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반구조화 인터뷰를 통한 농업부문 온실가스 감축정책의 방해 요인에 관한 탐색적 연구

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An Exploratory Study on the Barriers of Greenhouse Gas (GHG) Reduction Policy in the Agricultural Sector through Semi-Structured Interviews

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ABSTRACT

As the Intergovernmental Panel on Climate Change (IPCC) emphasized the transition to a carbon-neutral society globally by 2050, major countries such as Korea, Japan, and Europe declared carbon-neutral goals. The agricultural sector is a carbon-absorbing sector, and its importance has increased as the General Assembly of the Parties to the Climate Change Convention (COP 26) held in the UK in November 2021 emphasized the role of agriculture to discuss climate change. However, GHG reduction projects in the agricultural sector are not properly monitored considering the domestic situation, and a system for quantitative evaluation of the effectiveness or basis of implementing the project program is not in place. Therefore, a priori study is needed to understand the current status of existing policies and to review matters that need to be improved in order to facilitate policy design, implementation, and monitoring for GHG reduction in the agricultural sector. The purpose of this study is to examine the opinions of stakeholders by applying a semi-structured interview method to diagnose the current status of Korea's GHG reduction policy in the agricultural sector and identify factors that hinder policy implementation. As a result of the semi-structured interview, this study presented factors that hinder the promotion of GHG reduction policies in the agricultural sector according to four types of data and technology, finance, institutions, and perceptions. Some stakeholders also stressed that the pilot project could be helpful as a way to comprehensively consider the implications of this study, such as securing technology data, establishing a system for verifying effectiveness, and providing incentives and promoting them. Rather than drawing specific conclusions, this study is an exploratory study that diagnoses and reviews the progress of GHG reduction policies, and it can be used as useful basic data if it secures enough interview respondents and balances the number of samples by group.

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Key words: **Semi-structured interviews, Agricultural GHG emissions, Carbon neutrality, Climate change mitigation**

I. Introduction

In a special report on the impacts of 1.5°C global warming, the Intergovernmental Panel on Climate Change (IPCC) urged countries to achieve carbon neutrality by 2050 (IPCC, 2018). Additionally, the agriculture sector's potential for large-scale emissions reduction and carbon storage was highlighted as a crucial component for reaching net-zero emissions. In 2020, Government of the Republic of Korea joined other countries in announcing the 2050 carbon neutrality goals (Government of the Republic of Korea, 2020) to amend its history of high fossil fuel-dependency and having the highest increase in greenhouse gas (GHG) emissions since 1990 of all OECD countries (OECD, 2017). Compared to other economic sectors, the Korean agriculture sector emits a relatively small amount of GHG that constitutes about 3% (20.4 million-ton CO_{2eq} in 2017) of the total national GHG emissions (709.1 million-ton CO_{2eq} in 2017) (Government of the Republic of Korea, 2020). Despite its small scale, however, it is one of the largest sources of non-energy GHG emissions so its participation in the national emission reduction effort, which encompasses energy and non-energy emissions, is crucial (Lee *et al*., 2019).

National efforts to respond to climate change accelerated in the 2010s based on international commitments such as the Kyoto Protocol and the Paris Agreement. However, much of the agriculture sector's policies centered on climate change adaptation than emission mitigation (Kim *et al*., 2010). Starting with the Framework Act on Low Carbon Green Growth in 2011, the amendment to the "2030 Greenhouse Gas Reduction Roadmap" was finalized in 2018, and the agricultural and livestock sector should reduce its GHG reduction target by 7.9% compared to BAU (207 million tons CO_2). Accordingly, the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) promoted GHG reduction projects (e.g., a low-carbon agricultural and livestock product certification system) to reduce GHG for producers and consumers (Jeong *et al*., 2018). However, the evaluation for GHG reduction projects' programs is ineffectiveness due to gaps in policy design, implementation, on-farm application, and monitoring (Jeong *et al*., 2021c). Other programs such as Agricultural Cap and Trade System that is administered by the Ministry of Environment (MOE), Direct Payment Schemes, Efficient Energy Utilization Program, Agricultural Environmental Conservation Program, and sustainable agriculture promotion programs also generate GHG emissions reduction effects, but the technology system for estimating and monitoring GHG emissions is not organized (Lee, 2019). Additionally, the 2050 Agri-Food Sector Carbon Neutrality Implementation Strategy established 15.3 million-ton CO_{2eq} as the 2050 emission target and included plans to introduce new policies that specifically target agricultural emissions reduction (MAFRA, 2021). To improve upon existing programs that face difficulties in implementation and monitoring and prepare for new policies, a review of barriers to build an efficient agricultural emission reduction policy framework is needed.

