natura 2000 project is a good reference.

The Natura 2000 project is based on the 'Bird Control Bill' and the 1992 'Wildlife Habitat Control Bill', the latter of which serves as the basis for the EU's nature protection policies. Natura 2000 has the 'Natura 2000 Network' as a governance organization.

The Natura 2000 Network is defined as an EU wide eco-network that connects 'conservation regions' which are designated for maintaining or recovering endangered species and their habitats. The area included in this network occupies some 15 to 30% of the entire area of current EU member countries. This area is more than twice the size of Germany.

Although the Natura 2000 project is characterized as a program of natural environment conservation policies, it is not a program entirely dedicated to restriction. The project fosters development at the optimum level, which parallels the creation of a synergy effect between environmental conservation and economic growth, as described in section 3.3 of this report.

This policy program, designed essentially for protecting the natural environment, has enormous potential for creating economic and social benefits if included in the Natura 2000 network. Exemplary typical economic and social benefits include supplying ecological services, supplying agro-food or forest products produced in an environment-friendly way, the creation of employment led by a revitalized eco-tourism, diversifying the local economic structure, improving the quality of people's life, the mitigation of water pollution, etc.

The procedure for operating Natura 2000 project is as follow: Each EU member submits a list of the regions which comply with the standard of the related regulations (in this case the habitat control bill) to the EU Commission. The EU Commission then assesses the submitted proposal with the aid of the European Topic Center on Biological Diversity, various scientific groups, member country experts, NGOs, etc. Then, when the decision is made to include it in the Natura 2000 Network, the relevant country is responsible for ensuring the conservation of the region and preventing ecological deterioration. The country should also have sufficient manpower for creating or managing the necessary infrastructure. In principle, EU member countries pay all the costs, but joint finance by the EU is possible, if required.

As a result, the Natura 2000 Project is understood to be a plan agreement system for carrying out activities in specifically designated regions that leads to economic and social development while conserving the natural environment.

Activities carried out in individual regions within the Natura 2000 Network are integrated policies and inter-related restrictions. It is essential to systematically plan diversified activities in advance and so funded activities are strictly limited to 25 types in four fields. That is, it is a planning system designed to conform with the concept of green growth, in that it considers both environmental conservation and local economic development. In this respect, it seems that Korea does not have a full-scale local plan system for green growth. From the standpoint of local autonomies based on rural districts, green growth cannot be accomplished with some policy projects alone. The synergy effect of some policy measures will be achieved in combination with territorial environment plans. In this respect, EU's Natura 2000 project implies something important.

<Case of Natura 2000 Project>

Congost River Basin Sanitation and Environmental Recovery Project of Spain

The population of Granellers, which belongs to Barcelona, Spain, is roughly 56,000. More than 4,000 people per year visit the Congost river which flows through the city. There were few connections between the 6.7km long Congost river and the city's public places due to the ill advised planning of the river basin environment. In other words, people's access to the river was extremely limited.

Under these circumstances, the Congost river was selected as a region for the Natura 2000 Project, and the project was initiated as a river basin sanitation and environmental recovery project, in accordance with the 'Environment Action Plan' of the Spanish Government. The end result was a plan to maintain the Congost river in an environment-friendly way and to enhance people's accessibility. Some projects were enforced mainly with regards to areas of land running parallel to the river bank and the objectives thereof are described below.

- ○ Recover the river's eco-system and prevent water pollution.
- ○ Expand green spaces and improve roads.
- ○ Renovate the city area close to the river.
- ○ Integrate the area surrounding the city with the river basin environment.
- ○ Social, recreational and educational activities based on the river.
- ○ Encourage people to be interested in the area around the river.

Specific performance of the project is described below.

- ○ Construct a riverside park of 21ha in the city and the outskirt thereof.
- ○ Recover the riverside (8km), maintain the riverbed (3.2km) and create job opportunities thereby.
- ○ Remove polluted soil; the primary cause of water pollution.
- ○ Improve sewage treatment capability.
- ○ Construct a riverside road of 8km (for biking, walking and running).
  - This road is connected to the existing road of 33.46km for walking and biking.

2.6. Suggestions from green growth in major countries

The world's major countries are making ever greater efforts to cope with climate change and energy risks. They are attempting to minimize environmental burdens and achieve economic growth, e.g., energy reduction, efficiency increases, the development of low carbon green technology, the use of bio-energy, etc.

The following Table 5-13 shows comparison of the countermeasures for green growth in agriculture and rural districts in major developed countries including the USA, UK, Australia and Japan with those in Korea.

For reducing carbon emissions, most countries have introduced and enforced measures designed to promote environment-friendly agriculture and fisheries and the improvement of energy efficiency. These countries, but not Korea, have introduced and applied no-till farming and fallow. In the field of bio-energy, all of these countries have introduced and began using biogas plants which have as their feedstock livestock manure. In addition, Korea, unlike these other four countries, does not have bio-diesel and bio-ethanol plants as yet. With respect to other renewable energy, most of the countries on the list have introduced and use geothermal systems and small scale hydro power systems. Korea is the only country which has not introduced a solar energy system as yet. All of these countries, other than Australia and Korea, have introduced and utilize wind power systems.

With respect to adaptation to climate change, all of these countries, other than Korea, have introduced and applied variety improvement, cropping reorganization, management of bio-diversity, disaster preparedness, etc. All these countries, with the exception of the UK and Korea, have taken measures associated with improved soil management (carbon storage) for carbon absorption. To drive energy efficiency in the food sector, the UK, Australia and Japan have introduced and applied the carbon labeling system. Both the UK and Japan have introduced and applied the food mileage system, while the UK and Korea have introduced and applied the processing and logistics efficiency system.

All of the countries, Korea included, have introduced and applied green tourism for green rural districts. In addition, all of the countries (other than the UK) have introduced and applied the resource circulation village system. For tax financing, the UK and Japan have introduced and enforced a carbon tax for the agricultural sector. The USA and Japan have introduced and applied an emissions trading system for the agricultural sector. All of the countries have introduced and operate a green fund. All of the countries have introduced and operate other forums. All the countries (the UK excepted) have introduced and applied human resource development programs.

The USA, UK, Australia and Japan apply the means for green growth to almost all sectors.

Meanwhile, it was shown that Australia has large GHG emissions from its agricultural sector but does not use tax financing systems, e.g., a carbon tax or an emissions trading system. Korea, unlike developed countries, did not introduce and apply means for green growth to most sectors other than as adaptation measures to climate change. In particular, it was shown that it is necessary to introduce a means for tax financing, e.g., a carbon tax and an emission trading system, for bio-energy, e.g., diesel and ethanol, for other renewable energy, e.g., solar energy and wind power, for food, e.g., the carbon labeling system and food mileage, and for energy efficiency, etc.

The USA has programs for supporting carbon reduction incentives in the agricultural sector, e.g., resource conservation, wetland conservation, encouragement of environment improvement, conservation commitment, etc., to encourage farmers to adopt agricultural techniques for carbon reduction. If the carbon market is established with a resource conservation program, it is expected that farmers can still generate income because farmers can sell the carbon credits. In UK, the joint working group consisting of authorities associated with the agricultural sector prepared and edited the action plan for reducing GHG in the agricultural sector through discussion with the industry, and this case demonstrates how important social agreement is when establishing a plan associated with green growth. Australia has specific action options for carbon offset in compliance with the Kyoto Protocol, e.g., fertilizer application technologies (including improvements in fertilizer application periods), the improvement of fertilizer quality, the improvement of fertilizer management in pasture, improvements in the application of nitrogenous fertilizers. This is an example of a technology that both reduces costs and GHG emissions. Japan planned an emission trading system that would connect a plurality of farmers (sellers) to enterprises (buyers) and so create credits for reducing and absorbing GHG, and supports the participation of both parties in the system. Since Korea's agricultural conditions are similar to those of Japan, we can benchmark the case of Japan if Korea moves to introduce an emissions trading system.

Table 5-13. Comparison of major countries' green growth countermeasures for agriculture & rural districts

Green growth countermeasures			USA	UK	Australia	Japan	Korea
Carbon reduction	Environment-friendly agriculture/fishing		○	○	○	○	○
	No-till farming & fallow		○	○	○	○	-
	Improvement of energy efficiency		△	○	○	○	○
Bio-energy	Livestock wastes		○	○	○	○	○
	Diesel (agriculture)		○	○	○	○	-
	Ethanol		○	○	○	○	-
Other renewable energy	Geothermal		○	○	○	○	○
	LED		○	△	△	○	○
	Solar energy		○	○	○	○	-
	Wind power		○	○	△	○	-
	Small hydro power		△	○	○	○	○
Adaptation to climate change	Improvement of varieties		○	○	○	○	○
	Reorganization of cropping		○	○	○	○	○
	Bio-diversity management		○	○	○	○	○
	Disaster preparedness		○	○	○	○	○
Carbon absorption	Soil management (carbon sequestration)		○	-	○	○	-
Energy efficiency in food sector	Carbon labeling system		△	○	○	○	-
	Food mileage		△	○	-	○	-
	Efficient processing and logistics		△	○	-	-	○
Green rural districts	Green tourism		○	○	○	○	○
	Resource circulation village (Biomass Town)		○	-	○	○	○
Tax financing	Carbon tax	Non-agriculture	○	○	-	○	-
		Agriculture	-	○	-	○	-
	Emission trading system	Non-agriculture	○	○	-	○	
		Agriculture	○	-	○	○	-
	Green fund		○(R&D)	○	○	○	○
Others	Forum		○	○	○	○	○
	Human resource development		○	-	○	○	○

Note: '○': introduced·enforced, '-': not introduced·not enforced (including study·preparation), '△': uncertain·not identified.

Major Tasks for Green Growth

This chapter describes the major tasks for promoting green growth. These tasks are based not only on the outcomes of the diagnosis and empirical analysis of current conditions of green growth in agriculture and rural districts but also the case studies of international organizations and other major studies in green growth. As for tasks for the agricultural sector that will promote green growth, new policy programs are suggested that will produce visible outcomes. The need for policies to be visible comes from the results of a questionnaire survey of agricultural society and an evaluation of Ministry of Agriculture, Food, Forestry and Fisheries' green growth policies. Regarding the utilization of green technologies, the results of case studies of geothermal heat pumps, LEDs and biogas plants and their economic evaluation are presented. In addition, the case of a rice-based biorefinery that uses supercritical fluid as a new green convergence technology and a plan to utilize green finance are proposed. Tasks for promoting green growth in rural districts are described for each field, based on questionnaire survey for experts (Q-Method). With regard to plans to integrate green growth policies, the case of the Japanese Ministry of Agriculture, Forestry and Fisheries' ISO14001 implementation for green growth orientation and the re-organization of the policy implementation system is presented.

1. Tasks for Promoting Green Growth in the Agricultural Sector

1.1. Development of Low Carbon Policies in Relation to Income Increase

As suggested by the survey of the agricultural society's recognition of green growth, it is necessary to develop low carbon policy programs that directly contribute to increased income. This is deemed necessary to raise public interest and participation in green growth. Table 3-2 (in chapter three) shows that there are a variety of technologies available that can reduce agricultural sector GHG emissions. These technologies include, but are not limited to, organic farming practices, the cultivation of cover crops in fallows, conservation tillage, intermittent irrigation for rice crops, the improvement of ruminants' enteric fermentation using feed additives, the improvement of livestock waste treatment and biomass utilization. When low carbon agricultural technologies with high GHG reduction effects are put into practice, it needs to be accompanied by an appropriate financial incentive. One method of paying incentives to drive the adoption of low carbon farming methods would be the introduction of menu-driven direct-payment for low-carbon farming. This could conceivably take the form of an environmental cross-compliance program. A menu-driven direct payment for low carbon refers to a method whereby a direct payment is made to farming households when they meet the stipulated compliance standard using some of the many low carbon farming methods available to them. Their choice of methods would take into consideration their regional, household, and management circumstances (Changgil Kim *et al.*, 2009c, pp.130-140). In rice farming for example, it is suggested that no-till farming can reduce GHG emissions by about 20% (See to Figure 3-3). In this case, the unit cost for support of no-till farming may be priced at 0.6 million won/ha.[39] Also, cultivation of cover crops such as winter milk vetch helps reduce the chemical fertilizer usage per unit area through an improvement in soil fertility and thus can be used as a direct-payment menu item for low carbon farming. Per-ha unit support cost for cover crop cultivation is calculated as approximately 0.85~1 million won.[40] As suggested in chapter four Empirical Analysis of Green Productivity in the Agricultural Sector, if sound green

[39] No-till farming is usually connected to cultivation of cover crops like milk vetch and hairy vetch. An analysis of income from rice farming in a no-till milk vetch field shows that yields are about 67% that of conventional farming in the first year and 85% in the second year, but that yields exceed conventional farming yields from the third year onwards. Therefore, when the per-ha income from conventional farming is 4.52 million won, the income from no-till farming in the first and the second years would be 3.43 million won, or 76% on average, making the income gap 1.09 million won. By closing 50~60% of the income gap the per-ha unit support cost is calculated as 0.55~0.65 million won.

[40] The cost of cultivating winter cover crops like milk vetch and hairy vetch is estimated to be 0.1 to 0.2 million won (0.17 million won average) per *danbo* (unit field) including seed cost, tractor rental fee and labor cost and thus the per-ha support cost is calculated to be 0.85 ~ 1 million won, being 50 ~ 60% of the required cost.

growth is to be achieved then an important task would be to reduce nitrogenous fertilizer usage per unit area. However, as farmers heavily depend on the use of nitrogenous fertilizer and there is a limit to how much of a reduction in nitrogenous fertilizer usage can be achieved through cost control (due to cost non-elasticity of chemical fertilizer demand). Therefore, an urgent task for green growth in the agricultural sector is to reduce the nitrogenous fertilizer usage per unit area while ensuring farmers a steady income. An active examination of the implementation of incentives for income maintenance and the gross fertilizer usage control should be accompany the use of incentives, so that farmers and local government agricultural administrators can restrain excessive fertilizer application on farmland. Once low-carbon farming activities have been scientifically analyzed with an eye to the reduction and absorption of agricultural sector GHG emissions then a competent system for monitoring those activates can be established. The agricultural sector would then be able to create new revenue streams in connection with the carbon emission trading system.

