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Article

Analysis of green technology usage and inequality reduction related to climate change adaptation

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Abstract: The purpose of this study is to analyze issues related to the use of green technology and to provide a theoretical basis for how the application of green technology in agriculture can reduce inequality. Additionally, the study aims to explore policy alternatives based on the analysis of inequality reduction issues through farmer surveys. For this purpose, this study used survey data to analyze farmers' perceptions, acceptance status, willingness to accept green technology, and perceptions of inequality. The quantitative analysis was performed to analyze the relationship between the acceptance of green technology and perceptions of inequality. The results confirmed that access to information, perception of climate change, and awareness of the need to reduce greenhouse gas emissions are major factors. In particular, the higher the satisfaction with policies regarding the introduction of green technology, the lower the perception of inequality. Specifically, the acceptance of green technology showed a significant positive correlation with access to information, perception of climate change, and awareness of the need to reduce greenhouse gas emissions, while perceptions of inequality showed a significant negative correlation with policy satisfaction. In conclusion, green technology in agriculture is vital for reducing climate change damage and inequality. However, targeted policy support for small-scale farmers is essential for successful adoption. This study provides policy implications related to the application of green technology in the agricultural sector, which can promote sustainable agricultural development.

Keywords: green technology; climate change; inequality reduction; low-carbon agriculture; policy support

1. Introduction

Climate change is emerging as a serious global issue, with its impact being particularly pronounced in the agricultural sector. Agriculture is one of the most vulnerable sectors to the damage caused by climate change, with changes in temperature, precipitation, and sunlight significantly affecting crop quality and productivity (Abbass et al., 2022). Additionally, the damage caused by agricultural disasters due to abnormal weather is increasing every year (FAO, 2023). Increased temperatures can accelerate crop maturation, reducing the time for nutrient accumulation, which can severely impact yields. Altered precipitation patterns, including more frequent droughts and floods, further threaten agricultural productivity. Extreme weather events, such as heatwaves and hurricanes, can devastate crops and livestock, leading to substantial economic losses for farmers (Lobell et al., 2012). Additionally, the spread of pests and diseases, which thrive in warmer climates, poses another significant threat to agricultural output (Wheeler and von Braun, 2013). This situation can be particularly fatal to small-scale farmers and can consequently exacerbate inequality within the agricultural sector. Moreover, agriculture itself is a significant contributor to global greenhouse gas emissions, accounting for approximately 10%–12% of total global emissions (FAO, 2021), primarily through livestock production, rice cultivation, and the use of synthetic fertilizers.

The relevant previous studies found that various factors such as income levels, geographical characteristics, resource accessibility, and population composition (high proportion of elderly population) are identified as causes of inequality in the agricultural sector. Dell et al. (2014) explain that certain regions are more sensitive to temperature increases and changes in precipitation patterns, which can significantly affect crop yields and deepen income disparities among farmers. Ahmed et al. (2011) state that access to resources (water, fertilizer, technology, etc.) varies depending on regional and economic backgrounds and that small-scale farmers are more vulnerable to climate change compared to wealthy farmers. According to Wordofa et al. (2021), technological adaptation capacity is also an important factor in agricultural inequality. Kim and Moon (2013) explain that age, education level, frequency of agricultural-related education, income level, size of owned farmland, type of agriculture, farm location, and recent subsidy receipt can influence policy satisfaction. Kang (2017) emphasizes the need for climate-smart agriculture to respond to climate change and reduce carbon emissions, proposing policy tasks such as preparing measures to alleviate technological conflicts, providing scientific evidence and guidelines to overcome barriers to technology adoption by farmers, planning and developing technologies considering local conditions, promoting and educating for diffusion, building producer networks, fostering leading farms, and preparing voluntary participation measures for farmers. Lee (2019) points out that while the dissemination of greenhouse gas reduction technologies and policies can help achieve national greenhouse gas reduction targets, expanding greenhouse gas reduction policies without considering agricultural production or national food security can lead to decreased agricultural production and related industry damage. Therefore, detailed greenhouse gas reduction policies and the introduction of technologies considering the industrial characteristics of the agricultural sector and the relationship between greenhouse gas emission sources are needed.

This study differentiates from others by analyzing issues related to the use of green technology, or low-carbon agricultural technology, in the agricultural sector, and the mitigation of farmer inequality, while seeking policy alternatives.

Despite the fact that South Korea's overall greenhouse gas emissions have more than doubled over the past 30 years (1990–2021), there has been little change in the agricultural sector's greenhouse gas emissions (Ministry of Environment, 2021).

- National total: 292.2 million tons CO_2eq. in 1990 → 676.6 million tons CO_2eq. in 2021.
- Agricultural sector: 21.0 million tons CO_2eq. in 1990 → 21.4 million tons CO_2eq. in 2021.