The purpose of this study is to examine the opinions of stakeholders by applying a semi-structured interview method to diagnose the current status of Korea's GHG reduction policy in the agricultural sector and identify factors that hinder policy implementation. Therefore, this study is an exploratory study that diagnoses and reviews the current status of GHG reduction policies rather than drawing specific conclusions and can be used as basic data to specify future problems and find solutions. The next section reviews studies on barriers to climate

change mitigation strategies at home and abroad, and presents several studies using semi-structured interviews.

II. Literature Review

The majority of past research on Korean agricultural climate change centered more on climate adaptation rather than mitigation (Kim, 2019; Myung *et al*., 2013). Although climate mitigation policies were enforced since South Korea joined the Paris Agreement, they became more prioritized after the Korean government announced the 2050 carbon neutrality strategy in 2020 (Jeong *et al*., 2021a). Jeong *et al*.(2021a) suggested that the agricultural sector needs to expand low-carbon agriculture to achieve the 2030 and 2050 GHG reduction obligations while minimizing tradeoffs between emission mitigation and agricultural productivity. However, a survey of Korean farmers revealed that more than nine-tenths of the surveyed farmers did not participate in the Voluntary GHG Reduction Program due to barriers linked to information or awareness, technological applicability, and insufficient labor (Jeong *et al*., 2021c). Jeong *et al*. (2021b) supplemented this finding by identifying costly initial costs, maintenance costs, and lack of market incentives as barriers to implementing low-carbon agriculture on farms. In addition to the informational, technological, labor, and financial barriers, the absence of a comprehensive strategy, specific indicators (Myung *et al*., 2013), and a lack of bureaucratic capacity in local government (Kim, 2019) has been highlighted as barriers against implementing climate mitigation and adaptation policies.

Major barriers in climate change mitigation and adaptation policies in the agriculture sector may be categorized as socio-cultural, technological, economical, institutional, informational, ecological, and behavioral barriers (Table 1). Though the classification and definition of barriers differ from study to study, common themes emerged. Socio-cultural barriers

Table 1. Barriers to climate change and agriculture policies identified in literature

Category	Barrier	Reference
Socio-cultural	Social biases and traditions	Adger *et al*., 2007; Burch *et al*., 2010; Uittenbroek *et al*., 2013; Antwi-Agyei *et al*., 2015; Trærup *et al*., 2018
	Conflicting coalition or stakeholder group priorities	Stuart *et al*., 2012; Han and Kuhlicke, 2021
	Peer pressure	Long *et al*., 2016
Technological	Lags in technological development	Moser and Ekstrom, 2010; Uittenbroek *et al*., 2013; Antwi-Agyei *et al*., 2015; Kim, 2021
	Limited access to technical resources	Moser and Ekstrom, 2010; Harvey *et al*., 2014; Nguyen *et al*., 2021
	Technology transferability	Adger *et al*., 2007
	Limited technical capacity, expertise, and R&D	Nguyen and Ha-Duong, 2009; Harvey *et al*., 2014; Le Dang *et al*., 2013; Long *et al*., 2016; Trærup *et al*., 2018; Giles *et al*., 2021
	Poor technology quality and performance	Trærup *et al*., 2018
Economical	High costs (investment, maintenance, transaction, implementation)	Smith *et al*., 2007; Adger *et al*., 2007; Harvey *et al*., 2014; Girod *et al*., 2014; Long *et al*., 2016; Grosjean *et al*., 2016; Trærup *et al*., 2018; Jellason *et al*., 2021; Kim, 2021
	Limited budget and resources	Moser and Ekstrom, 2010; Biesbroek *et al*., 2011; Sietz *et al*., 2011; Harvey *et al*., 2014; Eisenack *et al*., 2014; Antwi-Agyei *et al*., 2015; Totin *et al*., 2015; Long *et al*., 2016; Kim, 2019; Wamsler *et al*., 2020; Giles *et al*., 2021