1.2. Development of GHG Reduction Programs

As discussed in chapter three, most of 34 programs for green growth in the agricultural sector have been formed within the framework of existing agricultural policies. There are only a very limited number of programs formed from the perspective of integrating green growth policies with environmental policies and energy policies for the purpose of GHG reduction. Therefore, it is necessary to develop programs that can produce visible GHG reduction outcomes. For this, plans should be sought that utilize the Clean Development Mechanism (CDM) available to Korea in compliance with Kyoto Protocol and the carbon emission trading market in preparation against the post-Kyoto scheme.

For CDM projects, no case has been suggested with regard to its application to the Korean agricultural sector. However, if CDM were to be applied on a small scale, it could be implemented within the agricultural sector. Analysis suggests that the formation of energy-independent green villages, biogas plants using livestock wastes, micro hydropower generation using agricultural reservoirs, the formation of environment-friendly agricultural complexes, and customized fertilizer businesses would all be feasible if they are methodologically complemented and a Measurable, Reportable and Verifiable system for GHG established (Changgil Kim *et al.*, 2010). Therefore, pilot programs for implementing CDM projects should be undertaken in such areas where biogas plants using livestock wastes, environment-friendly agricultural complex development projects and biomass town projects are highly feasible.

As discussed in the case study for green growth in major countries, an emission trading system is a representative policy program that most countries have already enforced or are planning to do so. Korea has undertaken an in-depth examination regarding legislation for its introduction and an implementation method. Japan has implemented and operated an agricultural sector emission trading system since 2008, believing it to be a policy program that can produce visible GHG reduction effects.. The Japanese system calculates the amount by which a farm household has reduced its GHG emissions using pre-determined methods such as the utilization of an energy reduction system and having done so grants credits to the farm household accordingly. The corresponding farm household prepares and submits an emission reduction plan to the credit recognition committee. Once the credit is recognized based on the emission reduction result report, the farm household can sell the credit to larger firms as a source of income. Korea can benchmark the Japanese system by means of concrete, in-depth research.

In reality, it is very difficult to reliably monitor the emission of methane and nitrous oxide, major sources of GHG emissions from the agricultural sector, as their emissions vary with natural conditions such as soil characteristics and the weather. The core of the carbon emission trading system is to measure and record the amount of emission reduction and/or absorption and then calculate the credit based on those measurements. Needless to say the guidelines require the installation of measuring equipment for monitoring and measurement and thus incurs expenses. Therefore, it is necessary to prepare proper policy measures to prepare for the future enforcement of an emission trading system.

Whereas Korea does not operate an emissions trading system, a it has operated a carbon labeling system since February 2009. The carbon labeling system, part of the government’s effort towards carbon reduction, has provided consumers and the producers with information about the amount carbon emissions from each production process as well as the amount of reduction. However, it has not been in full operation in the agricultural sector. Therefore, specific plans for implementing the carbon labeling system in the agricultural sector should be prepared, including the establishment of a Life-cycle Inventory (LCI) and proper division of roles assigned among the related organizations. Of late, policy research tasks have been carried out on how to implement a carbon labeling system in the agricultural sector (Jae-Jak Nam *et al.*, 2010). These policy research should be the basis for pilot projects, which could in turn serve as the basis of detailed step-by-step programs which should be implemented.

1.3. Utilization of Green Technologies

1.3.1. Geothermal, LED and Biogas Plant Application

A. Successful Cases of Geothermal Energy Utilization

Geothermal energy is one of the non-depletable environment-friendly renewable energy sources. Depending on the depth and temperature of ground, it is divided into geothermal generation and geothermal heating. An air conditioning system which uses the constant temperature (12~25℃) available throughout the year some 300m underground is called a geothermal heat pump.[41] A geothermal heat pump is essentially a heat exchanger buried underground. This heat exchanger can extract heat from warm underground water or soil by using a process of coolant circulation. Recently, the geothermal heat pump has come to be considered a promising means for green growth, since it can help reducing the heating cost for horticulture and also reducing GHG emissions.

The heat pump consists of compressor, condenser, expansion valve and evaporator, all of which are connected to each other through copper pipes. For safety during operation and handling, safety devices and accessories are attached to the pump. The compressor collects and compresses low-temperature, low-pressure refrigerant vapor from the evaporator, turning it into high-temperature high-pressure refrigerant vapor. The condenser refrigerates high-temperature high-pressure refrigerant vapor compressed by the compressor and radiates heat as high-temperature heat source. The expansion valve expands the high-temperature high-pressure liquid refrigerant sent from the condenser, to produce a refrigerant which is a mixture of low-temperature low-pressure gas and liquid. Lastly, the evaporator turns the low-

[41] The term 'heat pump' refers to a mechanical device that can move heat from a low place to ahigh place just the same way a pump carries water from a lower position to a higher position.

temperature low-pressure misty refrigerant into low-temperature low-pressure refrigerant vapor, using the heat absorbed from the geothermal source.

Depending on the circulation mode of heat exchanger, the geothermal heat pumps are divided into the closed loop type and the open loop type and depending on how they are buried, they are also divided into the horizontal type and the vertical type (Table 6-1). Heat sources for the heat pump include underground water, ground heat and surface water. The types of geothermal heat pumps mostly commonly used in the agricultural sector are the vertical closed-loop type, the vertical open-loop type, and the horizontal closed-loop type. The vertical closed-loop type uses the ground heat 100~200m underground and is suitable for small to medium-capacity air-conditioning systems. It can be installed in almost any area in Korea but the installation is expensive and takes a long time. The vertical open-loop type uses water from 350~450m underground and is suitable for medium to large-capacity air-conditioning systems. Though cheaper and faster to build than the vertical closed-loop type it works most effectively when installed in areas with abundant underground water. The horizontal closed-loop type uses ground heat from 2~3m underground and is cheaper and faster to build than the vertical closed-loop type However, as it requires a large installation area, it is difficult to secure the site.

In the agricultural sector, geothermal heat pumps can be used for heating and rapid water heating for agricultural facilities and houses and for drying agricultural products. They can also be used for cooling agricultural facilities and houses, refrigerating fruit, and the low-temperature storage of floral products.

The Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF) is promoting to spread the use of geothermal energy, as a core project for green growth. MIFAFF's low-input high-efficiency green industry strategy includes as an

Table 6–1. Characteristics of Each Type of Geothermal Heat Pumps

	Vertical Closed-loop Type	Vertical Open-loop Type	Horizontal Closed-loop Type
Heat Source	Ground heat 100~200m underground	Underground water 350~450m underground	Ground heat 2~3m Underground
Capacity	Small- to medium-capacity	Medium- to Large- capacity	Small- to medium-capacity
Applicable Regions	Almost any region	Regions with abundant underground water	Regions where a large area can be secured
Installation Cost/Period	Disadvantageous	Relatively advantageous	Relatively advantageous

Source: Youngseon Yoo (2008).

implementation strategy an expansion in the use of green technology and equipment, for includes the expansion of crop cultivation using geothermal energy. To replace fossil fuel and reduce GHGs, MIFAFF has been promoting the use of geothermal heat pumps in the horticulture farms since 2010.

The Korea Rural Community Corporation (KRC) has prepared plans (commissioned by MIFAFF) for implementing projects for efficient energy utilization by horticulture. The targets for these projects are farming households which are expert in cultivating horticultural crops and are capable of paying the project expenses. With respect to the facility requirements and standards, they should possess automated greenhouses and/or steel-framed greenhouses bigger than 0.1ha. In terms of the required expenses, 60% is fiscal support, 20% is local government support, and 20% paid at the household's own expense. The standard process procedure consists of project application and selection, business promotion, facility installation, post management, submission of a performance report with measurement data, a project evaluation and a review. The KRC's roles include educating the target households, outsourcing the education, advertising and supporting the project plans, selecting and supporting the target households, outsourcing the design and construction of the heat pumps to competent companies, reviewing the design, and supervising the construction.

For the MIFAFF project an initial 106 sites were selected to be supported for the geothermal energy promotion project in 2009. In 2010 a further 154 sites were selected. However, of the 106 selected in 2009 only about 10 sites completed the construction and have gone into operation. The reason why the project has not yet the planned scale is due to project delays and because some households cancelled their project plans.

The reason for cancellations are that even though the government supports 80%, the initial installation cost, the remaining 20% (at 20~30 thousand won per 3.3m^2) still represents a huge burden for small farms. Therefore, in order to lower the initial installation cost, it is necessary to reduce overall costs, solicit large firms to participate in the project, and promote policies related to the dissemination of the technology domestically.

<A Successful Case of Geothermal Heat Pump Use>

The Bugong Agricultural Cooperative, led by their President, Sooyoung Jeong is situated in Kimje, Jeollabukdo province. This five farm cooperative cultivates paprika in a 27,107m^2 Venlo greenhouse made of glass. Having previously used oil for heating, the cooperative installed a geothermal system with the capacity of 600RT in 2009. The total cost to the cooperative (after government support), was 2,705 million won. The cooperative bore 20% of the total cost. The geothermal system began operation from November 2009 and provided continuous heat until April 2010. From mid-May same year, it was instead used for cooling. Before the installation of the geothermal heat pump system, the total cost for the heating period was 450 million won but afterwards, it cost only 150 million won, recording a 66.7% decrease. The operating cost, prior to installation, was 7.2 million won and 68 million won after.

The total heating and operation costs for the greenhouse prior to the heat pump installation were compared with the total cost afterwards. The result was that costs fell 52.3% from 457.2 million won to 218 million won.

In addition, the yield increased by 33.3%.

< Costs before and after Installation of Geothermal Air-conditioning System >

	Before installation	After installation	Difference (%)
Heating cost	450 million won	150 million won	-66.7
Operating cost	7.2 million won	68 million won	844.4
Total cost	457.2 million won	218 million won	-52.3
Yield	480 tons	640 tons	33.3

Source: Internal data, Bugong Agricultural Cooperative (2010).

<Geothermal System installed at Paprika Farming Facility >

<Geothermal Power Supply Unit >

<Piping Systems >

<Inside Glass Greenhouse>

At present, the geothermal system capacity is set to 70% of the total capacity, which is suitable for the purpose of heating but not efficient for cooling, and thus it is necessary to expand the installation capacity. In order to promote the use of geothermal heat pump systems, consideration needs to be taken of the installation companies, the heat pump types suitable for regional characteristics, and the suitability for the crops cultivated.

B. Successful Cases of LED Utilization

The Light Emitting Diode (LED) is a next-generation light source. It is exceedingly energy efficient, converting 90% of electric energy into light since, unlike incandescent lamps, LEDs do not emit heat. They are also exceedingly durable, lasting 10~30 times longer than incandescent lamps. (Seongchang Hong, 2009). Plants can sense changes in red light (660nm) and ultra-red light (730nm) because of a phytochrome; a photo-receptor protein. The default state of the photo-receptor protein exists is inert (Pr) however it changes to an active state (Pfr) when red light is applied. Because of this, plants react to the change in environment by for example, perceiving and responding to the number of daylight hours, germinating the seed, transporting the products of photosynthesis within them, flowering, and expressing pigments. Agriculturally useful crop characteristics such as sugar content improvement, flowering control and growth promotion can also be controlled by phytochrome action.

There are such crops as green perillas, chrysanthemums and strawberries that yield more when they do not flower as they are lit with red electric light at night. As red light promotes photosynthesis more than white light does, it can improve the yield and quality of green perillas and chrysanthemums. Photophilous (light loving) crops like cucumbers and tomatoes do not yield properly if the number of overcast days is prolonged as they cannot be inseminated. In this case, by properly using red or blue LED lamps in lieu of solar light, it is possible to increase both yield and quality. The Rural Development Administration (RDA) has developed a red LED device for agricultural use, which is suitable for use in Korean greenhouses.

<A Successful Case of LED Use>

Museong Kim who lives in Chubu-myeon, Geumsan-gun in the province of Chungcheongnamdo grows green perillas in 10 greenhouses, with a total area of 660m^2). For light cultivation, he had installed and used 60W incandescent lights. However, in August 2008, he installed 25 10W red LEDs on the ceiling at an interval of 2 meters. The installation of the LEDs (including the necessary wiring) cost him around 11.4 million won for 990m^2.

A comparison of the costs and benefits, both before and after LED installation, for green perilla cultivation reveals that the fixed cost for having LED installed (and operate) is estimated to be 1.14 million won per year on the assumption that the durability of the LEDs is 10 years. On the other hand, his electricity bill 224,000 was a 70% drop from his bill when using 60W incandescent lights. In addition, his perilla yield increased by 10%, or by 1,712,000 won in cash terms. Thus the overall economic effect of applying LEDs to green perilla cultivation is calculated to be around 796,000 won per 10a/year. It also appears that the LEDs reduce the amount of electricity used by 13,207kw. As 424g of carbon dixode (CO_2) is emitted to generate 1kw of electricity, this translates into a CO_2 reduction of around 5.6 tons.

<Costs and Benefits before and after LED Installation for Green Perilla Cultivation >

Cost (/10a/year)		Benefits (/10a/year)	
Installation Cost	1.14 million won	Electricity Saving Increase of Production	0.224 million won 1.712 million won
Total	1.14 million won (A)		1.936 million won (B)
Economic Effect (B-A)			0.796 million won

Note: The installation costs 1.14 million won and the durability of LEDs is considered to be 10 years.

<LEDs installed in the Green Perilla Cultivation Facility >

<LED Power Supply Unit >	<LEDs Installed>	<ON/OFF Test>
		

According to an RDA analysis, LEDs can save up to 70% of the electricity needed for incandescent lights. Clearly, this can contribute to increasing farm household income while also reducing carbon emissions. LED use in agriculture is a green technology that will allow low carbon green growth. However, while LEDs save electricity, the initial installation cost is too high for to farmers bear unsupported. Thus, it is necessary to provide financial support for the initial installation cost in the short term and to prepare several plans to lower LED prices in the long term.

