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Strategies for Implementing the Global Methane Pledge in the Agriculture Sector

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Chapter 1

Summary

The level of implementation of methane reduction projects worldwide is disproportionate. The agricultural sector has the highest anthropogenic methane emissions but the lowest implementation rate.

- Global methane emissions account for 30% of global temperature rise, and agriculture is the sector with the highest anthropogenic methane emissions, accounting for approximately 40% of methane emissions and 16% of greenhouse gas emissions.
- More than 110 countries signed up to the Global Methane Pledge, committing to reduce human-caused methane emissions by 30% from 2020 levels by 2030. By continent, participation is high in North/South America and Europe, whereas it is lagging in Asia.
- The agricultural sector accounts for the largest share of anthropogenic methane emissions, approaching 40%; however, the implementation of Clean Development Mechanism (CDM) projects in this sector accounts for only 10% of the total CDM projects. Financial investment in methane reduction projects is also far below that for waste and energy.

Various policies and efforts have been made to reduce methane in the agriculture sector in the European Union (EU) and United States (US), which are the major participating countries of the Global Methane Pledge.

- In 2020, the EU announced the EU Methane Strategy to reduce methane emissions in the agriculture (54%), waste (28%), and energy (17%) sectors. The agricultural sector accounts for most of the methane emissions in Europe. The EU has established strategies for the agricultural sector to improve data collection; support the Common Agricultural Policy; promote innovative methane reduction technology, livestock feed, and breeding management; and create a source of income from organic waste resources in rural areas.
- In 2021, The US government established the US Methane Emissions Reduction Action Plan to reduce total methane emissions by 41 million tons from 2023 to 2035, achieving a 74% reduction compared to the 2005 level. The US Department of Agriculture is working to apply manure management systems, anaerobic digesters, low-methane feed, and composting as climate-friendly agriculture practices.

Reducing methane emissions in Korea's rural sector has significant potential and is supported by the government through relevant goals and demonstration projects.

- As of 2018, methane emissions from the agricultural sector accounted for 44% of the total methane emissions in South Korea, making their reduction crucial. The Korean government has set a national target to reduce methane by 30% compared to 2018 by 2030 and set a 9.7 Tg CO_2eq reduction target in the agricultural sector.
- For specific implementation measures, Korea is promoting a pilot project on best-practice technology to reduce methane emissions in agriculture through rice paddy water management at the national level and coefficient data for calculating methane reduction are being secured. Korean pilot projects emphasize the importance of public and private financing in addressing rice field methane emissions, laying the foundation for scaling up efforts, while discussions continue to expand funding opportunities.

To effectively address the urgent need for global methane reduction, advancing governance and financing strategies is crucial, involving an increase in investments and a multi-stakeholder approach, while simultaneously introducing innovative solutions to overcome challenges in agricultural methane reduction, including innovative financing models, cooperative partnerships, and scaled-up sustainable finance.

- To effectively achieve methane reduction goals and urgently address global methane emissions, it is imperative to increase current investments in methane abatement by tenfold, necessitating a multifaceted, multi-stakeholder financing approach that fosters collaboration among the public and private sectors and non-governmental organizations, all while emphasizing international cooperation and diverse financing strategies.
- To address methane mitigation in dairy, agriculture, and ric
- e cultivation comprehensively, it is imperative to adopt innovative financing models, promote cooperative partnerships for agricultural methane reduction projects, scale up sustainable finance for methane mitigation in rice cultivation, and create consumer-driven markets through certification and labeling.