This indicates a discrepancy between the business benefits and the responsibility for the damage related to climate change in terms of climate justice (Jeong et al., 2020). Nevertheless, the South Korean government's '2030 National Greenhouse Gas Reduction Target (NDC)' presents reduction targets for the agricultural sector as well as other sectors (Government of the Republic of Korea, 2021). However, there is criticism that these targets are set without sufficient analysis of how farmers can achieve them and that the targets are set with absolute numbers for reduction through mitigation technologies (Kwon, 2020).

To address the problems of differential greenhouse gas reduction obligations and excessive technology-centered reduction policies that do not consider the characteristics and conditions of the agricultural sector, it is necessary to first review the inequality and its causes related to climate change in the agricultural sector and among farmers. In this context, the use of green technology, or low-carbon agricultural technology is emerging as an important solution. Green technology helps to mitigate climate change by reducing carbon emissions, conserving natural resources, protecting ecosystem services, and maintaining biodiversity, thus helping to reduce the damage caused by climate change in the agricultural sector (He et al., 2021). The application of green technology can particularly contribute to reducing inequality within agriculture caused by climate change. However, significant resources and information are required for the adoption and utilization of green technology, which can be a major barrier for small-scale farmers to access these technologies. Therefore, it is important to promote the application of green technology through targeted policy support for them.

The purposes of this study are to analyze the theories related to the use of green technology (low-carbon agricultural technology) in the agricultural sector and the mitigation of inequality, and to draw implications from this analysis. Through this, this study aims to provide a theoretical basis for how the application of green technology in the agricultural sector can reduce inequality. Second, based on farmer surveys it aims to analyze issues related to inequality mitigation and seek policy alternatives. For this purpose, this paper reviewed relevant previous studies and used survey data to analyze farmers' perceptions, acceptance levels, willingness to adopt green technology, and their perceptions of inequality.

2. Materials and methods

2.1. Study area

To understand farmers' perceptions of climate change and greenhouse gas reduction, and their willingness to adopt greenhouse gas reduction technologies, a nationwide survey was conducted targeting rice farmers, greenhouse vegetable farmers, and livestock farmers. The survey was commissioned to a professional research firm, Research & Research Co., Ltd. (R&R), and was carried out from August 9 to 3 September 2021, through a combination of telephone interviews and individual face-to-face interviews with the target farms. Before participating, respondents were informed that "This survey is being conducted to investigate perceptions of greenhouse gas reduction in the agricultural sector and willingness to adopt greenhouse gas reduction technologies, with the aim of proposing measures to promote low-carbon agriculture. The information you provide will only be used for research purposes, and no personal details will be disclosed". The total number of respondents was 477 rice farmers, 433 greenhouse vegetable farmers, and 175 livestock farmers. The survey content included farm management characteristics, perceptions of climate change and greenhouse gases, current usage of greenhouse gas reduction technologies, and future willingness to adopt such technologies. It also included the socioeconomic characteristics of farmers.

2.2. Data collection

Table 1. Socio-economic characteristics of farmers.

Category		Paddy rice		Controlled horticulture		Livestock	
		N°	%	N°	%	N°	%
Region	Gyeonggi	55	11.5	48	11.1	22	12.6
	Gangwon	23	4.8	44	10.2	24	13.7
	Chungbuk	36	7.5	39	9.0	11	6.3
	Chungnam/Sejong	89	18.7	70	16.2	28	16.0
	Jeonbuk	53	11.1	36	8.3	21	12.0
	Jeonnam	85	17.8	42	9.7	21	12.0
	Gyeongbuk	67	14.0	74	17.1	25	14.3
	Gyeongnam	69	14.5	80	18.5	23	13.1
Age	Under 40	7	1.5	10	2.3	20	11.4
	40–49 years	20	4.2	34	7.9	14	8.0
	50–59 years	69	14.5	96	22.2	35	20.0
	60–69 years	176	36.9	173	40.0	81	46.3
	70 years and above	205	43.0	120	27.7	25	14.3
Education level	Elementary or below	86	18.0	47	10.9	7	4.0
	Middle School	141	29.6	92	21.2	26	14.9
	High School	209	43.8	215	49.7	72	41.1
	College or above	41	8.6	79	18.2	70	40.0
Farming experience	Less than 20 years	82	17.2	135	31.2	46	26.3
	20–30 years	58	12.2	76	17.6	22	12.6
	More than 30 years	337	70.6	222	51.3	107	61.1
Agricultural income (Annual)	Less than 10 million KRW	63	13.2	62	14.3	17	9.7
	10–30 million KRW	256	53.7	201	46.4	26	14.9
	30–50 million KRW	133	27.9	118	27.3	38	21.7
	50–70 million KRW	112	23.5	102	23.6	32	18.3
	More than 70 million KRW	30	6.3	39	9.0	62	35.4
Total		477	100.0	433	100.0	175	100.0