MIFAFF is promoting the development of green technologies, including LEDs, to spur national growth, itself one of strategies for promoting low carbon green growth. The detailed strategy includes the expansion of LED use to replace fossil fuels and in so doing, reduce GHG emissions as well as the development of technologies for promoting LED use in agricultural crop cultivation. Specifically, the experimental use of LEDs will be expanded to roses, gypsophila, paprika and lettuce. Those items for which empirical research has been completed, such as strawberries, chrysanthemums and green perillas will be established as pilot projects from 2010. In addition, LEDs will be installed at 25 sites a year between 2010 and 2012.

C. A Successful Case of Biogas Plant

Biogas plants refer to industrial facilities that generate power using biogases like methane and CO_2, both of which gases are produced when organic material is subjected to decomposition by micro-organisms. In that they generate energy on top of turning livestock waste into a resource, biogas plants are considered a better green technology than the existing livestock waste treatment. Biogas plants have been drawing more attention lately given that the expectation is that ocean dumping of wastes and other materials will be strictly regulated from 2012 in compliance with London Convention, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter .

The biogas plant can supply resources required for environment-friendly virtuous-cycle agriculture. It can also generate energy from biogases, separate CO_2 and methane from biogas and convert them into either compressed natural gas (CNG) or liquefied natural gas (LNG). The major advantages of the biogas plant include the following: First, it combusts methane and so reduces GHG emissions, given that the resulting CO_2 is a much less potent GHG. Second, the solid output, the product of anaerobic fermentation, has reduced nitrogen such that when it is used as manure, it prevents excessive nutrition to the soil. Third, the generation of electricity from biogas reduces foreign currency outflows by reducing oil imports. Fourth, it needs no additional management cost for solid compost treatment as it collects livestock waste as it is from the livestock farms. Fifth, it is environment-friendly and reduces the waste management cost as it can also utilize organic wastes from the neighborhood, including food waste and agricultural byproducts.

Northern European countries, like Germany and Denmark, have developed biogas plants over the last 30 years, contributing to reducing GHGs while producing green energy. They have also put in place resource-cycling agricultural systems that utilize the fermented manure as fertilizer for farmland. In Asia, China, Vietnam and the Philippines have developed and disseminated small-scale biogas plants for farmhouses.

Recently, in Korea, the central government and the local governments have begun promoting the biogas plant business so as to solve livestock waste treatment problems and turn wastes into resources. As part of a pilot project to spread the use of biogas plants for farmhouses promoted by the then Ministry of Industry and Resources (presently The Ministry of Knowledge Economy), biogas plants have been in operation at the Mojeon Agricultural Complex in Icheon City, Gyeonggido and at Yeoyang Farm in Cheongyang City, Chungcheongnamdo. In addition to these, a variety of projects are being promoted by local governments in the form of private investment projects (Table 6-2).

Table 6-2. Current Conditions of Livestock Waste Treatment Biogas Plants

Managing Local Governments (Place of Business)	Capacity	Electricity Generated	Status	Remarks
Changnyeong, Gyeongnamdo EaZyBio	100 tons/day	9,600 Kwh/day	Operating	Livestock Wastes + Food Wastes
Icheon, Gyeonggido Mojeon Agricultural Complex	20 tons/day	30 Kwh/day	Operating	-
Cheongyang, Chungnamdo Yeoyang Farm	20tons/day	400 Mwh/year	Operating	Sold electricity to KEPCO, for the first time
Anseong, Gyeonggido	5 tons/day	450 Kwh/day	Operating	Livestock Wastes + Food Wastes
Pocheon, Gyeonggido	196 tons/day 82.2 tons/day	11,425 Mwh/year	Under construction	Investment from KISC's Emission Funds

Source: Internal Data from Livestock Management Dept., MIFAFF

<A Successful Case of Biogas Plant>

EASY Bio System Inc. is a manufacturer of animal feed and additives. EasyBio System Inc, built a biogas plant in 2008 (in cooperation with Woopo World Agricultural Company) as a response to the London Convention prohibition on the dumping of livestock waste into the ocean - to be enforced from 2010. They were able to build the plant using 4,770 million won of private capital and without government aid. The plant has a capacity of 100 tons a day (70 tons of pig manure and 10 tons of other organic matters). It produces energy and fertilizers by processing livestock wastes and other organic wastes into resources, while also reducing GHGs, such as CO_2.

Analysis of the profitability of the plant reveals that expenses of 1,180 million won were incurred a year due to labor costs and manure treatment while total revenue amounted to 1,560 million won. The annual profit was thus 380 million won a year.

<Cons and Pros of Easy Biogas Plants >

(Unit: Thousand won)

Cons (A)	Pros (B)
o Increased Expenses - Staff salaries: 144 - Manure treatment: 324 - Depreciation: 238.5 - Interest: 333.9 - Others: 140.4 - Total (A): 1,180.8	o Increased Profits - Saving from food waste treatment cost: 450 - Saving from livestock waste treatment cost: 504 - Electricity sale: 483.84 - Manure distribution grant: 24.6 - CDM project: 97.2 - Total (B) :1,559.640
o Estimated profit (B-A) =378.84	

Note: Internal Data, EASY BIO System, Inc.

<EASY Biogas Plant >

<Front view of the Plant >	<Desulfurization Facility>	<Fermentation Tub>
		

As one of its green growth strategies, MIFAFF plans to build 15 biogas plants by 2013. In order to promote the spread of biogas plants in the future, appropriate strategies are required to raise the base price of electricity generation, localize the generation facilities, and add biogas plant processes to the joint recycling facilities.

1.4. Green Technologies using Supercritical Fluid Process[42]

1.4.1. Significance of Supercritical Fluid

One of the green technologies that has been attracting attention from the food and energy sectors as well as makers of various chemical ingredients and materials using biomass resources, is biochemical treatment technology using a supercritical fluid, from which has sprung the biorefinery industry. Supercritical fluid is a non-condensable fluid whose temperature and pressure exceeds the threshold of a gaseous liquid, whose properties are determined by temperature-pressure conditions in the same way as hold true for gases, liquids and solids. There has been intense worldwide research and development efforts to use supercritical fluids, solvents or reactants. Though there are many types of supercritical fluids, most attention focuses on supercritical CO_2, supercritical water, supercritical alcohol (methanol or ethanol) due to the fact that they have little load on the environment, are chemically stable and are safe and cheap.

1.4.2. Utilization of Biorefinery

The term ’biorefinery’ refers to technology designed to manufacture biofuels or chemical products from biomass through biological and/or chemical conversion processes. It also refers to a general plant system for implementing the technology (Figure 6-1); such a plant is comparable to an existing oil refinery.

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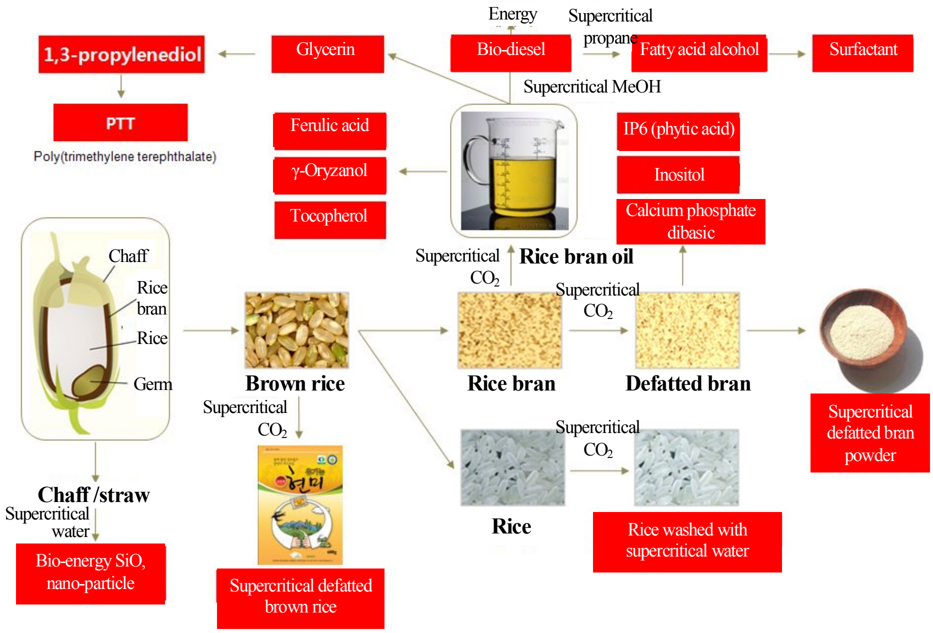
[42] This section on the use of supercritical fluid process as a green technology for the agricultural sector is an excerpt from “Plans to Apply Green Technology using Supercritical Fluid to the Agricultural Sector” by Prof. Yoonwoo Lee of Biochemical Engineering Department of Seoul National University.

Figure 6-1. Rice-based Biomass Refinery



The technology for using supercritical water is considered to be a core technology for biomass refinery, due to water's rapid reaction speed and simple synthesis by small devices. Biorefineries can be classified into lignocellulosic, glucosic and cellulosic biorefineries.

With regards the agricultural sector, cellulosic biorefinery for wheat and corn is especially important. A rice-based biorefinery is also a useful green technology for the agricultural sector. When brown rice is produced by applying the supercritical fluid process to rice grain, bioenergy and nano-particles can be extracted from its byproducts, namely chaff and straw. The brown rice is then separated into rice and bran. When the rice is washed with supercritical water, it becomes clean rice and when the bran is processed with supercritical CO_2, defatted bran and bran oil are produced. The bran oil can be converted into biodiesel through a supercritical refining process or into a surfactant when supercritical propane is applied in combination with a fatty acidic alcohol. On the other hand, it is also possible to produce phytic acid, inositol, calcium phosphate dibasic, and defatted bran powder from the defatted bran. Like this, the rice-based biorefinery using supercritical fluid process, which is a fusion of green and technology, can make rice a source of useful production resource as it allows for the creation of highly functional products in addition to pure rice.

1.4.3. Tasks to Promote Biorefineries

The promotion of biorefineries first requires a paradigm shift in the first place for the simple reason that it is difficult to realize economic efficiency by economy of scale when using distributed resources, such as biomass that assume material recycling. To ensure the success of the biorefinery concept, it is essential to establish a 'distributed' chemical process technology that can operate independently using the natural resources available in the corresponding area. Thinking along these lines means discarding the conventional wisdom of mass production, mass consumption and mass dumping, and switching over to a distributed proper production system. However, due to the fact that biorefinery technology occasionally uses high-temperature, high-pressure fluids, there is a possibility that installation costs would rise, making it increasingly difficult to manage the system on an economic basis. On the other hand, the use of high-temperature, high-pressure fluids can significantly reduce the processing time and ensure the biorefinery does not produce waste water. Therefore, it is necessary to seek for fields to which biorefinery technology can be applied based on the changed circumstances. When engineering technologies such as accurate control for high-speed transportation in micro- or nano-space, which are not bound to the conventional frame of high-pressure high-temperature technologies, are developed, biorefinery technology would then be able to demonstrate its excellence in various fields. In the process of searching for technologies that do not have adverse effects on the ecological system or the environment, the biorefinery using supercritical fluid technology will be applied to an ever greater extent. Thus, it is important to establish bases for the technology's application and prepare for its practical use.

1.5. Utilization of Green Finance for Green Growth[43]

1.5.1. Need of Green Finance

Although various green growth policies are being implemented in the agricultural sector, there are few signs that the private sectors are voluntarily participating in the corresponding policy projects. It is therefore necessary to utilize 'green finance' in order to improve this situation. Green finance is a cycle in which an investor supplies funds to a green firm through a financing firm or a capital market. The green firm then makes profit by utilizing the funds and returns the interest to the investor. However, in Korea the investment cycle has not yet been established. There are four obstacles to be overcome before it can be established. The first obstacles is that there are not many green business categories in the Korean agricultural sector that can meet investor profit expectations. The second obstacle is that the scope of green businesses and firms in the agricultural sector is not clearly defined as yet. The third obstacle is that the capital markets, which serves as an intermediary between the agricultural sector and investors, has not matured sufficiently. The fourth reason is that financing firms are not fully capable of assessing the economic value of green technology. In combination these four obstacles have thus far ensured that full-scale market-based voluntary green finance for green growth of the agricultural sector has not been established yet.

The government has proposed multilateral support plans to overcome these obstacles and so kick start the green growth of the agricultural sector. The government's political support has a positive impact in that it can temporarily expand financial resources for the green growth of the agricultural sector. However, given that resources are being disbursed before a proper screening and supervising system has been established, the effectiveness of policies might suffer as a result. Therefore, in order to promote the green growth of the agricultural sector in a more effective fashion, an urgent requirement is to establish the necessary infrastructure to screen good green firms and effectively supervise their management while expanding political support.

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[43] This section on utilization of green finance is an excerpt from "Plans to Utilize Green Finance for the Agricultural Sector" written by Dr. Jin Ik from Korea Insurance Research Institute.

1.5.2. Direction for Green Finance for the Agricultural Sector

MIFAFF is pursuing two major policy threads for the green growth of the agricultural sector. One is energy saving and energy efficiency; encouraging more people to use renewable energy. The second is the reduction of GHG emissions.

With regards promotion of the first thread, for energy saving and energy efficiency in the agricultural sector, examples of exemplary green finance schemes include the introduction of capital-intensive facilities for plant factories, environment-friendly crop insurance, environment-friendly building insurance, and the ESCO[44] project performance guarantee. With regards to promoting the use of renewable energy in the agricultural sector, such green finance tools as performance insurance and environmental pollution indemnity insurance can be utilized as a vehicle for funding the investment in agriculture required for bio-energy development.

With regards the second major policy thread, the reduction of GHG emissions from the agricultural sector, green finance can be implemented in the forms of conventional insurance for CDM business, aiming at reduction of GHG emission from the agricultural sector, Contingent Cap Forward (CCF) insurance, and emission Credit Delivery Guarantee (CDG).

As described above, green finance for the agricultural sector is most likely to be realized through insurance tools. For the banking sector, providing loans to green technologies/businesses/firms is a difficult undertaking. It is difficult for banks to actively lend money to such companies as it takes a long time to recover the investment capital, which they themselves have to raise through short-term savings. For green funds, it is not easy to raise a large amount of funds through public subscription when the venture characteristics of green firms for investment are taken into consideration. On the other hand, green insurance can provide green businesses/firms with the required funds while providing various risk management countermeasures against the risk factors involved in development of green technologies and/or the promotion of green businesses.