Chapter 2

Introduction

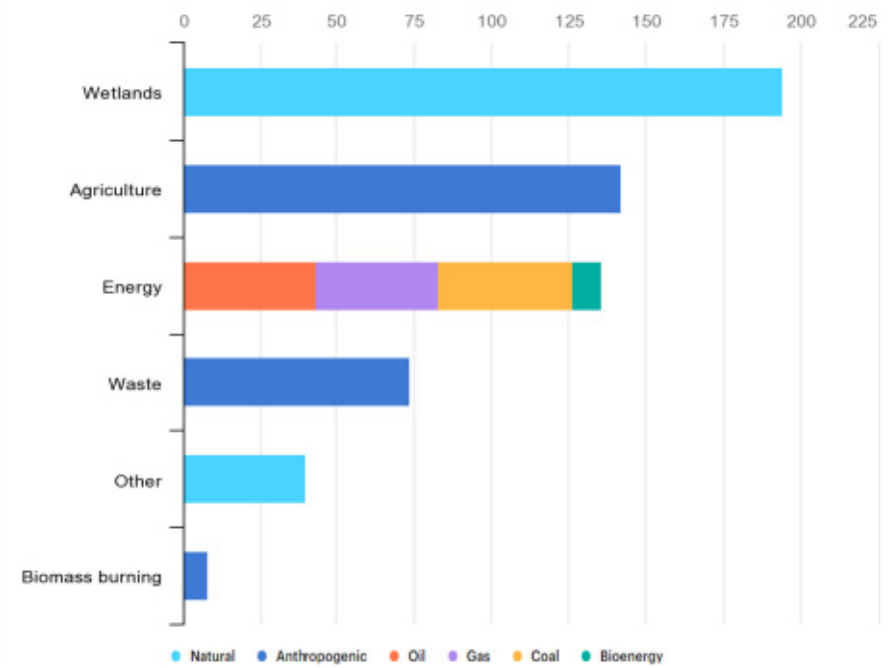
Reducing methane emissions: emphasizing the significance in addressing climate change

- Sharp and rapid reductions in methane emissions are essential to limit global warming to 1.5°C. Methane has a shorter lifetime in the atmosphere than CO_2 and thus has a shorter-lasting effect. However, methane absorbs more energy than CO_2, giving it 80 times the warming power in the first 20 years after emissions reach the atmosphere (UNEP, 2021). Therefore, methane is largely responsible for near-term global warming (CPI, 2022).
- Methane has been responsible for approximately 30% of the global temperature increase since the Industrial Revolution (IEA, 2022). The concentration of methane has increased rapidly and is currently 2.5 times greater than that in pre-industrial times and is breaking all records since the 1980s (UNEP, 2022). Annual global methane emissions are approximately 580 Mt (IEA, 2022), contributing approximately 16% of the radiative emissions from greenhouse gases (UNEP, 2022).

The agricultural sector accounts for the largest share of anthropogenic methane emissions

- Global methane emissions are increasing, especially from anthropogenic sources, such as agriculture, waste, and biomass. Approximately 60% of methane originates from anthropogenic sources, such as landfills, biomass, rice agriculture, and fossil fuels, and approximately 40% originates from natural sources (Figure 1-1) (Global Methane Initiative, 2022).
- According to the United Nations Framework Convention on Climate Change (UNFCCC), the agricultural sector is the sector with the largest anthropogenic methane emissions. Emissions from each sector are predicted to increase, which could be hazardous to global warming and the environment (Global Methane Initiative, 2022).
- Reducing human-caused methane emissions by 30% this decade from 2020 levels, as set out in the Global Methane Pledge, would avert at least 0.2°C of global warming by 2050 (United Nations Environment Programme and Climate and Clean Air Coalition, 2021).

[Figure 1-1] Sources of methane emissions 2021 (Unit: Mt CH_4)



(Source: IEA Global Methane Tracker, 2022)

Purpose and scope of research

- This study emphasizes the significance of agriculture in global methane emissions and provides policy implications to facilitate its implementation, since global methane reduction is undergoing a paradigm shift from project-based units that utilize market mechanisms, such as the CDM approach, to a goal-based approach.
- This study is structured as follows: Chapter 2 delves into the emergence of this significant transformation through the Global Methane Pledge, while Chapter 3 outlines the agricultural methane reduction policies of major participating countries (the US, EU, and Korea). Chapter 4 provides an overview of global methane reduction projects, particularly those operating under the market mechanism of the CDM scheme. In Chapter 5, we explore Korea's case of methane reduction in the agricultural sector, and ways to accelerate investments for methane emission reduction in agriculture. Finally, Chapter 6 offers policy insights into promoting global methane reduction through a collaborative governance approach involving both public and private entities.