The socio-economic characteristics of the surveyed farms in **Table 1** show that the highest proportion of respondents were in their 70s for rice farmers (43.0%), while for greenhouse vegetable and livestock farmers, the highest proportion were in their 60s (40.0% and 46.3%, respectively). In terms of education level, high school graduates made up the highest proportion among rice farmers, greenhouse vegetable farmers, and livestock farmers (43.8%, 49.7%, and 41.1%, respectively), with livestock farmers showing a higher proportion of college graduates (40.0%). Farming experience of over 30 years was the most common across all types of farms, with rice farmers at 70.6%, greenhouse vegetable farmers at 51.3%, and livestock farmers at 61.1%. Annual agricultural income for rice and greenhouse vegetable farmers was mostly between 10 million and 30 million KRW (53.7% and 46.4%, respectively), while for livestock farmers, it was predominantly over 70 million KRW (35.4%).

3. Results and discussion

3.1. Descriptive statistics

In this section, statistical analysis was conducted using survey data from South Korean farmers on their perceptions of greenhouse gas reduction technologies. The survey was divided into three parts: perceptions of greenhouse gas reduction in the agricultural sector, acceptance of greenhouse gas reduction technologies by farming type (rice, greenhouse vegetables, livestock) and perceptions of inequality.

Regarding the perception of climate change impacts on the agricultural sector, respondents were provided with brief information about climate change and South Korea's policies to address it beforehand. Among the surveyed farmers, 88.3% recognized that agriculture is more affected by climate change compared to other industries, such as manufacturing, mining, and services (**Figure 1**). When broken down by farming type (rice farming, greenhouse vegetable farming, and livestock farming), 86.4%, 91.0%, and 84.6% of respondents, respectively, agreed (strongly agree, agree). Regardless of age, income level, education level, or farming experience, over 80% of respondents across all categories recognized the severe impact of climate change on agriculture. This indicates a widespread awareness of the seriousness of climate change impacts within the agricultural sector.

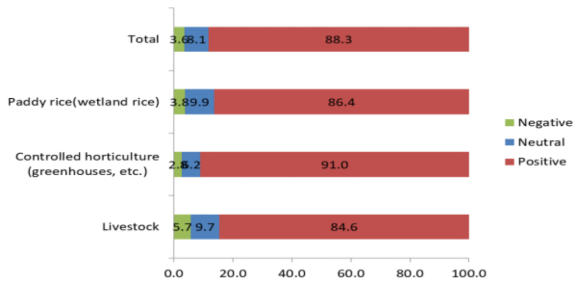

Figure 1. Perception of climate change impact compared to other industries.

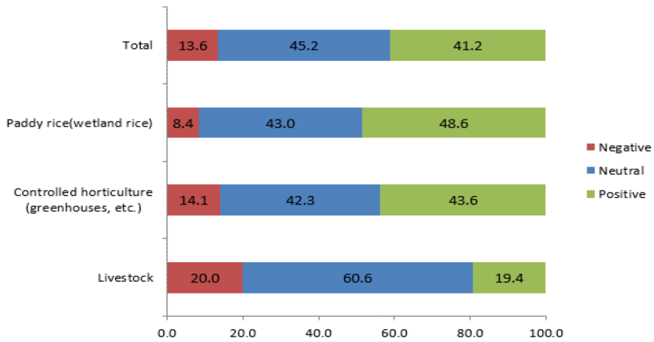

Figure 2. Satisfaction with greenhouse gas reduction and low-carbon agriculture policies.

Policy satisfaction regarding greenhouse gas reduction and low-carbon agriculture in the agricultural sector was generally above average (**Figure 2**). Dissatisfaction responses were lowest for rice farming (8.4%), followed by greenhouse vegetables (14.1%) and livestock (20.0%). Notably, livestock farming showed the lowest positive (satisfied, very satisfied) response at 19.4%, compared to 48.6% for rice and 43.6% for greenhouse vegetables. This suggests that livestock farmers are more concerned about the burden of greenhouse gas reduction due to higher emissions in their sector. Further, dissatisfaction was higher among farmers with shorter farming careers and higher agricultural income.

Figure 3 shows the perception of inequality related to greenhouse gas reduction and low-carbon agriculture. 57.0% of respondents recognized the existence of inequality within the agricultural sector or compared to other industries. Rice and greenhouse vegetable farmers reported higher perceptions of inequality within the agricultural sector (31.2% and 31.4%, respectively) than compared to other industries (15.1% and 15.9%). Conversely, livestock farmers reported higher perceptions of inequality compared to other industries (25.7%) than within the agricultural sector (20.6%).