Category	Barrier	Reference
Economical	Limited access to financial capital	Moser and Ekstrom, 2010; Long *et al*., 2016; Wreford *et al*., 2017; Wamsler *et al*., 2020; Nguyen *et al*., 2021
	Lack of or high uncertainty over cost-effectiveness	Long *et al*., 2016; Trærup *et al*., 2018; Grosjean *et al*., 2016; Wreford *et al*., 2017
	Complex financing structures	Nguyen and Ha-Duong, 2009; Stuart *et al*., 2012; Wamsler *et al*., 2020;
	Low economic incentive	Harvey *et al*., 2014; Mehedi *et al*., 2017; Gomes and Reidsma, 2021
Institutional	Lack of agreement or coordination problems (sectoral, institutional, organizational)	Nguyen and Ha-Duong, 2009; Amundsen *et al*., 2010; Moser and Ekstrom, 2010 Sietz *et al*., 2011; Eisenack *et al*., 2014; Pardoe *et al*., 2018; Wamsler *et al*., 2020; Giles *et al*., 2021
	Gaps and redundancies in institutional or regulatory mandates	Smith *et al*., 2007; Sietz *et al*., 2011; Uittenbroek *et al*., 2013; Harvey *et al*., 2014; Antwi-Agyei *et al*., 2015; Long *et al*., 2016; Han and Kuhlicke, 2021
	Complex administrative and bureaucratic structures	Moser and Ekstrom, 2010; Antwi-Agyei *et al*., 2015; Han and Kuhlicke, 2021
	Limited human resources and operational capacity	Totin *et al*., 2015; Long *et al*., 2016; Trærup *et al*., 2018; Ha, 2020; Han and Kuhlicke, 2021; Jellason *et al*., 2021
	Limited policy scope	Biesbroek *et al*., 2011; Harvey *et al*., 2014; Long *et al*., 2016
	Path dependency	Jantarasami *et al*., 2010; Moser and Ekstrom, 2010; Biesbroek *et al*., 2011; Long *et al*., 2016; Trærup *et al*., 2018; Heyen and Wolff, 2019; Ha, 2020
	Lack of stakeholder involvement	Biesbroek *et al*., 2011; Totin *et al*., 2015; Long *et al*., 2016; Ha, 2020
Informational	Lack of data and information	Nguyen and Ha-Duong, 2009; Amundsen *et al*., 2010; Jantarasami *et al*., 2010; Sietz *et al*., 2011; Antwi-Agyei *et al*., 2015; Long *et al*., 2016; Trærup *et al*., 2018
	Inadequate data and information management and monitoring system	Moser and Ekstrom, 2010; Sietz *et al*., 2011; Myung *et al*., 2013; Wamsler *et al*., 2020;
	Limited access to information or inadequate communication of information	Sietz *et al*., 2011; Harvey *et al*., 2014; Girod *et al*., 2014; Le Dang *et al*., 2013; Long *et al*., 2016; Mehedi *et al*., 2017; Ha, 2020; Wreford *et al*., 2017; Giles *et al*., 2021; Nguyen *et al*., 2021
	Inability to apply data to strategy	Jantarasami *et al*., 2010; Moser and Ekstrom, 2010
	Limited R&D capacity	Nguyen and Ha-Duong, 2009
Ecological	Incompatibility with natural conditions and environment	Smith *et al*., 2007; Adger *et al*., 2007; Kim, 2019; Gomes and Reidsma, 2021; Jellason *et al*., 2021
	Limited natural resource availability and accessibility	Smith *et al*., 2007; Mehedi *et al*., 2017
Perceptional	Limited awareness of climate change or its impact on the environment and agriculture	Lorenzoni *et al*., 2007; Stuart *et al*., 2012; Le Dang *et al*., 2013; García de Jalón, 2015; Trærup *et al*., 2018; Heyen *et al*., 2019; Kim, 2019; Wreford *et al*., 2017
	Lack of awareness of government programs	Han and Kuhlicke, 2021
	Skepticism or personal bias on information sources, technology, etc.	Lorenzoni *et al*., 2007; García de Jalón, 2015; Long *et al*., 2016; Gomes and Reidsma, 2021

result from differences in worldview, values, and beliefs at a societal level, such as social biases and tradition that guide agricultural practices (Trærup *et al*., 2018), peer pressure (Long *et al*., 2016), and coalition or stakeholder group priorities (Han and Kuhlicke, 2021). Technological barriers include one that hinders technological development, distribution, and on-farm adoption. Technological barriers include lags in technological development (Moser and Ekstrom, 2010), access to technical resources like extension services and expertise (Nguyen *et al*., 2021), and technology transferability (Adger *et al*., 2007), and more. Economic barriers result from limited financial and budgetary capacity at farm- or organizational levels such as high costs of investment and maintenance (Smith *et al*., 2007), limited budget and resources (Eisenack *et al*., 2014), and low economic incentives (Harvey *et al*., 2014), and more. Institutional barriers include organizational and regulatory barriers that hinder policy design and implementation processes such as coordination problems (Amundsen *et al*., 2010), gaps and redundancies in regulatory mandates (Uittenbroek *et al*., 2013), and limited operation capacity (Han and Kuhlicke, 2021). Ecological barriers include natural processes or ecological limitations beyond human control (Mehedi *et al*., 2017; Jellason *et al*., 2021). Finally, perceptional barriers pertain to psychological or cognitive awareness linking to perceptional change at individual and group levels, such as lack of awareness (Stuart *et al*., 2012) and skepticism (Lorenzoni *et al*., 2007). A detailed list of barriers by category is shown in Table 1.