[44] ESCO stands for Energy Service Company.. An ESCO is is a venture firm that takes on investment risk in anticipation of the profits from investment. The ESCO receives compensation for supplying technical and professional services and funds to energy users. The source of this compensation is the energy savings generated.

1.5.3. Possibility of Utilizing Green Finance for the Agricultural Sector

The plant factory is considered to be a representative example of green business in the agricultural sector in that it pursues energy saving and economic efficiency. It is therefore necessary to devise plans to utilize green finance to promote plant factories. A plant factory requires a large scale to cover the initial costs of installing LED systems, liquid fertilizer systems, and automation systems and the like. The level of this burden is of serious concern to investors.

Firstly, to overcome investor concerns, the plant factory business should have a stable market demand for its product. To ensure stable market demand green firms should utilize one type of green finance special compensation insurance for environment-friendly crops. This insurance will compensate consumers for any instance in which pesticide residue is detected on those crops, thus helping to ensure stable market demand. LIG Insurance entered into such insurance contracts with certified environment-friendly agricultural firms located in 22 cities and counties in Jeollanamdo in April, 2009.

Secondly, as plant factory buildings involve energy efficient construction, renewable energy utilization and ecological environment improvement outside the building itself, environment-friendly building insurance is considered to be another type of green finance. One exemplary environment-friendly building insurance is green upgrade coverage which pays the asset recovery cost (based on how much environment-friendly materials are used in a plant factory) when it is destroyed by fire or by other accidents. Another exemplary environment-friendly building insurance is green building project insurance[45] that pays out benefits at the time of premium calculation when a plant factory is re-constructed into an environment-friendly building.

Thirdly, another type of green finance is the guaranteed savings contract. Under the guaranteed savings contract, when a firm builds a plant factory as an ESCO project, the energy user pays the bill for the investment resources required for installing an energy saving facility and the ESCO guarantees the energy user energy savings, which have a cash value.

Production of bio-energy, which has attracted much interest in Korea and other

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[45] Based on the fact that buildings built in compliance with environment-friendly building criteria have fewer environmental risks, such insurance benefits as a premium discount and a credit rating upgrade can be applied.

countries, incurs large initial installation expense and involves a great risk of investment loss. Bio-energy firms are Technology-Based Small Firms (TBSF) and, due to their characteristics[46], it is not easy to get funding. In particular, it is difficult for a newly emerging or a growing bio-energy firm to utilize the conventional financing through a bank or a capital market.

For green finance for bio-energy firms, it is necessary to seek out ways and means of securing venture capital, angel investment, and venture finance. Another requirement is the use of performance guarantee insurance for bio-energy producing farms that buy performance-certified products, in order to manage risk factors. The performance guarantee insurance indemnifies bio-energy firms against contractual damages caused by the degradation of performance-certified products developed and produced by bio-energy firms and then purchased by the bio-energy production farms. By limiting eligible insurable products only to performance-certified products, it is possible to maintain a low premium level within the financial means of bio-energy producing farms.

CDM for GHG reduction in the agricultural sector involves various risks when carrying out project procedures. Some of these risks can be managed through the conventional countermeasures of risk management. For example, guarantee insurance can be applied to quality assurance and default for long-term purchase contracts, and property insurance and products susceptible to extreme weather events, as well as to natural disasters and fluctuations in the product yield. It is also possible to manage the risks of a CDM businesses in the agricultural sector through traditional insurances. For example, property and human losses due to technical factors like a design flaw or natural disasters can be covered by construction insurance or assembly insurance.

As a means of managing the loss that might be incurred by investors or the financing companies should the emissions price obtained from CDM business in the agricultural sector be lower than expected, a number of insurance products which underwrite the risk of investing in an emission cap (e.g., Contingent Cap Forward) can be used. The Contingent Cap Forward is an insurance vehicle designed to manage the risk another party's contract default with regard to emission credit delivery. Also, with regard to the emission cap forward contract, in accordance to the emissions trading agreement, a Credit Delivery Guarantee (CDG) insurance vehicle

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[46] Main characteristics of TBSFs include: they have high research and development costs; the company value depends on long-term growth possibility; the technical capability that provides a competitive advantage may work as barrier to market entry; and it is difficult to estimate the market demand for their products.

can be used to reduce the uncertainty of contract fulfillment. This insurance compensates for the loss sustained when an emission credit from a CDM business does not meet expectations or when the emission credit cannot be certified.

2. Tasks for Promoting Green Growth of Rural Districts

2.1. Formation of Policy Tasks through Q-Method

The green growth policies in the rural districts were categorized, so as to prepare them for tasks which use the Q-method.[47] The categories are classified into the preparation of the conditions for promoting green growth policies in local autonomies based on rural districts, the construction of green resource management systems, supporting green industry and creating green job opportunities, using renewable energy and construction of a basis for reducing energy (Table 6-3).

Table 6-3. Policy tasks for green growth of rural districts

Category	Policy tasks
1. Prepare conditions for promoting green growth policies in local autonomies based on rural districts	1.1. Consolidate regulations for green growth plans in cities and counties based on rural districts. 1.2. Form green growth governance of local autonomies and local people. 1.3. Develop green growth indices and set policy targets for local autonomies.
2. Construct green resource management systems	2.1. Secure and conserve oil resources and bio-diversity. 2.2. Conserve forests and farmland as highly valued carbon sinks. 2.3. Manage scenery of rural districts.
3. Support green industry and create green job opportunities	3.1. Energize eco-tourism. 3.2. Create green job opportunities and energize green enterprises. 3.3. Encourage green consumption by introducing a green product marking system.

[47] This is based on the result of Q-method for experts, officials in local autonomies and residents in rural districts. See 'Appendix 9' for the overview of survey, basic analysis result and suggestions.

Category	Policy tasks
4. Use renewable energy and construct a basis for reducing energy	4.1. Develop and diffuse energy-saving agriculture models. 4.2. Adopt biomass technology and support facilities thereof. 4.3. Organize energy-independent villages and towns 4.4. Develop and support energy-saving house models

2.2. Prepare conditions for green growth policies of local autonomies based on rural districts

There are diversified types of cities and counties based on the rural districts, which were described in Chapter four in terms of the green growth potential index. Although there is not a large disparity in the green growth potential in its comprehensive aspects, the situation differs greatly in terms of detailed variables, depending on local natural conditions or the local industrial structure. It is difficult to implement green growth strategies that are suitable for varied local conditions in a standardized, top down fashion, as directed by the city and county councils based on rural districts. Therefore, it is very important to establish policy targets that fit local conditions, to develop the indices which describe local conditions and to manage the targets in the process of performing the policies.

What could serve as the institutional basis for setting and executing strategies for implementing green growth, that on the one hand fully reflect local conditions, while on the other are balanced with other policy measures, which will be carried out simultaneously? Cities and counties should establish two legal plans mainly in association with land use, as set forth in the 'Act on National Land'. It is necessary to establish both a city master plan and then a city management plan to implement it. The 'plan for improving the quality of life' is a statutory plan that should be established according to the guidelines laid out in the 'Special act on improving the quality of life for farmers, forestry workers and fishermen and the development of forestry and fishing districts'. The 'Plan for developing daily living areas', which should be established by virtually all cities and counties based on rural districts is based on the aforementioned 'Special Act' because the budget for local development needs to be accounted for is not a mandatory plan but is allocated to basic autonomies in the form of comprehensive subsidies. In addition, the plan for developing agriculture in rural districts and the food industry is an optional plan based on the Special Act and established by many cities and counties based on rural districts. There is a statutory device for establishing a landscape plan according to the Landscape Act as enacted in 2007. There are some cities and counties based on rural districts which established a plan for developing environment-friendly agriculture in the relevant area.

It is necessary to establish so many plans as described above. Thankfully, these plans overlap in many ways. However, that being said, the competence of the local autonomies based on rural districts, which are charged with establishing the plan, is not equal to the task of establishing these vitally important plans. With respect to the plans described above, the details of the policy project that should be included are significantly associated with green growth. Given this, it is not an efficient use of resources to force every city and county to establish their own green growth plans. Recently, some people have suggested that plans be consolidated in a simplified manner on the basis of each individual act. It has been suggested that this would have two benefits. The first would be a reduction in the burden imposed on each basic local autonomy by the requirement that they establish local plans. The second would be ensuring organic unity among all sorts of local plans (Yoon Won-Geun, 2010). Although green growth plans are necessary for cities and counties based on rural districts, it is not reasonable for them to establish their own plans at the moment. Therefore, it is necessary to include the issue of 'system for establishing green growth plans' when consolidating planning systems so as to enhance the system.

It is impossible to accomplish green growth in rural districts by preforming policies in a unilateral way. One essential feature is the active cooperation and participation of the local people and of private sector entities. These features of governance are an important issue in all sorts of local plans or local development policies. However, the reality on the ground in rural districts, where social capital is not abundant due to a sharply decreasing population and an ageing society, sets a stage where 'forming a green growth governance' is not easy. Effort should be undertaken to attract the participation of local people, to form partnerships with local assistant bodies and then to consolidate competencies in the process of establishing the proper plans and the execution of policies.

2.3. Constructing a system for managing green resources

It is necessary to plant trees or reforest fallow land in order to maintain the carbon sink function of forests and to have more forests and forested areas. Another technical requirement is to develop and propagate tree species which have excellent carbon absorption capability. For farmland, it is necessary to have a statutory basis for the regular monitoring and management of the soil's carbon storage capacity. . The most important thing is to consolidate the system which integrates farmland and forest areas.

Some people say that it is necessary to be aware of the current system of development for agricultural areas and how it relates to both having and conserving farmland. Kim Soo-seok (2009) proposed to that the current system be improved so that it could perform as a tentative 'farmland conservation area scheme'.

Such a system would detail farmland in the current agricultural promotion area and also the farmland in the production management and conservation management areas. This would allow the same land use be stipulated so as conserve farmland and compensate for loss.

A scheme is proposed for introducing a direct payment system for compensating for financial losses incurred due to the low price of land earmarked for conservation as essential farmland. In addition, it was proposed that a reorganization of the process whereby farmland is converted to other forms of land use allow for a systematic and collective conversion system that has the capacity to block speculative demand for farmland. Such a proposal for reorganizing the farmland system acts on the perception that farmland so secured should be used for the purpose of supplying food. However, it is now necessary to further conceive a scheme for reorganizing the farmland system taking into consideration the land's use as carbon sinks.

Some people insist that it is necessary to improve the forest conversion system (Kim Chang-Gil, 2009). The proposal is that forest conversion-restricted areas, conversion restrictions and permit standards be re-examined and unified into the 'forest conversion feasibility review system'. In particular, Kim insisted that it is necessary to establish a 'comprehensive mid- and long-term forest management plan' and a forest management information system for nationwide systematic forest management. This would allow forests to be effectively managed as carbon sinks.

Biological diversity and heredity resources in rural districts are an invaluable basis for green growth. It is necessary to continue to support the conservation of more diversified heredity resources. Given that a significant number of organizations designated as institutions for agricultural heredity resources are under the local autonomies there is a need for more consolidation.

The landscape of rural districts is a typical green resource in that it can be used as means for realizing economic values in connection with tourism, regional strategic industries, etc. Regulations related to this aspect of land use are already significantly consolidated. However, the only direct payment system for landscape conservation as it relates to landscape management in agricultural and fishing districts in Korea: The landscape management scheme, promoted by means of the system of direct payments for landscape conservation, needs improvement in the following aspects. First of all, the system for direct payment of landscape conservation should be adopted systematically on the basis of eligibility. There are grounds for establishing a landscape plan in rural districts in the current 'Act on improving quality of living', but it is not well utilized in rural districts. It is necessary to improve the methods associated with establishing a landscape plan in rural districts, so that such activities will be performed well. Connected with this, it is necessary to publicize policies, projects or systems associated with landscape in rural districts. Next, it is necessary to encourage the local autonomies to take on a supervisory role (in cooperation with the local people in the rural districts) so as to more effectively promote landscape management projects.

2.4. Fostering green industry and creating green job opportunities

The movement towards operating tourism in rural districts in a more ecological way (a process which gained momentum from early 2000 onwards) was named 'eco-tourism'. Although the eco-tourism market is not growing rapidly it is growing steadily.

The demand for eco-tourism in Korea can be traced to the introduction of the five-working day system. At this point, the lifestyle of urban people changed significantly such that the tourism industry is increasingly catering to a tourism paradigm whereby experiencing locales with family members is coming more to the fore.

In terms of supply, while the trend is to conserve ecological elements in rural districts, ever more qualified people in rural districts are finding employment as forest guides. An exemplary case of expanding eco-tourism market is the nationwide ‘walking trail’ project in rural districts, such ‘Olegils’ exist in Jejudo. The term ‘Fair travel’ has come into use of late. This speaks to a changing tourism paradigm in rural districts, one that is moving in the direction of ecological conservation.

It is necessary to improve some aspects of current tourism policies in rural districts in order to further facilitate the trend of a gradual movement towards eco-tourism in rural districts.

First, it is necessary to avoid excessive experience, or ‘kitsch’ tourism, in each rural district village in a manner of artificial experience programs and to expand the frame of policy support so that diversified bodies can develop diversified goods and services.

Second, the government subsidies for tourism in rural districts have not been well associated with policy projects to encourage environment-friendly agriculture or encourage activities for ecological health in rural districts. When selecting villages for subsidy projects, some credit was given to them, taking into consideration their practice of environment-friendly agriculture. However, it is necessary further to consolidate the association among such policies.

As described in Chapter four, there are a considerable number of workers in the environmental industry. However, it is very difficult to increase green job opportunities on a step-by-step basis. Thus, it is necessary to find ways and means of creating green job opportunities using long-term approaches while transforming the rural economy to a green rural economy. From such a standpoint, schemes which expand short-term employment as typified by the Good Forest Project or the Four Rivers Recovery Project would not be considered the best option. Green job opportunities should necessarily be sustainable job opportunities. That being said, a considerable number of enterprises operating in rural districts of late are engaged in the, so called, green industry. One scheme is to adopt the concept of green growth in the frame of existing support policies so as to give priority to supporting such enterprises. To achieve this closer connection and integration between diversified government authorities and policy projects is essential.