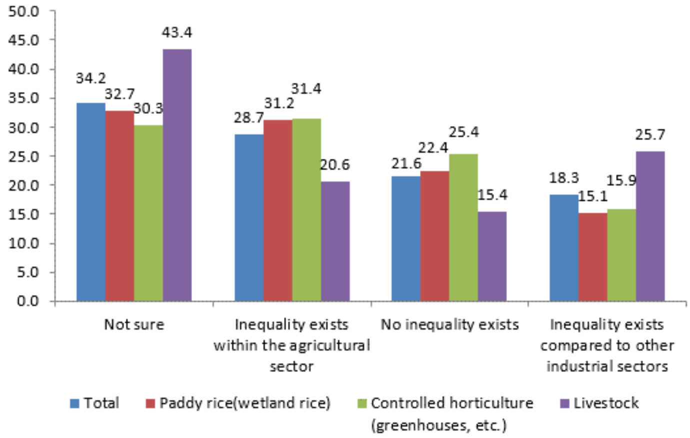

Figure 3. Perceptions of inequality related to greenhouse gas reduction.

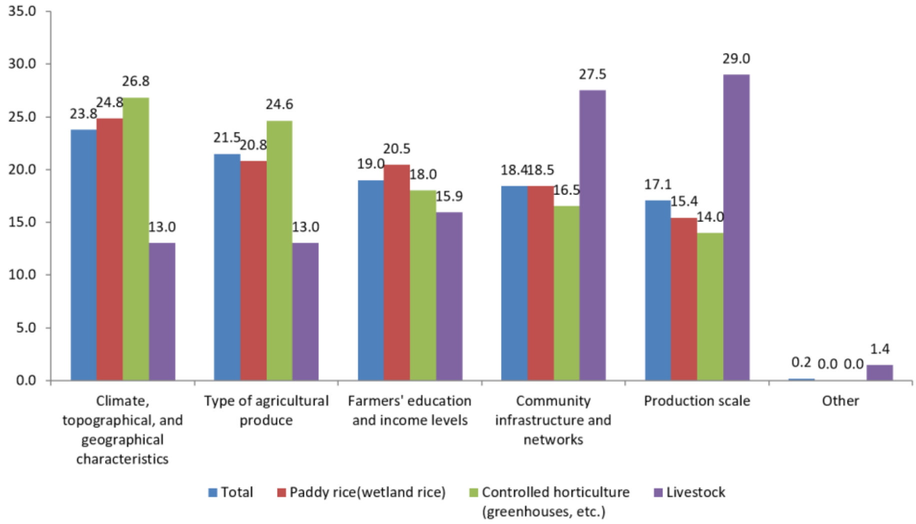

Figure 4. The reasons for the existence of inequality within the agricultural sector.

※ Results allocated as 100% of the sum of the top 1–2 rankings.

Regarding the causes of inequality within the agricultural sector (**Figure 4**), 23.8% of respondents identified 'climate/geographical/topographical characteristics' as the primary cause, followed by 'type of agricultural produce' (21.5%). Rice and greenhouse vegetable farmers identified 'climate/geographical/topographical characteristics' and 'type of agricultural produce' as the top causes, respectively. In contrast, livestock farmers identified 'production scale' (29.0%) and 'existing infrastructure, network (connections) within the local community' (27.5%) as the top causes. Similar trends were observed regarding the reasons for inequality within the agricultural sector based on income levels.

In addition to descriptive results, inferential statistical analyses such as T-test, correlation, and regression models were performed using STATA 16 to ensure precise and reliable results.

3.2. T-test and correlation analysis

Comparing the average information accessibility (ownership of information devices) between the two groups classified based on the perception of inequality shows that the inequality perception group (0.4356436) has higher information accessibility than the group without such perception (0.3294118). This suggests that farmers with higher information accessibility through computers, smartphones, etc., are more likely to perceive inequality. Similarly, comparing the average perception of climate change and its outlook between the two groups shows that the inequality perception group (4.378713 and 4.514851, respectively) has higher perceptions than the group without such perception (4.254902 and 4.278431, respectively). Farmers who perceive the impact of climate change more significantly also tend to perceive higher inequality. Comparing the average awareness of greenhouse gas emissions in the agricultural sector and the need for greenhouse gas reduction between the two groups shows that the inequality perception group (2.660891 and 4.170792, respectively) has higher awareness than the group without such perception (2.498039 and 3.856863, respectively). Farmers with higher awareness of greenhouse gas emissions and reduction obligations in the agricultural sector also perceive higher inequality.