Studies on barriers in climate change and agriculture policies commonly used survey and interview methods involving key stakeholders, such as farmers, policymakers and implementers, and scientists. On farm adaptation, Gomes and Reidsma (2021) applied this method to find barriers faced by Dutch farmers in adopting GHG emission mitigation practices. As a result, they found that the lack of farmers' willingness to change, difficulties in manure use, challenges in balancing and prioritizing environmental efforts, and economic challenges was the main barriers. Giles *et al*.(2021) used a similar approach to identify barriers in GHG emission reduction policy design, implementation, and monitoring in Vietnam. They found that the main barriers were related to inter-ministry collaboration, enforcement and verification, financial constraints, and technological capacity. In both studies, the interview method not only revealed main barriers to agricultural emission reduction but also extracted suggestions to facilitate the policy process for elevating the agriculture sector's contribution to national GHG emission reduction goals. Therefore, this study used a semi-structured interview method to examine the opinions of stakeholders on Korea's GHG reduction policy in the agricultural sector and investigate the factors that hinder implementation.

III. Methodology

In qualitative studies, most interviews are conducted in semi-structured form, and researchers are used to understand people's perspectives, such as thoughts, emotions, and intentions (Merriam, 2010). One of the purposes of semi-structured interviews can be considered preliminary interviews to obtain information to embody formal interview questions (Merriam, 2010; Newcomer *et al*., 2015). Semi-structured interview methods are mainly used for exploratory studies because they are conducted as open-ended questions and are not ordered (Merriam, 2010). This study used a semi-structured interview method to review the opinions of stakeholders on the implementation of Korea's GHG reduction policy in the agricultural field.

Research reports and press releases were reviewed to select stakeholders with backgrounds and experience in responding to and mitigating agricultural climate change, and a list of 62 people was secured through snowball extraction. Snowball extraction is a method of introducing and adding other respondents to the study criteria to a small number of initially selected respondents (Goodman, 1961;

Naderifar *et al*., 2017; Noi, 2008). Finally, a total of 16 people agreed to the interview through phone calls and e-mails. Qualitative research studies determine the number of samples based on the researcher's judgment and experience (Frank and Snijders; 1994; van Rijnover, 2017), and exploratory studies applying semi-structured interviews in agriculture sector usually targeted 10 to 20 respondents (Giles *et al*., 2021; Jang, 2015).

Interviews were conducted on 16 people from March to April 2022, and most of them were conducted one-on-one through Zoom due to the restrictions of COVID-19. The typical period for each interview was 1 to 1.5 hours, and all discussions were recorded with the consent of the interviewer. Most of the respondents were engaged in agriculture and/or climate change-related work for more than 10 years, and 16 interviewers were classified into government officials (GOs), farmers' associations (FAs), and researchers (Rs) according to institutions and roles (Table 3). The three groups include four government officials, four farmers' associations and eight researchers. Although the number of samples by group could be balanced by selecting representative stakeholders among the eight researchers, since this study does not generalize the results, this study judged that it is appropriate to proceed without reducing the number of researchers to collect more opinions from related stakeholders.

After explaining the purpose and the background of the study, the interviewer asked about 1) general opinion on the implementation of the GHG emission reduction policy in the agricultural sector, 2) major barriers and policy steps that need improvement, and 3) the future role of the agricultural sector in GHG emissions (Table 2).

The following sections provide preliminary findings from interviews. It should be noted that it is difficult to generalize the results since this study is an exploratory study.

IV. Preliminary Analyses

In the next section, this study presents the preliminary analysis results that analyzed the contents of semi-structured interviews according to the researcher's subjective judgment. Qualitative research has a limitation in that the subjective judgment of the researcher is involved, but it is a useful method for understanding the nature and reality of social phenomena. Although specific results cannot be generalized from this study, it is meaningful as a basic study to understand the problems facing stakeholders in reducing GHG emissions in the agricultural sector.

Table 2. Overview of interview questions

	Interview questions
General opinion on policy	· What do you think are the representative policies or programs for reducing GHG emissions in the agricultural sector? · What groups do you think are leading policies or programs related to GHG reduction in the agricultural sector? · What field of experts are involved in creating a GHG reduction policy?
Major barriers hindering the implementation of GHG reduction policies in the agricultural sector.	· What do you think are the factors that hinder the implementation of GHG reduction policies in the agricultural sector? (e.g., finance/economy, information/technology, institutions/organizations, laws/regulations, behavior/attitudes, nature/ecology, etc.) · Are there any conflicts between GHG reduction programs?
Comprehensive or prioritized measures to increase efficiency in implementing policies to reduce greenhouse gas emissions in the agricultural sector	· What do you think should be a priority for reducing GHG emissions in the agricultural sector?