2.5. Using renewable energy and constructing a basis for energy saving

The Korean Government's 'Five-year Plan for Green Growth' project aims to construct 600 'low carbon green towns' by 2020. As a part of that project, five model projects have gotten underway. Of the five model projects, two are overseen by the Ministry of Public Administration and Security, one by MIFAFF, one by the Ministry of Environment, and one by the Forest Service. The maximum government subsidy for one model project is roughly five billion won, and the subsidy ratio is around 50%. These model projects are promoted by each government Ministry which is recommended to establish its own project model.

If energy-independent green town model projects had been planned on the basis of solar energy rather than biomass, it would have been very difficult to promote the model projects. Some rural villages successfully made the transition to a green village without government subsidies (Deungyong village in Booangoon, Hwasoonri in Jejudo, Namjeonri in Injegoon all installed facilities that use solar energy). The commonality between successful cases in Korea and in other countries, in which renewable energy was used by villages themselves in rural districts, is the support of incentive policies, e.g., FIT (feed-in tariff) whereby public sector electricity utilities purchase electrical energy produced by people in rural districts, who usually are using a small renewable energy plant. In any case, the Ministry of Economic Affairs abandoned FIT in 2010 and decided to allocate the ratio of renewable energy use, e.g., electricity, to energy suppliers on a quarterly basis. Given this, energy suppliers will seek to invest in one place in a large scale, capital intensive renewable energy project or purchase it from an energy producing company rather than purchasing energy from small-scale producers, e.g., several villages scattered in rural districts. That is, the well known energy-independent villages are assuming incentive policies for the people living there, and there will be no incentives from now on.

Electric energy will still be produced, using biomass as opposed to sunlight. However, there are still some technical problems which need to be resolved. Eunhee Choi (2009) suggested in the agricultural sector that some amount of biomass is a precondition. For example a biomass village or town is connected to the organic circulation system. Therefore, it is necessary to increase the number of livestock as a proportion of the required biomass energy in order to construct villages or towns using biomass energy derived from livestock farm byproducts. As a result, after considering the relative costs and benefits, there will only be a very small number of places in which biomass villages or towns can be constructed.

3. Scheme of promoting policy integration for green growth in agriculture and rural district

The six basic principles for policy integration are described below. It was conceived after diagnosing the current policy integration as it pertains to agriculture and rural districts and then combining this with some generalizations arrived at using the results of a questionnaire which surveyed a pool of experts.

First, facilitate policy integration focused on environmental efficiency in order to switch agricultural policies and environmental policies from a relationship characterized by conflict to one of mutual supplementation.

Second, lay the emphasis on environmental efficiency as a vehicle for achieving balance and harmony between conflicting policy objectives, reorganize policy implementation systems and governance, supplement the budget system and the assessment system due to the fact that policies for green growth are facilitated by means of general agricultural policies.

Third, configure a policy portfolio based on policy integration that maximizes the synergy effect of economy and environment. Achieving this synergy is a key factor of green growth.

Fourth, facilitate policy integration based on both qualitative and quantitative assessments. Use these assessments to gauge assessing the level of policy effectiveness in association with green growth.

Fifth, use the policy feedback system, e.g., planning, enforcement and assessment of policies to the full, so that policy integration for green growth can be continued.

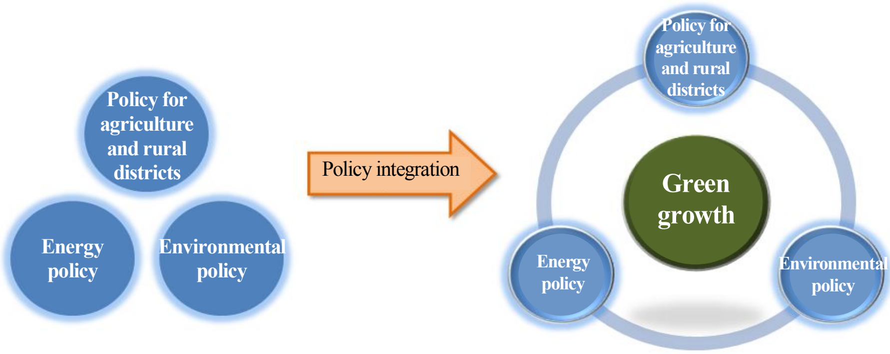
Sixth, use green technology to mitigate obstacles undermining the necessary preconditions of green growth, e.g., expenses, ease of acceptance of the green production and consumption systems.

On the basis of these aforementioned basic principles, schemes for promoting each means of policy integration will be described in the following.

3.1. Setting objective and basic direction of agricultural administration for harmony between economy and environmental efficiency

The goal of policy integration for the green growth of agriculture and rural districts is to organically interrelate and integrate agricultural, environmental and energy policies that have only been individually promoted so far, so as to achieve the higher objective of green growth.

Figure 6-2. Concept of policy integration associated with agriculture and rural districts for green growth



As described in Chapter three, the agricultural administration vision and policy missions of Vision 2020 display a harmonized balance between economic efficiency and environmental efficiency. However, the basic direction set forth in the 'Act on agriculture, fisheries, rural and fishing districts and food industry framework' is generally understood to place emphasis on economic efficiency at the expense of environmental aspects, and the energy sector is not even given a mention. Therefore, it is necessary to readjust the emphasis so that it emphasizes economic growth and conservation of resource environment equally. Therefore, it is necessary to revise Chapter two (Basic direction of agriculture, fisheries, rural and fishing districts and food industry policies)-Article six (Basic principle of establishing and enforcing policies)- ① of "Framework Act on Agriculture, Fisheries and Food Industry to "The national government and local autonomies should consider economic efficiency and maximization of public profit in agriculture, fisheries, rural and fishing districts on the basis of the principle of market economy when setting and enforcing policies for agriculture, fisheries, rural and fishing districts and the food industry". It is necessary to include, in this basic direction, an article outlining how the agricultural sector should produce and use energy so as to be efficient in terms of economy, whilst simultaneously reducing environmental load and promoting resource circulation to the maximum possible extent.

It was shown that experts in fields related to this topic believe that the objectives of agricultural policies are in conflict with both energy and environmental policies. They comment that the most important thing is harmony between these policies and suggest that a rearrangement of targets and objectives serve as the means of policy integration. Although the agricultural administration vision and missions on Vision 2020 include harmony and balance between the economy and the environment, the negative opinions of experts may result from the fact that this is not well emphasized in the targets and objectives of the actual policies in each sector. Therefore, it is extremely important to eliminate any conflict between these policy targets. These conflicts may be mitigated by means of various future measures employed to facilitate policy integration.

3.2. Reorganizing the system for promotion of policies

As described in Chapter three, since green growth is now the national agenda, it is necessary that MIFAFF reorganizes its system for promoting green growth and enhances the governance of this system. There are three suggestions as to how to proceed.

First, examine how best to create a division in charge of energy and environment policies in association with agriculture and rural districts. From the survey, the experts answered that the creation of a division tasked with ensuring the smooth progress of policy integration is very important.

Second, change the status of the Green Growth Task Force, which by definition operates temporarily, to the Green Growth Task Commission (tentative), which is tasked with achieving consensus. This Commission will be tasked with establishing and adjusting major policies and comprehensive plans of green growth in the agricultural sector, affairs related to budget allocation and efficient operation associated with green growth, plans for adopting the budget for green growth technology and discussions and decisions on research and developments investment recommendations by engaged institutions. Since the Green Growth Working Group is a kind of council in which many institutions engaged in agriculture participate, it is not easy to facilitate further discussion on detailed policies. It is therefore necessary to create divisions specialized in each field (under the auspices of the Green Growth Task Commission) which can conceive and assess policies and then act as an organization vital to the establishment and assessment of budgets. It is necessary that these specialized divisions encourage the participation of government authorities, experts from private sectors and farmers. It is also necessary to install a specialized division expert in, and tasked with, enhancing the efficiency of green activities within the overarching agricultural policies from a perspective of policy integration across fields, in addition to divisions specialized in each field.

Third, it is necessary to benchmark the environmental policy of MAFF (The Ministry of Agriculture, Forestry and Fisheries of Japan) and ISO14001 when reorganizing the system for promoting agricultural policies for green growth. Japan's MAFF has for some considerable time been aware of the importance of environmental issues, e.g., waste on the increase, bio-diversity on a downward spiral and global warming advancing. MAFF is aware that it is essential to maintain and enhance the natural circulation of the agriculture, forest and fisheries industries in addition to conserving and managing local resources, e.g., farmland and water for farming, so as to ensure the continuous development of the agriculture, forest and fisheries industries.. Accordingly, MAFF prepared the guideline 'Basic Direction of Policies for Environment of Agriculture, Forestry and Fisheries.' in December, 2003. This guideline specifies how to maintain and enhance the natural circulation of the agriculture, forestry and fisheries industries and how to promote policies for conserving and creating healthy and abundant natural environments in rural, forestry and fishing districts.

MAFF introduced an environment management system, based on ISO14001, which it used to promote a scheme for reducing environmental burdens and for environmental conservation. Accordingly, the involved departments under the 'comprehensive division of environment biomass policies' within the ministerial secretariat joined forces to prepare the 'Table of Environmental Targets, Environmental Objectives and the Plan for Enforcement Thereof' on 'those affairs of MAFF directly affecting the environment' and the 'planning and draft of policies of agriculture, forestry and fisheries' every year, and enforces the policies.

MAFF Directive No.17 specifies the basic details on 'the MAFF system of managing the environment' which conform to the requirements of ISO14001:2004 (JISQ14001:2004) and sets out measures that contribute to environmental consideration and conservation when the various departments of MAFF perform their tasks. The MAFF tasks connected with carrying out investigation on the environment (according to ISO14001) are described below in Table 6-4.

Table 6-4. Tasks of MAFF for investigation on environment according to ISO14001

Tasks directly affecting environment	(1) Official work	Including daily work among the work directly affecting environment - Use of fuel for official vehicles, use of electricity, use of fuel related to energy supply facilities, use of paper, use of tap water, discharge of waste, use of office supplies
	(2) Other work directly affecting environment	Works not included in (1) directly affecting environment
Tasks indirectly affecting environment	(1) Planning and drafting environmental conservation policies	Including planning and drafting agricultural, forestry and fishery policies aiming at environmental conservation
	(2) Planning and drafting agriculture, forestry and fishery policies indirectly affecting environment other than (1)	Planning and drafting agriculture, forestry and fishery policies involving modification of land shapes, etc., work not included in (1)

Source: MAFF (2005).

The table of investigation on environmental aspects includes all environmental concerns connected with these tasks, e.g., air pollution, water pollution, soil pollution, bad smell, global warming, ozone layer depletion, resource depletion, discharge of waste, damages to human health, etc. When preparing the table of investigation on environmental aspects, it is recommended that consideration be given to the frequency with which environmental load occurs, the volume of environmental load which occurs and the significance of the environmental load.

Fourth, it is necessary to introduce a training and incentive system to enhance policy maker awareness of policy integration. Perhaps the one thing more important than policy integration itself is the policy maker's awareness as contrasted with the policy implementation system itself. That is, it is necessary that all of policy makers, as well as the green growth policy maker's maintain a positive awareness. Given this, it is possible to consider policy elements for green growth in overall agriculture and rural district policies.

To this end, it is necessary to make policy makers aware of green growth and policy integration so as to force them to take compulsory training in the concept of, necessity for and means to promote green growth and policy integration. Incentives may be provided to individuals which reflect the result of taking said compulsory training on their performance appraisal.

Fifth, it is necessary to consolidate the communication and strategic knowledge management involved in green growth policies. Many prior studies show that policy integration is successfully achieved when citizens, the government and private groups are sustainably and effectively managed and when social, political and economic sympathy is harnessed for development that demonstrates responsibility towards future generations. For example, the Danish Government enforced policies for expanding use of renewable energy in the 1970s. It did so in order to solve the problems facing agriculture as well as insufficient energy resources and a high ratio of unemployment. It is now engaged in promoting the integrated 'Action Plan'. As a result, Denmark is currently one of the leading countries in the field of wind power generation (Hamdouch, *et al*., 2010). The success of integration policies for solving current problems and preparing for the future has as its foundation the support of citizens, the government, private enterprises, research institutes, banks and trading organizations and lobby groups.

Because policy integration thrives when support is forthcoming from all parts of the society as well as strong government policy, communication and strategic knowledge management is absolutely vital. However, the results of survey of experts were that they did not place great value on communication and the performance of strategic knowledge management as related to green growth policies. The experts said that the following was needed for communication, the construction of joint knowledge bases and strategic knowledge management.

First, search for successful cases upon which to expand training and education. In other words, find the current bright spots and expand upon them.

Second, install specialized divisions or employ more workers in the related divisions to promote strategic knowledge management and networks. Such institutions or divisions would then serve as a control tower with which the government-the community-the university cooperate and network, and vitalize communication in which involved bodies of farmers, policy makers and researchers participate in.

Third, secure a pool of specialized human manpower and expand training for green technology. In the previously outlined example of a green energy project using livestock manures as its feedstock, specialized manpower is needed who can instruct, conduct, assess, promote and give feedback on the project.

Fourth, develop a hub network to comprehensively collect, arrange, monitor and analyze associated policies and information. Closely connected to this is the need to prepare a policy map to check the connections between policies and projects. A gateway on the internet is needed to comprehensively manage agriculture, rural districts, energy, environment and knowledge bases. The benefit of this would be to facilitate easy access to information and data on policies, the results of research, involved knowledge and experts.

3.3. Consolidating connectivity between budget and performance management and establishing mid- and long-term plans

In relation to the budget system, it is necessary to consolidate the connection between the program budget project and the performance management system. As described in Chapter three, policies involved in green growth in the food sector within agriculture, forestry and fisheries are classified into different categories on the performance management enforcement plan and program budget. Accordingly, it difficult to structure the entire process of planning, organizing, allocating, enforcing, accounting, assessing and providing feedback budgets focused on the program and to manage project performance in connection with the performance management system. Therefore, it is necessary to match policies and classifications on the ‘performance management enforcement plan’ and the program budget project’ as closely as possible. Only by doing this can budgets be closely connected to the development and promotion of green growth policies and performance assessment and from there via feedback loops to budgets. This will promote policy integration in terms of performance assessment and budget distribution.