From **Table 2**, comparing the average number of agricultural-related training or technical guidance sessions between the two groups shows that the inequality perception group (1.801980) has fewer training sessions than the group without such perception (2.196078). This indicates that as farmers receive more diverse agricultural-related training or technical guidance, inequality is alleviated. Additionally, comparing the average policy satisfaction regarding greenhouse gas reduction and low-carbon agriculture between the two groups shows that the inequality perception group (3.160891) has lower policy satisfaction than the group without such perception (3.392157). This suggests that higher satisfaction with economic incentives and new greenhouse gas reduction technology applications can help alleviate inequality.

Table 2. Difference in inequality perception between two groups.

Variable	Group	Obs.	Mean	Std. Dev	*t*-value	*p*-value
Information Access	0	510	0.3294	0.4704	−3.2877	0.001
	1	404	0.4356	0.4964		
Climate Change Perception	0	510	4.2549	0.7158	−2.5211	0.011
	1	404	4.3787	0.7539		
Climate Change Outlook	0	510	4.2784	0.7316	−5.3345	0.000
	1	404	4.5148	0.6078		
Awareness of GHG Emissions	0	510	2.4980	0.9164	−2.7411	0.000
	1	404	2.6608	0.8721		
Awareness of the Need for GHG Reduction	0	510	3.8568	0.8959	−5.9617	0.000
	1	404	4.1707	0.6959		
Number of Training Sessions	0	510	2.1960	1.4756	4.5354	0.000
	1	404	1.8019	1.1512		
Policy Satisfaction	0	510	3.3921	0.7195	4.6094	0.000
	1	404	3.1608	0.7789		

※Group 1 = Inequality perception group.

Correlation coefficients were derived and statistical significance was examined to investigate the relationships between the factors in each of the three survey areas. **Table 3** presents the variable names and descriptions used for the correlation analysis.

Table 3. Variable names and descriptions for correlation analysis.

Variable name	Description
unfair	Inequality exists in the application of greenhouse gas reduction technology
ccconti	Climate change is expected to continue
netzero	Awareness of the 2050 carbon neutrality goal
greengas	Awareness of the need for greenhouse gas reduction
cceffdum	Belief that agriculture is more affected by climate change than other sectors
policysatis	Satisfaction with agricultural greenhouse gas reduction and low-carbon policies
greentechuse	Usage or acceptance of greenhouse gas reduction technology

Table 4 shows the results of the correlation analysis in matrix form. The 'unfair' variable shows a positive correlation with the 'ccconti,' 'greengas,' and 'greentechuse' variables, all of which are statistically significant. Conversely, it shows a negative correlation with the 'policysatis' variable. Since this correlation analysis assumes a linear relationship between two variables, the positive correlation between 'unfair' and 'greentechuse' variables is contrary to expectations. The 'ccconti' variable is correlated with all variables, while the 'netzero' variable is statistically correlated only with the 'greengas' variable. The 'greengas' variable shows positive correlations with 'cceffdum' and 'greentechuse,' aligning with expectations.

Table 4. Results of correlation analysis.

Variables	unfair	ccconti	netzero	greengas	cceffdum	policysatis	greentechuse
unfair	1						
ccconti	0.1704*	1					
netzero	−0.0053	0.1727*	1				
greengas	0.1884*	0.4519*	0.3196*	1			
cceffdum	0.0500	0.1382*	0.003	0.1626*	1		
policysatis	−0.1522*	−0.1041*	−0.0163	−0.047	0.0272	1	
greentechuse	0.1018*	0.1379*	0.0166	0.0834*	0.0059	0.0064	1

*Statistical significance within 5%.

3.3. Quantitative analysis

Table 5. Variable names and descriptions.

Variable name	Variable type	Description
unfair	Dummy	Inequality exists in the application of greenhouse gas reduction technology (1: yes, 0:no)
greentechuse	Dummy	Usage or acceptance of greenhouse gas reduction technology (1: yes, 0: no)
infouse	Dummy	Use of information devices (computer, smartphone, etc.) for farm management (1: yes, 0: no)
ccconti	Continuous	Expectation that climate change will continue (1: Not at all likely to continue, ..., 5: Very likely to continue)
netzero	Continuous	Awareness of the 2050 carbon neutrality goal (1: Not aware at all, ..., 5: Very well aware)
greengas	Continuous	Awareness of the need for greenhouse gas reduction (1: Not aware at all, ..., 5: Very well aware)
cceffdum	Dummy	Belief that agriculture is more affected by climate change than other sectors (1: Agree, strongly agree, 0: Otherwise)
policysatis	Continuous	Satisfaction with agricultural greenhouse gas reduction and low-carbon policies (1: Very dissatisfied, ..., 5: Very satisfied)
age	Continuous	Respondent's age
career	Continuous	Respondent's farming experience
linc	Dummy	Low-income farm (annual agricultural income below 20 million KRW in 2020)
minc	Dummy	Middle-income farm (annual agricultural income between 20 and 50 million KRW in 2020)
hinc	Dummy	High-income farm (annual agricultural income above 50 million KRW in 2020)
rice	Dummy	Rice farming household
horticulture	Dummy	Greenhouse vegetable farming household
livestock	Dummy	Livestock farming household