Table 3. Distribution and profile of interviewees

Field of Stakeholder	No.	Position	Organization
Government Officials	GO1	Senior Official	Ministry of Agriculture, Food, and Rural Affairs (MAFRA)
	GO2		
	GO3		
	GO1	Team Lead	Korea Agriculture Technology Promotion Agency (KOAT)
Farmer Association	FA1	Senior Member	Korea Federation of Sustainable Agriculture Organization
	FA2		Korean Organic Agriculture Board
	FA3		Korean Rural Leaders' Central Association
	FA4		Korean Advanced Farmer Federation
Research	R1	Professor	Seoul National University
	R2		
	R3	Senior Researcher	Rural Research Institute
	R4		Korea Environment Institute
	R5		Korea Rural Economic Institute
	R6		APEC Climate Center
	R7		National Institute of Agricultural Sciences
	R8		Korean Precision Agriculture Institute

4.1. General opinion of policy portfolio : Evaluation the role of main government agencies

Voluntary GHG reduction projects in agricultural villages, external projects in emission trading systems, and low-carbon agricultural products certification systems were identified as representative GHG reduction policies in the agriculture sector. All interviewees positively evaluated the role of implementing agencies and affiliated governing bodies (e.g., the Ministry of Environment on planning and implementation strategies, the Rural Economic Research Institute on policy development, the Rural Development Administration on research and technology development, the Korea Rural Community Corporation, Korea Agricultural Technology Promotion Agency, and Local government).

4.2. Key barriers and suggested solutions

The barriers to implementing GHG reduction policies identified in the agricultural sector are similar to the seven items reviewed in Table 1, and this study narrowed them down to four categories: data and technology, finance, institution, and perception. Stakeholder groups corresponding to each type are presented in Table 4.

4.2.1. Data and technological barriers

Government Officials (GO) and researchers (R) highlighted the lack of data and monitoring, verification, and reporting (MVR) systems as a main risk and challenge in the policy design and implementation phases, which may result from the absence of widespread use of digital and precision agriculture technologies. Current monitoring and evaluation (M&E) systems consist of process and result-based components, both of which are exposed to data validity and reliability issues. Whereas process-based M&E collects proof of conduct such as photos, input purchase records, and installation cost records, result-based M&E quantifies the effect of certain emission reduction activities using emission factors (EF) and activity data (AD) (MOE, 2020). On this, some Rs pointed out that there exists an imbalance in governmental support in terms of agricultural technology. Only a few sets of

technologies are supported by the government while others are not. As a result, technologies with governmental support can get access to enough data to estimate the emission effects; however, many technologies that are not supported by the government can only collect data via surveys. Although it is difficult to generalize the preliminary results presented in this study, further research is needed on the imbalance of government support in terms of agricultural technology. Furthermore, if data on technology is not available, it is difficult to justify the costs associated with developing evidence-based policies and reducing agricultural emissions. And since government officials cannot estimate GHG reduction effects and productivity changes, it will be difficult to persuade farmers about the importance of adopting GHG reduction activities.

To address uncertainty about the effectiveness of the technology, some Rs recommended that active emission data collection and development of higher-tier EF for more technology and commodities are needed. For example, digital and precision agriculture technologies that utilize artificial intelligence, cloud systems, and big data (e.g., agricultural drones, robots, greenhouse facilities, and temperature control systems) not only automate agricultural practices but also generate and record data that could be used for better data collection (KISTI, 2022). Additionally, the Korea Institute for Energy Economics (KEI) and the Korea Rural Economic Institute (KREI) said larger sample sizes are still needed to reflect actual figures on gasoline use and other energy emissions to improve the current GHG database. Overall, technology development can diversify ways to reduce GHG emissions in agriculture and will play an important role in achieving the 2050 GHG emission reduction targets. Also, database, data collection, R&D, and technology evaluation must involve building digital data infrastructures and developing clear manuals for data reporting.

4.2.2. Financial barriers

Another barrier in developing GHG emission reduction policies is to identify appropriate incentive amounts and funding mechanisms to encourage farmers' uptake of GHG emissions reduction practices. On financial need, both Rs and the farmer association (FA) pointed out a need for adopting emission reduction technology and that the current incentive level is insufficient to balance the financial costs associated with adopting emission reduction activities. Rs stated that the capacity to adopt new technology differs across farms based on their scale, requiring some farms to require financial assistance if they decide to use emission reduction technology. Further, on funding mechanisms, FAs expressed that older farmers have a difficult time adjusting to emission reduction technologies, so younger farmers participate more. However, because of the complex financing systems, not all farmers can take full advantage of the financing options. Despite the availability of government assistance, the current price of financing for agricultural emission reduction under compensates farmers' efforts for changing their farming practices.