In the field of policies, the one field that most require the above measures are the agricultural sector energy policies. The energy policies in agriculture detailed in the performance management enforcement plan in 2010 include major policies promoted by means of tasks for management, e.g., supporting environment-friendly livestock farming, strengthening low carbon and green growth infrastructures, promoting energy saving and use of renewable energy in the agricultural and fishery sectors, and bio-diesel rape production. However, they are not specified as separate programs in the program budget project but rather tacked on to other projects. However, since energy policies are a major category for green growth and are important in terms of policy integration, it is necessary to assign them separate program status as this will facilitate the connection between their budgets and the performance management system.

Second, it is necessary to establish mid- and long-term plans, e.g., the ‘Plan for sustainable management and utilization of natural resources and environment of rural districts (tentative)’ and the ‘master plan for energy management for agriculture and rural districts (tentative)’ in order to promote and assess policies and to secure budgets. MIFAFF has established and promotes a system of planning, which develops plans for supporting environment-friendly agriculture for development of environment-friendly agriculture every four years, according to the ‘Act on Supporting Environment-friendly Agriculture’. The five-year plan for supporting environment-friendly agriculture (2006 to 2010) set the vision and missions of environment-friendly agriculture, which is to ‘realize people’s healthy lifestyle and agriculture as a living environment’ and ‘ensure both consumer trust and the conservation of the land environment by supplying environment-friendly safe agro-food’. The objective of driving the conservation of natural resources and environment, which is to say soil, water, forest, and other life resources, by means of environment-friendly agriculture is clearly indicated by the inclusion of the ‘conservation of national land environment’ statement in each mission. However, the problem is that in the detailed plan for supporting environment-friendly agriculture, such missions are interpreted seeking to conserve, i.e. protect, the national land environment from the results of supporting environment-friendly agriculture. Additionally, the conservation and sustainable use of natural resources and the environment in agriculture and rural districts, which is centrally important to the concept of green growth and sustainability are not included as direct policy objectives,

Another matter of importance to green growth is to strengthen the ecological and environmental conservation of natural resources and to make environment-friendly agriculture, and indeed all agriculture, use natural resources in an environment-friendly way. Therefore, it is essential to establish the ‘plan for managing and using natural resources and environment sustainably in agriculture, rural and fishery districts (tentative)' in order to promote policies effectively and secure budgets easily. To this end, experts specialized in the field counsel that it is necessary to prepare the legal and systematic ground, develop detailed policies, secure more strategic human power, create specialized departments, and promote cooperation between all the authorities involved.

In the agricultural sector, diversified policies related to energy have been enforced. However, there is no system for managing and promoting policies for supplying energy in the agricultural sector comprehensively in either the mid- or long-term. On the other hand, the government established the 'Master Plan for National Energy (2008-2030)' which is the highest plan related to energy in August, 2008, and presented five green growth visions in the energy sector.

It is necessary that the sector of agriculture and rural districts establishes a 'master plan for energy management for agriculture and rural districts (tentative)'. This should be appropriate for agriculture and rural districts and in accordance with the 'Master plan for National Energy' and other master plans. It should so promote policies in connection with the agriculture, rural districts and energy, and secures budgets.

Third, it is necessary to benchmark policy projects undertaken by the government of Japan as useful case studies of policy integration with budgets. The policy project of Japan was enforced by the Koizumi Cabinet, having been introduced from the budget organization in 2004. A total of 17 policy projects were under enforcement as of 2009. The policy projects of Japan are directed towards achieving policy objectives by a plurality of government ministries in connection with regulation, system innovation and budgets so as to harness the private sector's potential to the maximum.

Because there are existing multiple systems related to energy for biomass expansion policies and other objectives, it is necessary to examine systems like the policy project of Japan to consider related regulations and systems as well as budgets. In order to expand use of biomass, policies for expansion itself are required and it is necessary to balance these policies with other regulations, systems and policies that are competing for the use of the same biomass.

Existing energy related systems competing with biomass include the night thermal-storage power service, tax-free gasoline for farming, a tax exemption for kerosene for heating in rural, forestry and fishing districts, and support systems for using coal, e.g., 'the coal supply and demand stabilization project' and the 'anthracite development support project', etc.[48] It is necessary to find a harmonized balance between policies which have different objectives, e.g., energy welfare for low income people, industrial development and the policies for expanding biomass for environment-friendly energy.

Meanwhile, FIT will be phased out by 2012 and the Renewable Portfolio Standard (RPS) will be introduced. Biogas plants need lots of cost for initial set-up of facilities and management after construction and the electricity rate is 110 won per kWh which is 1/5 the rate of sunlight (583 won). In this context, it is necessary to enhance economic efficiency by providing more support to bridge the cost differential for biogas rather than abolishing FIT. Because FIT is important for energy independency in the relevant region, because it energizes local communities through local people's positive participation and because it boosts the local economy, many people say it is desirable to keep FIT and not phase it out.

3.4. Introduction of Environmental Impact Analysis System for Agricultural Policies

As described above, green growth policies are assessed by diverse means. However, whichever system of assessment is used, it is difficult to find a system, which in terms of policy integration, allows an assessment to be made as to how much different policies affect green growth before and after enforcement.

Therefore, it is necessary to devise a scheme to produce an assessment system, e.g., 'Green Growth Impact Analysis (tentative)', that can assess the level of impact of individual policies on, and contribution to, green growth. and for reflecting the result of assessment on the budget proposal.

In order to introduce a 'Green Growth Impact Analysis', it is necessary to develop, or have in place, a green growth index that can reliably assess the environment, energy and the economy. Prior- and post-assessment could then be based on this selected green growth index. If feasibility can be confirmed at the prior-assessment stage, then policy programs can be better enforced and policy failures minimized in frequency and extent. If policy targets are set on the basis of the selected green growth index, it should then be possible to assess the policy's performance, achieved

48 Jeonghwan Bae. 2009. Scheme for improving biomass diffusion policies. Databook for 17th Annual Symposium. Agricultural Administration Research Center.

by means of policy enforcement, and so allow feedback to be carried out that can adjusting and/or complement policies and so improve them.

There have been active efforts for developing agricultural environment indices similar to 'Green Growth Impact Analysis (tentative)' and for assessing agricultural environment policies in OECD and EU.

The OECD agricultural environment index is divided into a key index and a local index for assessment. The key index is focused on factors which are applicable to all of OECD member countries.[49] The OECD agricultural environment index comprehensively comprises energy and economy sectors as well as the environmental aspect, and is appropriate for developing the green growth index.

The EU is very much aware of the need to measure the effect of individual agricultural policies on the environment with the aid of a natural resource management indicator in rural and fishing districts. The need is all the greater in the EU due to the difficulty of integrating policies when there is policy conflict between environment policies and those agricultural policies which aim at increasing agricultural production and income. Given this need, the CAP (Common Agriculture Policy) of the EU has developed IRENA (Indicator Reporting on the Integration of Environmental Concerns into Agriculture Policy) as a means for setting agriculture/environment policy targets of and assessing those policies.

The environmental results for Korea are not as favorable as most other OECD countries in terms of indicators for the last 10 years. This is the result of an absence of systematic policies for improving the agricultural environment.

In Korea, assessment and study using such indicators is in need of more improvement. It is necessary to develop a system, in particular integrated assessment systems for assessing agricultural/environmental policies, using such indicators. It is necessary to build up a system for producing the basic data set which is needed to calculate the indicators for assessing policies.

One exemplary scheme would be to introduce an independent assessment system, e.g., 'Green Growth Impact Analysis (tentative). However, an alternative would be to include assessment factors related to green growth in the existing frame of performance management to carry out assessment.

The role of such an impact analysis system is basically to ensure the smooth progress of policy integration, but it should not inhibit agricultural growth and the

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[49] Rural Development Administration. 「Research of agricultural policy feedback using OECD agricultural environment index」. 2009.

improvement of agricultural competitiveness by considering agricultural growth and improvement of agricultural competitiveness as well. It is necessary to ensure the effectiveness and reliability of assessment of the method of assessment through further study of the qualitative and quantitative elements for analysis.

Chapter 7

Summary and Conclusion

Korea is the world's 10th largest energy consumer, and imports 97% of its energy consumption. The government therefore has an urgent need to prepare for the regulatory effects of combating climate change and the depletion of fossil fuel.

The regulatory effects of combating global warming as it progresses, has seen the international community has strengthening environmental regulations intended to reduce greenhouse gases (GHGs). This strengthening has come into being by means of international cooperation. Given such international circumstances, the Korean government has presented "low carbon green growth" as a core strategy for the future national development in order to preemptively cope with climate change and deal with an impending energy crisis.

The agricultural sector, like other sectors, is promoting various low carbon green growth measures such as promoting the use of biomass, expanding the supply of green technology and equipment, utilizing multidisciplinary technology, and strengthening its ability to cope with climate change. By doing so the sector is attempting to handle the problems inherent in the sector, including the negative impacts of climate change, increasing management costs and ongoing damage to the agricultural environment. In the era where energy and climate are truly major issues, it seems that green growth will likewise be a key issue, both domestically and internationally, for some time. Thus, presenting effective practical strategies, developed on the basis of comprehensive diagnosis and systematic analysis of green growth in agriculture and rural districts, is an important and historic task.

This report is one of the outcomes of the first-year of research on the "Development of Strategies for Promoting Green Growth in Agriculture and Rural Districts" which will be carried out over two years, 2010 and 2011, as a cooperative task under the auspices of Korea Council of Economic & Social Research Institutes. It aims at presenting systematic and practical strategies for promoting green growth in agriculture and rural districts founded on an in-depth analysis of the domestic and international trends of green growth from industrial and spatial aspects.

The main accomplishments of this research are summarized below:

First, GHGs emitted from the agricultural sector account for 2.9% of gross national emissions and have to be reduced by 0.5% based on the 2005 level by 2020 (when the BAU scenario was estimated), according to the IPCC guidelines for calculating GHG emissions. The resultant level is still higher than -4.0%, which is the national target for GHG reduction, which implies that various additional GHG mitigation measures are needed in the agricultural sector including, but not limited to, the development of technologies for reducing GHG emission from the farmland, storing organic carbon in the soil and improving ruminants' enteric fermentation.

Second, an evaluation of the green growth policies for the agricultural sector shows that green growth measures have been formed properly. However, the development of policy programs to produce visible accomplishments and to effectively spread green technologies appears to be insufficient. Analysis of the green growth policies for rural districts reveals that it is necessary to develop policy means to materialize detailed tasks and to supplement the current green growth policies and systems for rural districts.

Third, the result of a survey of farmers' and experts' recognition of green growth in agriculture shows that they are highly aware of green growth and look positively on the parallel implementation of environmental preservation and economic growth. With regards the policy programs they would like to see promoted first, 'promotion of utilization of biomass energy' and 'expansion of green technology supply' were the clear favorites. In addition, 'strengthening of preventive measures against climate change' and 'expansion of environment-friendly agricultural district formation projects' were also suggested as being important, though to a slightly lesser degree.

Fourth, the diagnosis of the current conditions of green growth policy integration based on expert survey and policy integration theories reveals that it is necessary to reorient the agricultural administration towards the goal of harmoniously balancing the economy and the environment while simultaneously strengthening the policy promotion system. With regard to policy integration in the agricultural sector, it appears that a budget system and mid/long-term plans linked to performance management are lacking. It also appears to be necessary to establish a system that can evaluate the contribution of certain policies towards green growth.

Fifth, an analysis of ecological efficiency of organic agriculture and geothermal heat pumps carried out as a part of empirical analysis of green growth in the agricultural sector revealed that the ecological efficiency of organic agriculture is 32.0% higher than that of conventional agriculture and geothermal heat pumps 5.1%

higher than oil heating facilities. The technological efficiency of rice production using organic farming methods was analyzed and compared with the ecological efficiency index. The comparison shows that when the technology efficiency is high, the ecological efficiency index also appears to be high.

Sixth, empirical analysis of green growth using carbon productivity index reveals that the agricultural sector has a higher green productivity than non- agricultural sectors. However, given that reductions in nitrogenous fertilizer usage brought about by reduction in rice cultivation area in combination with a GDP increase caused by an increase in pig farming in the livestock sector greatly contribute to the increase in green productivity of the agricultural sector, there are limitations in considering it to be green growth through the use of low carbon green technology. In order for sound green growth in the future agricultural sector to occur, it is essential to draw up core tasks for green growth, including the promotion of green technologies for reducing the nitrogenous fertilizer usage per unit area, as opposed to reducing the cultivated area, and by reducing GHG emissions from ruminants.

Seventh, according to the result of analysis of the green growth potential index for rural districts drawn using the OECD index frame, the green growth potential indices with regards 'green production,' 'green consumption,' 'green resource basis' and 'quality of living environment' appear to be higher in such mountainous areas as the provinces of Gangwondo and Gyeongsangbukdo and some plains areas in the provinces of Jeollanamdo and Jeollabukdo Province, both of which are less urbanized than other areas of the country.

Eighth, it is necessary to develop feasible low carbon policy programs for the increase of income from agricultural activities that also contribute to the reduction and/or absorption of greenhouse gases. One example would be the utilization of a carbon emission trading system, which would doubtless spur green growth in the agricultural sector. Green technologies, such as geothermal pumps, LED, biogas plants, and rice-based biorefinery using supercritical fluid process, can all be utilized in the agricultural sector to reduce energy costs and the environmental burden. As they involve considerable business risks including high initial costs, proper green finance programs that can mitigate such risks must be supported.

Ninth, with regards to policy tasks for green growth in the rural districts, the suggestions are to establish proper policy objectives based on the current conditions of each area, to prepare conditions for promoting the established green growth policies, to build up an efficient green resource management system, to create green industry jobs for rural districts, and to establish bases for utilizing recycled energy and reducing energy cost.