In this section, independent quantitative models were estimated to enhance the utilization of green technology and to mitigate inequality in the application of greenhouse gas reduction technologies in the agricultural sector. Additionally, a Seemingly Unrelated Bivariate Probit (SUBP) model was estimated to consider the correlation between the two variables. **Table 5** shows the variable names and descriptions used in the three types of quantitative models, while **Table 6** presents the basic statistics of each variable. The 'unfair' variable, representing the dependent variable for enhancing inequality mitigation, was binary-coded. It was coded as 1 if respondents perceived inequality within or between the agricultural sector and other industries, and 0 otherwise, with a mean value of approximately 0.44 and a standard deviation of 0.497. The 'greentechuse' variable, representing the dependent variable for enhancing the utilization of green technology, was also binary-coded. It was coded as 1 if respondents used or intended to use greenhouse gas reduction technologies in their respective agricultural sectors and 0 otherwise. The 'age' variable represents the respondent's age, while the 'career' variable represents their farming experience. The 'linc' to 'hinc' variables indicate agricultural income categories in 2020 and were treated as dummy variables. Lastly, the 'rice' to 'livestock' variables indicate the type of agricultural sector and were also treated as dummy variables.

Table 6. Basic statistics of variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
unfair	914	0.4420	0.4969	0	1
greentechuse	914	0.8009	0.3996	0	1
infouse	914	0.3764	0.4847	0	1
ccconti	914	4.3829	0.6894	1	5
netzero	914	2.2505	0.9229	1	4
greengas	914	3.9956	0.8280	1	5
cceffdum	914	0.8829	0.3217	0	1
policysatis	914	3.2899	0.7548	1	5
age	914	63.3862	11.5048	23	94
career	914	31.2155	15.8484	1	70
linc	914	0.3425	0.4748	0	1
minc	914	0.4847	0.5000	0	1
hinc	914	0.1729	0.3783	0	1
rice	914	0.5219	0.4998	0	1
horticulture	914	0.3085	0.4621	0	1
livestock	914	0.1696	0.3755	0	1

4. Results

This paper estimated three different models. 1st model in **Table 7** identified the factors affecting the likelihood of using greenhouse gas reduction technologies (dependent variable: greentechuse). Among the various explanatory variables, 'greengas,' 'cceffdum,' 'age,' 'career,' 'linc,' 'minc,' 'rice,' and 'horticulture' were statistically significant. The results indicate that the better the awareness of the need to reduce greenhouse gases, the more one believes that agriculture is more affected by climate change than other sectors, the younger the respondents, and the more farming experience they have, the higher the likelihood of using or accepting greenhouse gas reduction technologies. The 'linc,' 'minc,' 'rice,' and 'horticulture' variables are interpreted in comparison to their baseline variables. Low- and middle-income farms are less likely to use or accept greenhouse gas reduction technologies compared to high-income farms. Rice farmers are more likely to use greenhouse gas reduction technologies compared to livestock farmers, while greenhouse vegetable farmers are less likely.

2nd model in **Table 7** is to identify the factors affecting the likelihood of perceiving inequality in the application of greenhouse gas reduction technologies (dependent variable: unfair). Most explanatory variables (except 'cceffdum,' 'age,' and 'career') were statistically significant. The results indicate that the more farmers use information devices for farm management, the more they expect climate change to continue, and the better they are aware of the need to reduce greenhouse gases, the higher the likelihood of perceiving inequality in the application of greenhouse gas reduction technologies. Conversely, the better they are aware of the 2050 carbon neutrality goal and the higher their satisfaction with agricultural greenhouse gas reduction and low-carbon agriculture policies, the lower the likelihood of perceiving inequality.