Also, to estimate the optimal and cost-effective incentive amount that can drive farmer participation, a valuation of the emission reduction benefits per technology is needed. Primary conditions to resolve this issue include the availability of accurate data for benefit estimation and a sufficient budget to execute any payoff mechanisms. All interviewees expressed a need for further exploration of various incentive mechanisms (e.g., tax breaks, direct payments, agricultural emission permit prices) that leverage existing policy frameworks and actors. On agricultural permit prices, Rs have suggested that such incentive programs are not successful because agricultural emission permits constitute only a small portion of the cap-and-trade system so that their price remains low and is not likely to make any significant impact. They also pointed out that the low-carbon certification system that could provide market incentives for low-carbon practices is not implemented well and the agricultural cap and trade system is still not fully developed. Regarding voluntary emission reduction

programs, there is a political issue of whether it is necessary to grant emission reduction benefits only to farmers, or whether it is necessary to share them with implementers and facilitators, such as the Agricultural Technology Promotion Agency (KOAT).

Therefore, clear delineation of incentive mechanisms and actors' roles are needed. Recent researches on agricultural subsidies show that most OECD countries use a combination of subsidies based on production output and market price support through trade measures and suggests that funding mechanisms need to target high-emission sources more (Laborde *et al*., 2021). In Korea, Lee *et al*. (2019) recommended complementary uses of subsidies for emission reduction technology and compensation or permits for emission reduction because they can encourage new technology uptake while minimizing mitigation and productivity tradeoffs.

4.2.3. Institutional barriers

Budget allocation issues are closely tied to how sectoral emission reduction targets are apportioned. Some FAs and Rs asserted that the allocation of emission reduction targets for the agriculture sector poorly reflects its contribution to the total national GHG emission, which may result from gaps in the institutional networks and priorities. For example, the MOE oversees the process of setting national GHG emission reduction targets by coordinating with other ministries. However, even if they may have the overall emission contributions, they do not adjust the emission reduction targets to reflect the sectoral contributions. If there was a body within or outside of MOE that played that role, small-contribution sectors like agriculture may not be subject to pressure for emissions reduction. This analysis was echoed by other interviewees who thought that emission reduction responsibilities were disproportionately allocated to the agriculture sector, which constitutes about 3% of the national GHG emissions and have some unavoidable GHG emissions resulting from the natural food production processes. In response, several Rs expressed a need for strengthening institutional facilitation at both inter- and intra-ministerial levels. For instance, facilitative roles could be transferred from the MOE to a higher-level governing institution (e.g., the Office of the Prime Minister) for it can hold higher jurisdiction in distributing emission reduction targets over ministry heads. Therefore, to facilitate the MAFRA's cross-departmental promotion, it may be considered to create a group dedicated to setting targets and activities on reducing GHG emissions in the sub-sector.

Some FAs and Rs suggested that improved institutional structures could aid in streamlining existing policy frameworks that counteract agricultural emission mitigation, such as subsidies for fossil fuel and the promotion of sustainable agriculture. Policies like tax deductions for oil and agricultural electricity could lower the price of energy that is vital for operating facility horticulture. Since farmers seek cost-minimizing inputs, they continually use fossil fuel energy despite their negative environmental effects. Additionally, sustainable agriculture policies prioritize limiting environmental pollution and promoting ecological diversity and conservation in the agricultural methods (e.g., fertilizer management) emit GHG and yield counteractive effects to GHG mitigation objectives. According to comments made by FAs on direct payment schemes, there are cases when farmers are denied for direct payments because the aerial verification photos showed no signs of soil tillage or any agricultural activity. If there are policies that promote low-carbon practices like no-tillage, misalignments with other policies need to be modified. Therefore, a careful review of all existing policy measures is needed in the process of designing agricultural emission reduction policies. Also, following international efforts to ban any subsidies for fossil fuel-based energy, R&D on alternative energy sources that minimize the financial burden to farmers should be considered.

4.2.4. Perceptional barriers

To successfully transition from policy design to implementation, FAs suggested that consensus must

be reached with farmers from the policy design stage and educational or promotional programs that allow communication between government officials and farmers need to be prioritized. It was further added that, even though there are educational and promotional programs that seek to change farmers' perceptions and behaviors toward agricultural emission reduction, they only meet the minimum requirements with superficial engagement between farmers and others involved with policy design and implementation. Some Rs identified that many farmers are interested in agricultural emissions but gaps in their awareness arise because emission reduction is not clearly distinguished from existing program focuses like sustainable agriculture. For instance, farmers may apply more animal manure as fertilizer since it is considered a sustainable agricultural practice, but they may not be aware of their negative emission effects.