Chapter 3

Global Methane Pledge

The Global Methane Pledge is a commitment by the international community to collectively explore cooperative measures to reduce global methane emissions by at least 30% compared to 2020 levels by 2030.

- The Global Methane Pledge was launched in November 2021 at COP26 to take action regarding the reduction of anthropogenic methane emissions. This pledge was led by the United Nations (UN) and the EU and, as of November 2022, has over 150 country participant countries that are collectively responsible for 45% of methane emissions (IEA, 2021). By joining the Global Methane Pledge, countries commit to collectively reduce methane emissions by at least 30% below 2020 levels by 2030.

[Figure 2-1] Member countries of the Global Methane Pledge (Nov. 2022)

※ Source: Methane Moment, 2022

- In terms of participation, the American continent, including both South and North America, is highly involved in the Global Methane Pledge. European participation is also relatively high, which can be attributed to EU governance, which effectively drives the participation of member states

in the Global Methane Pledge, and the EU's financing program, in which the European Development Bank provides funding support (European Commission, 2021). While participation is expanding in Africa, participation in Asia remains relatively low, suggesting an alternative regional governance approach.

[Table 2-1] Current member countries of the Global Methane Pledge

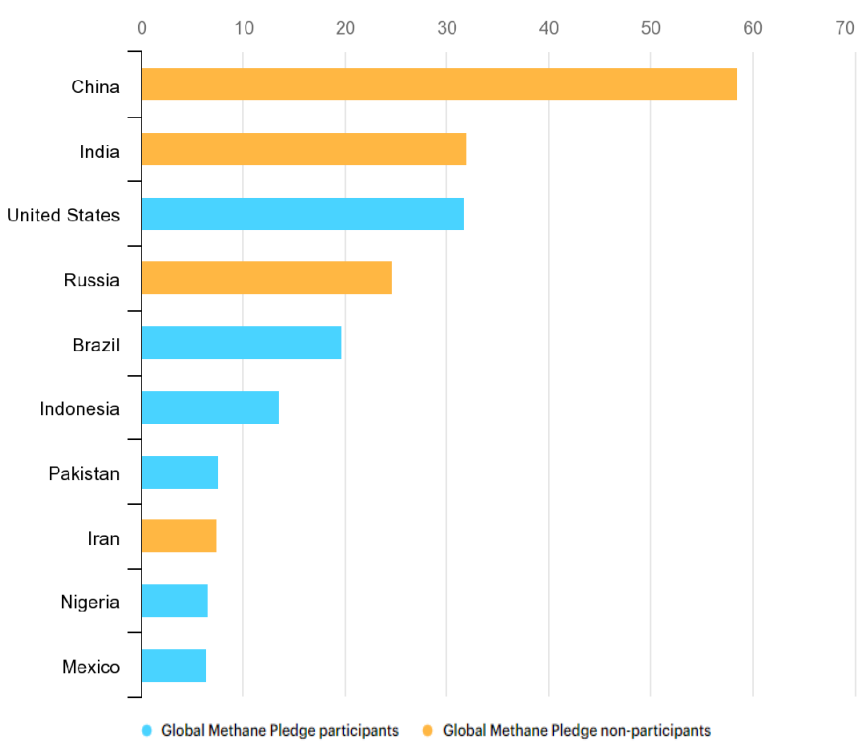
Region	Country	Region	Country	Region	Country
Asia	South Korea, Armenia, Bahrain, Bangladesh, Cambodia, East Timor, Georgia, Indonesia, Iraq, Israel, Japan, Jordan, Kuwait, Kyrgyzstan, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Sri Lanka, Uzbekistan, Vietnam	Middle East	Lebanon, Oman, United Arab Emirates, Yemen	Africa	Benin, Burkina Faso, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, The Democratic Republic of the Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Lesotho, Liberia, Libya, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo, Rwanda, São Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Togo, Tunisia, Zambia
South America	Antigua and Barbuda, Argentina, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guyana, Haiti, Honduras, Jamaica, Panama, Peru, Saint Kitts and Nevis, Saint Lucia, Suriname, Trinidad & Tobago, Uruguay	Europe	European Union, Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Kosovo, Liechtenstein, Luxemburg, Malta, Moldova, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Portugal, San Marino, Serbia, Slovakia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom	Oceania	Australia, Cook Islands, Federated States of Micronesia, Fiji, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu
North America	Canada, Mexico, United States				