The last 3rd model in **Table 7** represents a seemingly unrelated bivariate probit (SUBP) model, which jointly estimates 1st and 2nd model, considering the correlation between the variables 'greentechuse' (willingness to use or accept greenhouse gas reduction technology) and 'unfair' (perception of inequality in the application of greenhouse gas reduction technology). The third column in **Table 7** shows the estimation results of the SUBP model, indicating statistical significance at the 1% level, thereby rejecting the null hypothesis of zero correlation between the 'greentechuse' and 'unfair' variables. This confirms the correlation between the two variables, suggesting the statistical efficiency of the joint estimation. Compared to 1st model (first column in **Table 7**) there were no significant changes in the statistical significance of the variables, although the coefficient estimates changed. Compared to 2nd model (second column in **Table 7**) the most notable change was the sign of the 'greentechuse' variable, which was initially estimated as positive (contrary to expectations) but turned negative in the SUBP model, with a significant change in the estimated coefficient. The estimation results suggest that farmers' willingness to use or accept greenhouse gas reduction technologies reduces the likelihood of perceiving inequality in their application. This highlights the importance of policy alternatives or strategies to enhance the willingness to use or accept such technologies, thereby mitigating perceived inequality among farmers.

Table 7. Comparison of estimation results.

	1st model		2nd model		3rd model	
Variables	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
					greentechuse	
constant	0.2306	0.6317			−0.0275	0.5758
infouse	−0.0394	0.1396			−0.0637	0.1310
ccconti	0.1090	0.0965			0.0641	0.0932
netzero	0.0694	0.0718			0.0203	0.0661
greengas	0.2058**	0.0849			0.1978**	0.0795
cceffdum	0.3047*	0.1845			0.2443	0.1761
policysatis	0.0271	0.0817			0.0829	0.0721
age	−0.0152**	0.0075			−0.0163**	0.0071

Table 7. (*Continued*).

	1st model		2nd model		3rd model	
Variables	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
					greentechuse	
career	0.0217***	0.0056			0.0208***	0.0051
linc	−0.4892**	0.2075				(omitted)
minc	−0.3506*	0.1930			0.1619	0.1251
hinc		(omitted)			0.4434***	0.1701
rice	0.4898**	0.2165			0.5316***	0.2002
horticulture	−1.4440***	0.2006			−1.3424***	0.1854
livestock		(omitted)				(omitted)
					unfair	
constant			−1.3594***	0.4850	−0.0771	0.4725
greentechuse			0.3541**	0.1393	−1.3193***	0.1826
infouse			0.2297**	0.1050	0.1406	0.0995
ccconti			0.1372*	0.0740	0.1628**	0.0699
netzero			−0.1190**	0.0518	−0.0703	0.0492
greengas			0.2315***	0.0638	0.2517***	0.0601
cceffdum			0.0256	0.1398	0.1044	0.1324
policysatis			−0.2593***	0.0608	−0.2116***	0.0572
age			−0.0048	0.0060	−0.0108*	0.0056
career			0.0046	0.0043	0.0115***	0.0041
linc				(omitted)		(omitted)
minc			0.3979***	0.1005	0.3891***	0.0949
hinc			0.2955**	0.1393	0.4157***	0.1309
rice			0.3441**	0.1423	0.3622***	0.1364
horticulture			0.4257***	0.1559	−0.3516**	0.1676
livestock				(omitted)		(omitted)
LL	−291.24		−577.17		−577.17	
test of ρ = 0					$\chi^2(1) = 8.53$	test of ρ = 0

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Table 8. Marginal effects (3rd Model).

Variables	**dy/dx**	**Delta-Method Std. Err.**	***z***	***P* > *z***
greentechuse	−0.52298	0.073845	−7.08	0
ccconti	0.064544	0.02772	2.33	0.02
greengas	0.099775	0.023825	4.19	0
policysatis	−0.08387	0.022627	−3.71	0
age	−0.00429	0.002235	−1.92	0.055
career	0.004551	0.001607	2.83	0.005

Table 8 shows the estimated marginal effects (probability changes) for statistically significant explanatory variables, while **Figure 5** visualizes these marginal effects with 95% confidence intervals.

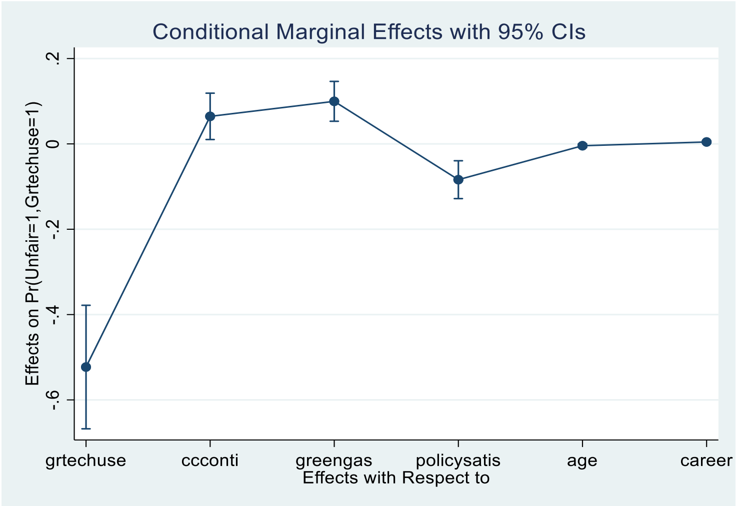

Figure 5. Marginal effects with 95% confidence intervals.