Lastly, in order to achieve the agricultural administration's policy objective of achieving a balance between the economy and the environment several measures need to be undertaken. First, an evaluation system for green growth policies for agriculture and rural districts needs to established. This requires the re-organization of the institutional framework to strengthen the link between budget and performance management; to evaluate the impact of individual policy and its contribution to green growth; and to reflect the results of evaluation in the budget book.

The first-year research on the development of strategies for promoting green growth in agriculture and rural districts focused on the diagnosis of the actual conditions of green growth and the formation of core tasks for each field by means of empirical analysis. The second-year research will focus on forming specific implementation strategies for the successful promotion of green growth, deciding the priority of each implementation policy, and presenting a concrete and systematic plan for policy integration. Detailed tasks to be handled in the second-year research are outlined below:

First of all, in-depth policy evaluation of the green growth policies being promoted at present will be carried out for agriculture and rural districts, to establish the validity of each policy, the adequacy of performance index, the level of compliance with the implementation schedule, policy expansion efforts, and the effectiveness and extent to which performance goal have been achieved (Detailed Tasks 1 & 2).

Second, the second-year of the study will investigate specific cases of green growth policy programs and implementation strategies of major advanced countries that Korea can benchmark, and suggest their implications (Detailed Tasks 1 & 2).

Third, it will present implementation strategies on an implementation roadmap for firmly establishing green growth in the agricultural sector and green growth in general. These implementation strategies will also set the basic direction for establishing strategies that promote green growth and allow for the design of a policy portfolio for green growth, based on analysis of economic effects regarding social costs and benefits (Detailed Task 1).

Fourth, it will suggest detailed plans and step-by-step implementation strategies for major policy tasks for green growth in rural districts, and propose a policy implementation system for promoting green growth policies for rural districts (Detailed Task 2).

Last, but not least, the second-year study will propose plans to promote the integration of agriculture and rural district related policies for green growth, i.e. a policy portfolio encompassing agriculture and rural district policies, environmental policies, energy policies and technology policies, the priorities of policy integration for each policy field and means, and a roadmap for policy integration (Detailed Task 3)

Appendix 1

Details of the Framework Act on Low Carbon Green Growth

Attached Table 1. Details of the Framework Act on Low Carbon Green Growth

Article	Clause	Description
Chapter 1. General provisions	(1~8)	- Objective of the Act, definitions of low carbon, green growth, green technology. - Basic principle of promoting low carbon, green growth, regulations on the government, the local autonomies, and obligations of citizens. - Relation to other regulations, etc.
Chapter 2. National strategy for low carbon and green growth	(9~13)	- Definitions of responsibility of central administration authorities and local autonomies in establishing and enforcing national strategies for low carbon and green growth - Inspection and assessment of progress, opinions on policies, etc.
Chapter 3. Green growth commission	(14~21)	- General details of configuration, operation and tasks of the Presidential Commission on Green Growth - Configuration of a sub-commission and a green growth task force, requesting assistance of government officials, installation and operation of a local commission on green growth, designation of a responsible officer for green growth
Chapter 4. Promoting low carbon green growth	(22~37)	- Presentation of basic principle for implementing green economy and green industry - Tax and financial support for green economy and green industry, details for information and communication technology and supporting small and medium-sized enterprises - Creation of job opportunities for green technology and green industry, refined regulations and response to international regulations.
Chapter 5. Implementation of low carbon society	(38~48)	- Establish basic principles and plans to cope with climate change, basic principles and plans, e.g., energy policies - Construct a system for coping with climate change, managing energy targets and GHG, specific limit emission trading system, support nuclear power industry, etc.

Attached Table 1. Continued

Article	Clause	Description
Chapter 6. Implement green living and sustainable growth	(49~59)	- Implement green living and sustainable growth, establish and enforce basic plan for sustainable growth - Manage national land, water and transportation system, and buildings, promote green living, trading and publicization thereof - 55. Promote environment-friendly agriculture, forestry and fisheries and expand carbon sinks : develop agricultural technology for energy saving and bio-energy production, diffuse production, distribution and consumption of products by environment-friendly and organic agriculture, forestry and fisheries and wooden products - 56. Promote eco-tourism: conserve, recover and use habitats of plants and animals and the natural environment to make them tourism resources, boost local economy to promote eco-tourism. - 57. Propagate production and consumption for green growth, save and efficiently use energy and resources in the whole process of living and provide information to consumers.
Chapter 7. Supplementary rules	(60~64)	- Request to submit data, improve international cooperation, report to the parliament and prepare reports, negligence fines, etc.

Note: The Act on Framework for Low-carbon Green Growth was enacted on January 13, 2010, and has been enforced since April 14, 2010.

Appendix 2

List of Green Growth Policies for the Agricultural Sector

Attached Table 2. List of Green Growth Policies for the Agricultural Sector

Category		Policies	Farmers	Experts	Gov't offcials
Climate policies	Mitigation policies (GHG reduction & absorption)	. Construct a statistics system for calculating accurate GHGs in each field.		○	
		. Develop emission and absorption coefficients complying with international standards, and install more statistics verification systems.			○
		. Introduce the emission trading system to the agricultural sector.	○		○
		. Construct and operate systems for statistics and management of GHG emission in the agricultural sector.		○	
		. Introduce a scheme for providing incentives in reducing GHGs.	○	○	
		. Construct an inventory system for GHG in agricultural and livestock farming sector.		○	
		. Construct a basis for tracing carbon history of agro-food		○	○
		. Introduce carbon tax to the agricultural sector			○
		. Develop carbon sequestration and low carbon technology for the agricultural sector	○	○	
	Adaptation policies	. Develop technology for observing ecological changes of plants and animals and devise an adaptation program.		○	

Attached Table 2. Continued

Category		Policies	Farmers	Expert	Gov't officaials
Climate policies	Adaptation policies	. Reorganize and facilitate the crop damage insurance.	○	○	○
		. Assess and predict influence on food production due to climate change.	○	○	
		. Assess vulnerability of the Korean agro-ecological system and edit a map of vulnerability.		○	
		. Construct an grain harvest information system for production and consumption countries.	○	○	
		. Organize a national network for preventing and controlling diseases and harmful insects.	○	○	
		. Select cultivation regions suitable for each crop and re-arrange crops.	○	○	
		. Develop climate-friendly food production technology.	○	○	
		. Develop adaptation and control methods to/for weather disasters, diseases and harmful insects.	○	○	
		. Develop disaster assessment and damage minimizing technology for agriculture by abnormal weather.	○	○	
		. Introduce and assess subtropical crops and develop cultivation methods.	○	○	
Energy policies	Energy efficiency	. Improve thermal insulation of protected horticulture and agriculture facilities and diffuse energy saving devices.	○		○
		. Supply geothermal heat pumps to protected horticulture farmers.	○		○
		. Improve the tax free gasoline system for agriculture.	○		○
		. Enact policies for reasonably regulating exhaust for machines used for agriculture.		○	○

Attached Table 2. Continued

Category		Policies	Farmers	Experts	Gov't officials
Energy policies	Renewable energy	. Expand facilities for making resources and energy with livestock manures.	○	○	
		. Study and develop non-food crop varieties, e.g., reeds and eulalias for reclaimed land, fallow, and water front areas to commercialize them.	○	○	
		. Prepared a distribution chart of biomass resources in the agricultural sector.		○	
		. Produce high quality compost and manures and set criteria for quality assessment.		○	
		. Encourage the production of renewable energy, e.g., solar power and wind power.	○		○
		. Produce and supply electric energy using irrigation water in reservoirs, river water and surplus water for agriculture.	○		○
		. Develop the most efficient system for producing bio-energy from raw crops.	○	○	
	Develop new energy	. Develop and diffuse technology for practically using LED lights in cultivating crops.	○	○	
		. Develop technology for improving productivity and quality of protected horticulture crops, using LED lights.	○	○	
		. Promote a project for diffusing LED facilities for agriculture.	○		○
Environment and resources management policies	Provide green spaces	. Provide green spaces, e.g., experience and recreation facilities in rural and fishing districts specialized in each farm household, village and area.	○		○
		. Construct experience bases using landscape, culture, history and ecological resources in rural and fishing districts (green rural districts for experience, eco-recreation villages, etc.), develop and provide programs.	○	○	○

Attached Table 2. Continued

Category		Policies	Farmers	Expert	Gov't officials
Environment and resources management policies	Provide green spaces	. Develop Saemangeum areas as a model complex for complex production of agro-industry combining natural circulation (tillage . livestock farming) and renewable energy systems.			○
		. Construct energy-independent green towns.			○
		. Develop and diffuse standard blueprints for environment-friendly and low energy consuming houses in rural and fishing districts.	○	○	○
		. Promote the Beautiful Paldogangsan project for setting a new model for future rural and fishing districts.			○
		. Develop green space plan indicators and study eco-community continuity.		○	
		. Conceive amenity resources and construct a system for supporting green space plans in rural districts.			○
		. Encourage varied urban-rural exchanges for inviting urban people and facilitating live rural and fishing districts and operate programs thereof.	○		○
		. Encourage farming while living in cities and home horticulture to expand green urban spaces.			○
		. Develop technology for producing crops in reclaimed land.	○	○	
	Manage resources	. Maintain infrastructures and consolidate water management for improving water quality and preventing disasters in 4 major rivers.			○
		. Promote efficient use of and saving water	○	○	
		. Develop, adopt and commercialize environment-friendly water saving technology.	○	○	○
		. Set water saving irrigation criteria, prepare and supply guidelines.	○	○	○

Attached Table 2. Continued

Category		Policies	Farmers	Expert	Gov't officials
Green industry policies	Encourage environment-friendly agriculture	. Develop and supply manuals for using microorganisms for each crop.	○	○	○
		. Expand bases for environment-friendly agricultural production, e.g., environment-friendly rural districts, regional environment-friendly agricultural complexes.	○		○
		. Encourage water distribution for environment-friendly farming and livestock farming.	○		○
		. Encourage people to use environment-friendly farm products when cooking school lunch.			○
		. Boost environment-friendly agricultural industry, e.g., bio-pesticide (natural enemies) and organic fertilizers.			○
		. Continue to promote the 2nd green revolution, e.g., cultivate food and feed crops in winter fallow and riverbeds, and improve the efficiency of using land.	○		○
		. Develop IT technology-integrated intelligent agricultural production systems, e.g., vertical plant factories.	○	○	
		. Develop green manure crop varieties and technology to use them.		○	
	Green food	. Consolidate authentication of processed organic foods.	○		○
		. Provide incentives to food manufacturers who use raw materials produced in Korea.			○
		. Promote mixing and merging producers in agriculture and fisheries with food processing companies in each region.			○
		. Enhance usability of farm and marine products produced in Korea by studying their functionality.		○	
		. Create the national food cluster (Iksan, Jeonbuk) in an environment-friendly way by using renewable energy, joint use of research and logistics facilities, and installing highly efficient energy facilities.			○

Attached Table 2. Continued

Category		Policies	Farmers	Expert	Gov't officials
Green industry policies	Green food	. Expand items for marking the origin for processed food and food in restaurants.			○
		. Encourage the use of food mileage to indicate the distance of food transportation.	○		○
		. Introduce the carbon labeling system for farm and marine food industry.			○
		. Prepare LCI (life cycle inventory) for farm and livestock products and agricultural materials.		○	
		. Publicize Korean food, a representative of fermented and slow foods throughout the world to upgrade the national image of Korea and to create economic value added.	○		○
		. Construct core infrastructures to lead development of food industry.		○	○
		. Improve the reliability of food safety and develop technology for high-tech distribution.		○	
		. Industrialize fermented foods.			○
		. Develop programs for low carbon food culture and vitalize green consumption.		○	
	Green financing	. Financial support when capital-intensive protective horticulture farmers adopt green energy.	○		○
		. Use green technology, e.g., energy saving and efficiency in terms of production. Financial support in packaging and transportation in terms of agricultural facilities and distribution.	○		○
		. Diffuse agriculture related green technology by means of the agriculture investment fund. Lend money of preferential interest to enterprises.			○
		. Develop green insurance for risk management in the agricultural sector.			○

Attached Table 2. Continued

Category		Policies	Farmers	Experts	Gov't officials
Green industry policies	Life industry	. Ensure and conserve varied agricultural heredity resources.		○	
		. Produce strategic new varieties using the agricultural heredity resources.		○	
		. Specify seeds as a strategic item for export to expand export.	○		○
		. Develop protein production technology for medical use, using insects and plants.		○	
		. Acquire core source technology for developing high value added GM crops and develop safety assessment technology.		○	
		. Develop technology for using heredity resources native to Korea.		○	
		. Develop technology for industrializing new functional crops and new materials, using BT and nano technology.		○	
		. Develop artificial skin, bio-cosmetics and natural pigments, using mandarins, minor cereals.		○	
	Create job opportunities	. Create job opportunities by promoting the green new-deal project.			○
		. Create job opportunities by technology development and supporting industries.	○		○
		. Positively support green enterprises.			○
		. Construct a comprehensive info network for green job opportunities.			○
Green technology policies		. Adopt the green technology authentication system to boost private investment.	○		○
		. Support fund of low interest for investment in green technology and projects, and provide incentives for supporting export and insurance.	○		○
		. Develop agricultural robots and construct IT-BT merged automation and informationization systems.	○	○	○

Attached Table 2. Continued

Category	Policies	Farmers	Experts	Gov't officials
Green technology policies	. Consolidate comprehensive adjustment of R&D for upgrading green technology development efficiency.		○	○
	. Organize and operate an integrated group for developing green technology.			○
	. Construct a system for connecting the industry-university-research for improving green technology development efficiency.	○	○	○
	. Establish a strategy for acquiring effective green technology.			○
	. Create a base for research and development of green technology in the agricultural sector.		○	○
	. Construct a base for diffusing and commercializing green technology.	○		○
	. Promote authentication of new green technology and commercial application.			○
	. Facilitate and support growth of green technology business.	○		○
	. Establish a green technology criterion system and develop international standardization.			○
	. Construct green technology related comprehensive information and DB.	○	○	
	. Construct a Korean and international cooperative network related to green technology information.		○	
	. Boost live international cooperation for developing green technology.		○	
	. Informationize IT technology merged agriculture and develop agricultural sensor technology.	○	○	
	. Automate farm work and develop precision agriculture machines.	○	○	
	. Produce rice bran using supercritical fluid and adopt rice bio-refineries.		○	

Note: ○ denotes relation of relevant bodies including policy inventory related farmers, experts and persons responsible for policies to the relevant policies.