※ Source:Methane Moment, 2022

- The methane emissions from the ten leading countries are shown in Figure 4. Certain high-emission nations are yet to commit to the Global Methane Pledge. The global community must make collective efforts to encourage the participation of major methane emitters, including China, India, and Russia, to achieve substantial reductions in global methane emissions.

- As a global climate governance scheme, the Global Methane Pledge helps promote the participation of each country and provides a normative framework in which the opinions of participating countries can be equitably expressed. Additionally, as a norm, it can present a clear reference point for each country's policy establishment based on scientific expertise in the knowledge community.
- Since its launch at COP 26, the Global Methane Pledge has spurred unprecedented momentum in efforts to address methane emissions and has been endorsed by over 150 countries worldwide. In addition, a variety of national methane action plans have been implemented. For instance, there is a direction for new financial resources towards methane mitigation efforts, and collaborative partners have devised policies and initiatives aimed at bolstering regulations and increasing investments in this regard.

[Figure 2-2] Top ten emitters of methane 2021 (Mt CH_4)



※ Source: IEA Global Methane Tracker, 2022

Chapter 4

Global Policy Landscape for the Methane Reduction in the Agricultural Sector

In 2022, the US announced new actions to address methane emissions in line with the Methane Emissions Reduction Action Plan.

- The US is taking significant steps to combat methane emissions by 2030. In 2021, the US Environmental Protection Agency (EPA) formulated policies to regulate emissions from the oil and gas industry right after President Biden's Executive Order (The White House, 2021). In parallel with these regulations, the EPA has worked on implementing much stronger pollution standards for landfills and the Department of Transportation's Pipeline and Hazardous Materials and Safety Administration continues to take action to reduce methane leakage from pipelines (ibid).
- The US government supports research and innovation in livestock farming to find new ways to reduce methane emissions, including the development of methane capture systems in animal housing facilities and the exploration of sustainable feed options. The US livestock industry is also researching and adopting technologies and practices to reduce methane emissions, including the development of dietary additives that can reduce methane production during digestion as well as improved manure management techniques to capture methane emissions. Accurate data collection and reporting of methane emissions from the livestock sector are crucial for tracking progress and identifying areas for improvement. Therefore, the US government is working to improve data collection methods and reporting systems.
- Collaboration between the government and livestock industry is also essential for driving methane reduction efforts. Partnerships with industry stakeholders lead to the implementation of best practices and technologies on a larger scale. In this regard, the US Department of Agriculture is working to significantly expand the voluntary adoption of climate-friendly agricultural practices in partnership with US farmers and ranchers that will reduce methane emissions from key agricultural sources by incentivizing the deployment of improved manure management systems, anaerobic digesters, new livestock feeds, composting, and other practices (The White House, 2021). To support these actions, the US government and various states provide financial incentives and technical assistance to farmers who implement methane reduction measures. The US Congress is also planning to fund and support these practices. The US is continuously working through the Climate and Clean Air Coalition (CCAC) to combat the problem of methane emissions (ibid).

The EU Methane Strategy focuses on mitigating methane emissions in the agriculture, waste, and energy sectors, which account for almost all anthropogenic methane emissions.