In summary, enhancing farmers' willingness to use or accept greenhouse gas reduction technologies can significantly mitigate the perception of inequality. The SUBP model results underscore the importance of policy strategies aimed at increasing the adoption of such technologies to address inequality perceptions effectively.

5. Conclusions

The agricultural sector faces significant challenges due to the impacts of climate change, which exacerbate existing inequalities, particularly among small-scale farmers. One of the key problems identified in this study is the underutilization of green technology, which has the potential to mitigate these inequalities but remains insufficiently adopted due to various barriers. This study aimed to explore the relationship between the adoption of green technology and inequality in the agricultural sector, with the goal of identifying policy alternatives that could address these challenges.

This study contributes to the understanding of how increased utilization and acceptance of green technology can play a crucial role in reducing inequality within the agricultural sector. By conducting a comprehensive statistical analysis of survey data from farmers, the research provides valuable insights into the factors that influence the adoption of green technology and the perceived inequalities associated with current agricultural policies.

The key findings are as follows. First, increasing the utilization and acceptance of green technology is essential to mitigate inequality. The econometric analysis of farmers' surveys revealed that a higher willingness to use and accept green technology is correlated with reduced inequality. Dissatisfaction with greenhouse gas reduction and low-carbon agriculture policies was primarily due to the lack of diversity in support policies and the technical limitations of green technology compared to other industrial sectors. Therefore, it is crucial to develop and disseminate a variety of green technologies that address these technical limitations, supported by targeted R&D initiatives and other policy measures.

Second, improving policy satisfaction is another vital component in mitigating inequality. This can be achieved by diversifying support policies, including green technology, and expanding economic incentives such as tax reductions, market development, and other forms of financial support. The study underscores the importance of considering the varying levels of policy satisfaction and inequality based on the characteristics of agricultural workers and regions. Additionally, the research highlights the need to address the dissatisfaction stemming from the inadequate response to the green transition of the agricultural sector, particularly in areas like food security, biodiversity protection, and carbon absorption/storage.

Third, there is a need to strengthen education and promotion efforts related to national carbon neutrality goals. The analysis shows that increased awareness and education contribute significantly to reducing inequality. However, many farmers cited a lack of information and promotion as a reason for their dissatisfaction with current greenhouse gas reduction and low-carbon agriculture policies. The study recommends that, alongside technical education, there should be a concerted effort to promote the multifunctionality of agriculture and the necessity of a fundamental green transition in the agricultural sector.

Finally, the research emphasizes that agricultural policies should not only focus on agriculture itself but also consider the broader context of rural society. The impacts of climate change on agriculture are intertwined with broader rural issues, such as aging populations and declining urbanization, which also affect agricultural production and quality. The study recommends that these broader issues be addressed in tandem with agricultural policies, with a particular focus on education and promotion tailored to the characteristics of rural communities to enhance policy perception and satisfaction.

While this study provides critical data and insights that can inform policy-making related to the application of green technology in the agricultural sector, there are certain limitations. The data was collected at a specific point in time, which may not fully capture changes over time. Additionally, the survey respondents may not represent the entire agricultural population of South Korea, potentially limiting the generalizability of the findings. Moreover, while the study analyzes the theoretical implications of green technology adoption, there is a need for more detailed case studies to understand how these technologies are applied in practice. Finally, the proposed policy recommendations are based on theoretical analysis, and further research is required to address potential challenges in actual policy implementation.

For future work, it is recommended that longitudinal studies be conducted to track changes in farmers' perceptions and behaviors over time, providing a more dynamic understanding of the impact of green technology adoption. Additionally, expanding the research to include a more diverse sample of farmers across different regions and scales of operation could enhance the generalizability of the findings. Further research should also explore the practical implementation of green technologies in real-world farming environments, identifying barriers and facilitators to adoption. Finally, it would be beneficial to investigate the long-term impacts of these technologies on both environmental sustainability and economic viability, ensuring that future policies are well-informed and effective.

In conclusion, this study offers actionable recommendations that could lead to increased farm income, job creation, and overall positive spillover effects in the sector. By highlighting the potential for green technology to reduce inequality and contribute to sustainable agricultural development, the study provides a foundation for future policy-making aimed at fostering a more equitable and resilient agricultural sector.

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