Therefore, targeted education and promotion programs that center on agricultural GHG emissions need to accompany existing educational and training programs on sustainable or organic farming technology. Also, most interviewees expressed that consumers' perceptions on agricultural GHG emissions need to change. They voiced that there is no significant demand for low-carbon agricultural goods from the market that will motivate farmers to seek low-carbon certification. The fact that low-carbon goods are cost-beneficial among farmers and consumers should be properly informed for such programs to thrive.

4.3. The role of the agricultural sector in the future

Most interviewees contested the cost-effectiveness of agricultural emission reduction efforts. Based on the national GHG inventory, the agriculture sector (including livestock and fisheries) constitutes the smallest portion of national GHG emissions compared to all other economic sectors. Of the entire 12 trillion KRW allocated for carbon-neutrality, 18.3 billion KRW was allocated to the agriculture sector, which is insufficient to cover the costs of education for farmers, financial incentives, modifying existing policies, and systemizing MVR. Internationally and in Korea, agricultural activities, especially livestock and rice production, are major emitters of GHG like CO_2 and CH_4 (Laborde *et al*., 2022; Talcuder *et al*., 2020; Hwang *et al*., 2020), which emphasize a greater need to mobilize funding to mitigate agricultural GHG in Korea.

Several interviewees pointed out the cost-effectiveness of efforts to reduce agricultural emissions. For instance, recent studies on the carbon footprint of food systems suggest that countries need to adopt a broader perspective on agricultural GHG emissions. Carbon emission from the entire agri-food supply chain (including production, food processing, packaging, transport, consumption, and waste management) constitutes about 31% of human activity-induced emissions (Crippa *et al*., 2021; Tubiello *et al*., 2022). This broader scope to address food systems, instead of on-farm activities alone, is reflected in the food system strategies of the EU Green Deal (Schebesta and Candel, 2020). Similar studies on GHG emissions and energy consumption in the food sector and agricultural value chains suggest an expansion of policy scopes to cover the whole of agri-food sector emissions (Han and Kim, 2022; Kim and Im, 2021). Therefore, it is necessary to consider integrating and expanding the scope of agricultural emissions to include non-agricultural emissions that contribute to food system GHG emissions. If emissions from a wide range of agri-food systems are reflected in the national list of GHG emissions, the institutional approach to accounting for sectoral GHG emissions and managing emissions target strategies should be reviewed.

Also, regarding emission reduction, productivity, and other climate change disruptions allocation, an extensive database on the effects of existing and new technology is also needed to execute. The lack of emission data of different emission reduction practices and technology is closely linked to other barriers in addition to informational barriers. Insufficient data aggravates uncertainty over the effects of emission

Table 4. Barriers to GHG emission reduction policies in Korea's agriculture sector

Category	Barrier per Policy Phase	Expert No.
Data & Technological	Insufficient data availability (Design)	R1, R5, R7
	Unreliable data collection methods (Impl.)	R2, R3
	Limited range of emission factors (Design)	R5, R7
	Lack of verification of technological innovation (Impl.)	R1, R3, R7
	Lack of clear monitoring and reporting structure (Impl.)	R1, R3, PM2
Financial	Difficulty in estimating incentive level (Design)	R5, R7, R8
	Lack of cost-effective incentive level (Design)	I1, FA1
	Inappropriate funding mechanisms (Design)	FA1, FA1, R3
	Ambiguities in benefit allocation (Design)	R3, R7
	High initial and operational costs (Impl.)	FA1, R5, PM2
	Insufficient budget allocation (Design)	PM1, PM2
Institutional	Intra-ministry/ Inter-ministry facilitation (Design)	R3, R7, PM1, PM2
	Conflicting effects with existing policy measures (Design)	FA3
	Disproportionate allocation of sectoral goals (Design)	R3, R7, PM2
Perceptional	Lack of educational or promotional programs specifically targeting GHG emissions from farming (Design)	FA4, R4, R5
	Lack of consumer awareness of agricultural GHG emissions in purchase decisions (Impl.)	FA1, R5, PM2, PM3

reduction technology resulting from complications estimation of optimal economic incentive levels and precise GHG emission level from the agriculture sector. Improved MVR of already supported technology and practices are still needed. However, because Korea's agricultural emission reduction efforts are still in development, many agricultural technologies remain without verified effects. Therefore, pilot tests need to be scaled up to assess the impact of a wider range of technology based on an extensive agricultural emission database that can be used as evidence for policymaking. Rural Development Administration (RDA) is administering pilot tests of emission reduction activities, but its scale remains small. Upscaling of the number of tests and diversifying the sample commodities and technology type will help expand the database needed to overcome financial, institutional, and perceptional barriers. Table 4 summarizes the barriers to Korea's GHG reduction policy in the agricultural sector and shows stakeholders who presented their opinions. Although it is difficult for this study to generalize the preliminary analysis results as an exploratory study, it can be referred to as basic data to diagnose and review the current status of GHG reduction policies.