- The EU plans to reduce methane emissions by almost 55% by 2030 compared to 1990 levels. For this purpose, the European Commission (EC) is set to introduce legislative measures aimed at effectively monitoring, reporting, and validating methane emissions, while also establishing stringent controls on venting and flaring practices. These proposed regulations will additionally mandate the implementation of leak detection and repair protocols.
- Under the Horizon Europe program, the EU is investing in research and innovation to develop methane-reducing technologies and practices for livestock farming. This includes exploring dietary adjustments to reduce methane emissions during digestion. Innovative feed additives and dietary changes are being investigated to make livestock farming environmentally friendly.
- Accurate data collection and reporting are essential for tracking progress and identifying intervention areas, and the EU is also working to improve monitoring and reporting of methane emissions from the livestock sector. The most significant step that the EU is taking is to support the United Nations Environmental Programme (UNEP) financially by establishing an independent International Methane Emissions Observatory (IMEO), which will ensure transparency in emissions data and will make sure that proper methane emissions calculations are performed to track the performance of each country towards the Global Methane Pledge (The White House, 2021).
- The EC is also working to accelerate the uptake of mitigation technologies through the wider deployment of 'carbon farming' in EU Member States and through their Common Agricultural Policy Strategic Plans and to promote biomethane production from agricultural waste and residues. The farm-to-fork strategy is also a central component of the European Green Deal, which outlines the European EU's commitment to sustainability and climate action. This strategy aims to make the EU's food system more sustainable, including livestock farming. It has set ambitious targets for reducing greenhouse gas emissions, including methane, from agriculture. Efforts are currently underway to improve manure management practices in livestock farming. This includes capturing methane emissions from manure and using it as a renewable energy source or implementing technologies to reduce emissions during storage and application.
- The EU has also engaged in international cooperation to address methane emissions from agriculture. Collaborative efforts and knowledge sharing with other regions and countries contribute to global methane reduction goals.

The Republic of Korea has set plans to reduce methane emissions by 2030.

- In 2020, Korea's methane emissions reached 27 million tons, with approximately 60% originating from anthropogenic sources, including natural gas production and use, agriculture, and waste management.

- In line with the Global Methane Pledge launched at COP26, Korea committed to reducing its emissions by 30% by 2030 compared to the 2018 level.
- The reduction targets for each sector, measured in Tg CO_2eq, are as follows (Table 3-1):
  - Agriculture and livestock: Emissions must decrease from 12.2 to 9.7, representing a 20.5% reduction.
  - Energy: Emissions should decrease from 6.3 to 4.5, representing a 28.6% reduction.
  - Waste: emissions should decrease from 8.6 to 4.6, representing a 46.5% reduction.
  - Industrial process: Emissions are targeted to increase slightly from 0.6 to 0.7, representing an increase of 13.3%.
  - Forest and land-use changes: The emissions are set to remain constant at 0.3, resulting in a reduction rate of 0%.
  - Overall, the comprehensive goal is to decrease total emissions from 28.0 million tons in 2018 to 19.8 million tons in 2030, effectively achieving the targeted reduction rate of 30%.

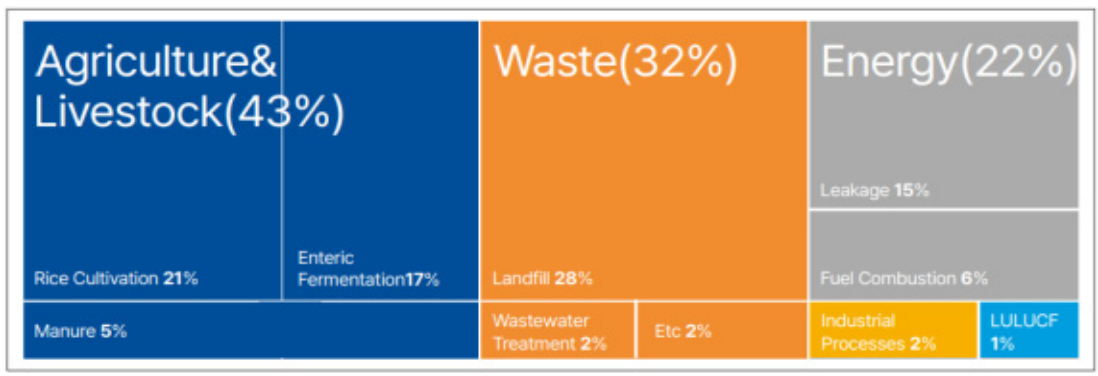
[Table 3-1] Methane reduction targets of the Korean government