Appendix 3

Tasks for the Agricultural Sector in the Five-year Plan for Green Growth

Attached Table 3. Tasks for the Agricultural Sector in the Five–year Plan for Green Growth

Direction of 3 major strategies	Direction of 10 major Policies	50 major practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Adaptation to climate change and energy independence	Effectively reduce greenhouse gases	Society with visible carbon	Construct and operate a national GHG emission statistics and management system.	2009	Continued	Green Commission, RDA, Forest Service, etc.
		Society reducing carbon	Reduce GHG in agricultural and livestock farming sectors.	2009	Continued	MIFAFF, RDA
		Carbon-recycling society	Carbon circulation by developing carbon sequestration and low carbon technology for the agricultural sector	2009	2013	RDA, MIFAFF
	Strengthen oil-free energy independence	Diffuse clean energy	Diffusion to the heating sector	2009	2013	ME,MIFAF, (MKE)
	Strengthen competence for climate change	Establish a national system for food security	Assessment and prediction of the impact of climate change on food production	2007	2020	RDA, (MIFAFF)
			Develop climate-friendly food production technology	2000	2030	RDA, MIFAFF
			Prepare bases for agricultural informationization and automation	2008	2030	RDA, MIFAFF
			Prepare a foundation for stabilized food production	2005	2030	RDA, (MIFAFF)
			Encourage people to have 'green diet'	2007	Continued	RDA, (MIFAFF)
			Construct a harvesting information system for major grain production and consumption countries	2010	2013	RDA,KMA, (NIS)

Attached Table 3. Continued

Direction of 3 major strategies	Direction of 10 major policies	50 major practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Adaptation to climate change and energy independence	Strengthen competence for climate change	Establish a national system for food security	International cooperation for flexible food demand and supply	2000	Continued	KMA,RDA MIFAFF
		Strengthen competence for stable water resources m anagement	Ensure safe and pleasant rivers by the 4 major river recovery project	2009	2013	MLTM,ME MIFAFF
			Promote efficient use of water and saving thereof	2000	Continued	ME, (MLTM), (RDA)
		Strengthen disaster management to cope with climate change	Vitalize training and the natural disaster insurance for strengthening competence for coping with risks	2009	2013	NEMA, MIFAFF
Create new growth driver	Develop green technology and make it growth power	Develop green technology strategic expansion of investment	Prepare a plan for acquiring additional finance for developing green technology	2010	2013	MOSF, each competent ministry
			Establish an investment strategy for developing green technology	2009	2013	Green Commission, NSTC, each competent ministry.
			Green Tech. 2015 Initiative project	2009	2015	MEST,MKE , each competent ministry.
			Apply the concept of green to existing national R&D projects	2009	2013	MEST, each competent ministry.
			Apply the concept of green to the system for supporting technology development	2009	2013	Green Committee, NSTC, each competent ministry.

Attached Table 3. Continued

Direction of 3 major strategies	Direction of 10 major policies	50 major practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Create new growth driver	Develop green technology and make it growth power	Construct a system for developing efficient green technology	Consolidate comprehensive adjustment of R&D for enhancing green technology development efficiency	2010	2013	NSTC, each competent authority
			Organize and run an integrated project task force for green technology development	2010	2015	NSTC, each competent authority
			Construct a system for connecting the industry, university and research for upgrading green technology development efficiency	2010	2013	MEST, each competent authority
			Establish a strategy for acquiring effective green technology	2010	2013	Green Committee, each competent authority
			Create a base for green technology R&D	2010	2012	MEST,MKE, each competent authority
		Adopt and commercialize green technology	Construct a basis for adopting and commercializing green technology	2009	2013	MKE,ME, each competent authority
			Promote authentication and commercialization of new green technology	2010	2013	Green commission , MKE, ME, each competent authority
			Support green technology business and growth	2009	2013	MKE,ME, each competent authority
			Support enterprises specialized in green technology R&D and commercialization	2010	2013	MKE, each competent authority
			Train and support manpower in charge of commercializing green technology	2010	2013	MEST,MKE, each competent authority

Attached Table 3. Continued

Direction of 3 major strategies	Direction of 10 major policies	50 major practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Create new growth driver	Develop green technology for growth power	Expand infrastructure for green technology and industrial development	Train future-based core research manpower	2009	2013	MEST, each competent authority
			Establish a system for standardizing green technology and promote international standardization	2009	2013	MKE, each competent authority
			Construct comprehensive info system and DB related to green technology	2009	2013	NSTC, each competent authority
			Construct Korean and international networks related to green technology info.	2010	2013	MEST, each competent authority
Create new growth driver	Develop green technology for growth power	Boost live international cooperation for developing green technology	Boost live strategic partnership for developing global green technology	2010	2013	MEST, each competent authority
			Participate in setting international standards for green technology cooperation	2010	2013	MEST, each competent authority
			Joint research with major developed countries for green technology	2010	2013	MEST, each competent authority
			International cooperation with major developing countries for green technology	2010	2013	MEST,MKE, ME, each competent authority
			International cooperation for making the green technology industry a new growth driver	2010	2013	MKE, each competent authority
			Set global green technology standards	2010	2013	MKE, each competent authority
		Support new growth driver of green technology	Create market demand for LED application	2009	2013	MKE, MLTM, MIFAFF
	Encourage and support green industry	Propagate green transformation and innovation for each industry	Support environment-friendly agro-food industry	2009	2016	MIFAFF, (RDA)

Attached Table 3. Continued

Direction of 3 major strategies	Direction of 10 major policies	50 practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Create new growth driver	Refine industrial structure	Support new growth driver and high-tech merging industry	Develop bio-resources	2009	2013	MKE,RDA, (MEST)
			Upgrade bio-medicine manufacturing (support) and medical instrument system	2009	2012	MKE, Ministry of Health and Welfare RDA, (KFDA)
			Develop strategic items of high value added foods	2009	2013	MIFAFF, (RDA)
			Create core infrastructures to lead development of food industry	2009	2013	MIFAFF
			Create more demand for high value added food in Korea and other countries	2009	2013	MIFAFF
	Create a green economy basis	Create green job opportunities	Create job opportunities by supporting the green new deal project	2009	2013	11 authorities
			Create green job opportunities by supporting technology development and industries	2009	2013	each competent authority
			Positively support green enterprises	2009	2013	each competent authority
			Construct a comprehensive info network for green job opportunities	2010	2013	each competent authority
Improve quality of living and upgrade national prestige	Create green national land and transportation	Crate green national land and cities	Positively conserve forests, forests in cities, farmland, water resources, ocean highly valuable as carbon sinks	2010	2012	MLTM,ME, MIFAFF, Forest Service
		Provide more eco-space	Expand multi-functional eco-space in cities by inhabiting organisms, flood control, and ensuring water resources	2010	2013	ME,MLTM, MIFAFF
			Expand greens in residential areas by creating low carbon green forests and city parks	2009	2013	ME, Forest Service, MIFAFF
		Provide more green buildings	Develop and diffuse model green homes of environment-friendly low energy in each area	2009	2013	MKE,MLTM (MIFAFF)

Attached Table 3. Continued

Direction of 3 major strategies	Direction of 10 major policies	50 practical tasks	Detailed tasks	Implementation Period		Supervising Authority Cooperating Authority
				Start	Completion	
Improve quality of living and upgrade national prestige	Green revolution of living	Promotion of green consumption	Propagate green consumption living in daily life (ordinary people)	2009	2013	ME,MKE, MIFAFF, (KFDA)
			Expand the green distribution network consumers are easily accessible to	2009	2013	ME, (MIFAFF)
		Construct and publicize green towns	Create and support low carbon green towns by the government	2010	2013	ME,MPAS, MIFAFF, Forest Service
			Campaign the green town movement	2010	2013	ME, (MPAS) (MIFAFF), (KFDA)

Source: The Presidential Committee on Green Growth (2009).

Appendix 4

50 Practical Tasks for Green Growth in Agro-food Sector

3 strategies ·	9 initiatives	50 practical tasks
Green industrialization of low input and high efficiency	① Promote use of biomass energy	▪ Produce resources and energy with livestock manures ▪ Expand demand for wood pellets ▪ Produce biomass energy with seaweeds ▪ Supply forestry biomass. ▪ Produce biomass energy with agricultural products.
	② Adopt green technology and equipment	▪ Invest green technology R&D ▪ Improve efficiency of using LED lights for agriculture ▪ Save cost for oil used in fishing boats. ▪ Develop underground seawater. ▪ Supply energy saving equipment for protected horticulture. ▪ Develop technology for using useful microbes. ▪ Develop electricity systems for small fishing boats. ▪ Micro hydropower generation
	③ Consolidate capability to cope with climate change	▪ Build GHG inventory. ▪ Develop GHG reduction technology in agriculture and livestock farming ▪ Collect overseas agriculture information ▪ Informationization and automation of agricultural management ▪ Encourage crop cultivation insurance ▪ Support forest and shared river recovery in North Korea. ▪ Introduce the emission trading system. ▪ Cooperation with other countries, e.g., for forestation in developing countries, installation of international organizations ▪ Manage ocean forecasting, changes in fish resources. ▪ Manage damages by diseases of animals, plants and marine products. ▪ Prevent forest disasters and monitor the eco-system
Use and manage natural resources in a sustainable way	④ Vitalize rural, forestry and fishing districts	▪ Expand eco-tourism infrastructure experience. ▪ Create low carbon green towns (rural district type, forestry type) ▪ Upgrade water management for agriculture. ▪ Encourage more urban-rural exchanges ▪ Operate Saemangeum as a model area for green growth. ▪ Develop and adopt standard blueprints for environment-friendly houses in rural and fishing districts.

	⑤ Maintain and expand green space for carbon absorption.	▪ Forest more fallow and cities. ▪ Conserve and strengthen the marine eco-system (sea forest).	▪ Conserve and strengthen the forest eco-system (eco-forest) ▪ Encourage people to enjoy general horticulture in daily life
	⑥ High value-added life industry	▪ Develop functional crops for new materials. ▪ Support high value-added seed industry.	▪ Support the marine bio-industry. ▪ Develop genetically modified livestock.
People's healthy living and upgraded national prestige	⑦ Support bases for environment-friendly agricultural industry	▪ Support more environment-friendly agriculture. ▪ Supply more environment-friendly fishing tackles.	▪ Support environment-friendly agricultural materials. ▪ Promote second green revolution.
	⑧ Construct a national low carbon food system	▪ Expand high-tech food clusters. ▪ Develop high value-added low carbon food technology. ▪ Adopt the carbon labeling system in the sector of food from agriculture, forestry and fisheries.	▪ Provide more food information (origin, food mileage). ▪ Publicize Korean food in the world.
	⑨ Encourage green food diet	▪ Encourage green diet	

Appendix 5

Questionnaires for farmers

「**Survey for farmers on green growth of the agricultural sector**」

Hi.

Korea Rural Economic Institute is a research institute under the Korean Government and performs research on establishing and assessing policies for development of agriculture. This year, we are doing research on development of strategies for promoting green growth of the agricultural sector in conformity with low carbon and green growth which is the core policy of the Government. The purpose of this research is to develop Green Growth Policies for the Agricultural Sector which farmers can actually be aware of through analysis and assessment of current green growth of the agricultural sector.

This survey is to accurately identify current green growth of the agricultural sector and to collect farmers' opinion required for taking practical measures.

We ensure that your information is for research only and not used for other purposes.

We will appreciate your cooperation very much.

Thank you.

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※ Your details

Name		Gender	① M ② F
Age			
e-mail address			
Phone No.		Farming career	Years
Major crops in cultivation			
Area of residence	① Seoul ② Busan ③ Daegu ④ Gwangjoo ⑤ Incheon ⑥ Daejeon ⑦ Woolsan ⑧ Gyeonggido ⑨ Gangwondo ⑩ Chungbu ⑪ Chungnam ⑫ Jeonbuk ⑬ Jeonnam ⑭ Gyeongbuk ⑮ Gyeongnam ⑯ Jejudo		
Academic career	① Primary school or less ② Middle school ③ High school ④ University or higher		

♠ Generals concerning Green Growth ♠

※ We will ask you some questions to see how much you are aware of and how you understand green growth which is promoted as a core task for future national development by the Government.

A1. Have you ever recently heard of or seen the term of “green growth” promoted by the Government?

Aware of the details	Aware of some	Heard of it	Never	Other ( )
①	②	③	④	⑤

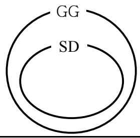
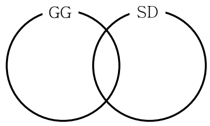
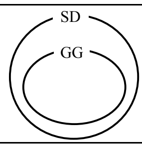
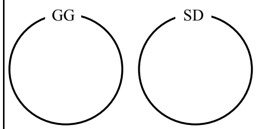
A2. Green growth means ‘growth in which economy is harmonized with environment’. Do you think it is possible to achieve both of environmental conservation and economic growth?

Highly possible	Possible	Yes	No	Impossible
①	②	③	④	⑤

A3. Have you recently heard or seen the term of “sustainable development”?

Aware of the details	Aware of some	Heard of it	Never	Other ( )
①	②	③	④	⑤

A4. Which relation do you think there is between “green growth (GG)” and “sustainable development (SD)”?

①	②	③	④
			
Green growth is larger concept comprising sustainable growth.	Some common part between green growth and sustainable growth.	Sustainable growth is larger concept comprising green growth.	Green growth is totally different from sustainable growth.

♠ Green Growth Policies for the Agricultural Sector ♠

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KREI
Korea Rural Economic Institute

Research Report R613 (English Edition)
Strategies for Promoting Green Growth in Agriculture and Rural Districts (The 1/2th Report)

Publisher Lee, Dong-Phil
Printed in Decemebr 2011
Published in December 2011
Registration Number: 6-0007 (25 May, 1979)
Printed at Munwonsa (munwonsa@chol.com)

ISBN 978-89-6013-237-5 93520