V. Summary and Discussion

This study examined the opinions of stakeholders through a semi-structured interview method to examine the factors that hinder the promotion of GHG reduction policies in the agricultural sector in Korea. As mentioned earlier, this study is an exploratory study that reviews the current status of GHG reduction policies, and further research can be conducted by specifying future interview questions through preliminary interviews. As a result of the semi-structured interview, this study presented factors that hinder the promotion of GHG reduction policies in the agricultural sector according to four types of data and technology, finance, instruction, and perception. The implications of this study are as

follows. It is difficult to generalize the research results of the qualitative research method used in this study. However, it is significant in that a priori study was conducted to reduce GHG in the agricultural sector.

First, it is important to establish an M&E system using big data to monitor technology and verify its effectiveness. Having a framework for building, monitoring, and evaluating data help persuade farmers or secure budgets. Furthermore, preparations for pilot testing will be needed for technological innovation and data utilization. Second, incentive support is needed so that farmers can accept technologies to reduce GHG emissions. Also, it is necessary to conduct a benefit analysis study on GHG emissions reduction by technology to prepare the scope of incentive support and to prepare a mechanism that can differentiate incentive support according to the level of emission reduction. Third, improvements to conflicting or contradictory aspects of policies to reduce GHG emissions in the agricultural sector need to be made, and research on the development of alternative energy sources should be conducted to minimize the financial burden on farmers. Fourth, it is necessary to inform farmers and consumers that it is advantageous to generate profits by promoting GHG emission reduction programs in the agricultural sector.

Finally, some stakeholders emphasize that the pilot project can be helpful as a way to comprehensively consider the implications presented above. This is because a system for securing data and verifying the effectiveness of technology can be prepared through pilot projects. It was also suggested that the scope of GHG emissions calculations in the agricultural sector should be reviewed. This study reviewed and presented the nature and status of the obstacles to the promotion of the GHG reduction policy. If further analysis is conducted in the future by securing sufficient interview respondents and balancing the number of samples by group, this study can be used as useful basic data.

적 요

기후변화에 관한 정부간 협의체(IPCC)가 2050년까지 전지구적으로 탄소중립(Carbon Neutrality) 사회로의 전환을 강조함에 따라 한국, 일본, 유럽 등 주요국들은 탄소중립 목표를 선언하였다. 농업분야는 탄소 흡수가 가능한 분야이며, 2021년 11월 영국에서 개최된 기후변화협약 당사국총회(COP 26)에서 기후변화 논의를 위한 농업의 역할을 강조하면서 그 중요성이 높아졌다. 그러나 농업분야의 온실가스 감축 사업은 국내 상황을 고려한 모니터링이 제대로 이루어지지 않고 있으며, 사업 프로그램 이행에 대한 효과나 근거를 정량적으로 평가할 수 있는 체계가 마련되지 않아 농업 현장에서의 적용이 원활히 이루어지지 않는 실정이다. 그러므로 농업분야 온실가스 감축을 위한 정책 설계, 시행 및 모니터링을 원활하게 하기 위해 기존 정책의 현황을 이해하고 개선이 필요한 사항을 검토하기 위한 선험적인 연구가 필요하다. 본 연구의 목적은 농업분야에서 우리나라 온실가스 감축정책 현황 진단 및 정책 추진의 방해 요인을 파악하기 위해 반구조화 인터뷰 방식을 적용해 이해관계자들의 의견을 검토하는 것이다. 반구조화 인터뷰를 진행한 결과, 본 연구는 농업부문 온실가스 감축정책의 추진을 저해하는 요인들을 데이터 및 기술, 금융, 제도 및 인식의 4가지 유형에 따라 제시하였다. 또한 일부 이해관계자들은 기술의 데이터 확보, 효과 검증을 위한 체계를 마련, 인센티브 지급 및 홍보 등 본 연구에서 제시한 시사점을 종합적으로 고려할 수 있는 방안으로서 시범사업 추진이 도움이 될 수 있음을 강조하였다. 본 연구는 구체적인 결론을 도출하기보다는 온실가스 감축정책 추진 현황을 진단하고 검토하는 탐색적 연구의 성격을 가지며, 향후 면접 응답자를 충분히 확보하고 그룹별 표본 수를 균형 있게 조정하여 추가 분석을 실시한다면 본 연구는 유용한 기초자료로 활용될 수 있을 것이다.

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