Sectors	Emissions in 2018 (Tg of CO_2eq)	Emissions in 2030 (Tg of CO_2eq)	Reduction rate
Agriculture and livestock	12.2	-9.7	-20.5%
Waste	8.6	4.6	-46.5%
Energy	6.3	4.5	-28.6%
Industrial process	0.6	0.7	+13.3%
Forest and land use change	0.3	0.3	0%
Total	**28**	**19.8**	**-30%**

※ Source: Ministry of Trade, Industry and Energy, 2021

- Concerning the 2020 Breakdown of Methane Emissions in Korea, the agricultural sector is a notable source of methane emissions, primarily stemming from rice cultivation processes, enteric fermentation in livestock digestive systems, and livestock manure management. In response to this, the Korean government is committed to mitigating methane emissions from agriculture. This commitment is manifested through various measures, including the diversification of livestock manure usage, its purification, and conversion into energy resources. The government is also actively engaged in the development and distribution of low-methane, low-protein animal feed, in addition to the enhancement of water management practices in rice fields (MOTIE, 2021).
  - The Ministry of Agriculture, Food, and Rural Affairs (MAFRA); Ministry of Environment; Ministry of Trade, Industry, and Energy; and other relevant ministries also have formulated sector-specific reduction plans. In particular, MAFRA plans to achieve methane reduction in the agriculture and livestock sectors through measures such as the energy conversion of livestock manure and the development and dissemination of low-methane feed.

[Figure 3-1] Breakdown of Methane Emissions in Korea in 2020



※ Source: Ministry of Environment, 2022

- In South Korea, various national laws potentially address methane emissions within the agricultural and livestock sectors. However, these laws currently serve as declarative regulations, outlining the responsibilities of central and local governments in implementing greenhouse gas (GHG) emissions reduction policies.[1)]
  - For instance, the Agricultural Community Development Promotion Act incorporates provisions related to GHG reduction and energy conservation. Simultaneously, the Agricultural and Rural Voluntary Greenhouse Gas Reduction Operation Regulation presents technological solutions for voluntary GHG reduction in agricultural and rural areas. The Act on the Management and Use of Livestock Excreta establishes a regulatory framework for livestock manure management but lacks specific regulations for mitigating methane emissions. Similarly, the Control of Livestock and Fish Feed Act focuses on feed quality control to prevent environmental pollution, without current considerations for methane emissions (Solutions for Our Climate, 2023).
  - Notably, South Korea currently lacks regulations explicitly targeting methane emissions originating from rice cultivation. However, the Agricultural and Rural Voluntary Greenhouse Gas Reduction Project Operation Regulations hold the potential to introduce methane abatement requirements, particularly through sustainable water management practices in rice cultivation.
  - In the interest of rural prosperity, both central and local governments in South Korea can offer support to boost farmer income, finance rural business cooperatives, and facilitate investments in methane reduction projects. These actions can be executed within the legal framework established by the Agriculture and Food Act, which includes provisions for enhancing farmer income and ensuring the stable management of agricultural businesses.

1) Framework Act on Carbon Neutrality and Green Growth for the Climate Change (Carbon Neutrality Act)
Framework Act on Agriculture, Rural Community and Food Industry (Agriculture and Food Act)
Act on the Promotion of Environment- friendly Agriculture and Fisheries and the Management of and Support for Organic Foods (Environment-Friendly Agro- Fishery Act)
Agricultural Community Development Promotion Act (Agricultural Community Act)
The Framework Act on Agriculture, Rural Community and Food Industry
The Act on the Promotion of Environment-friendly Agriculture and Fisheries and the Management of and Support for Organic Foods

- Moving forward, South Korea's legal efforts may include amendments to the Act on the Management and Use of Livestock Excreta to incorporate protocols addressing methane-reducing livestock manure and anaerobic digestion. Similarly, revisions to the Control of Livestock and Fish Feed Act may involve the inclusion of provisions for methane-reducing feed additives and low-methane feed options.

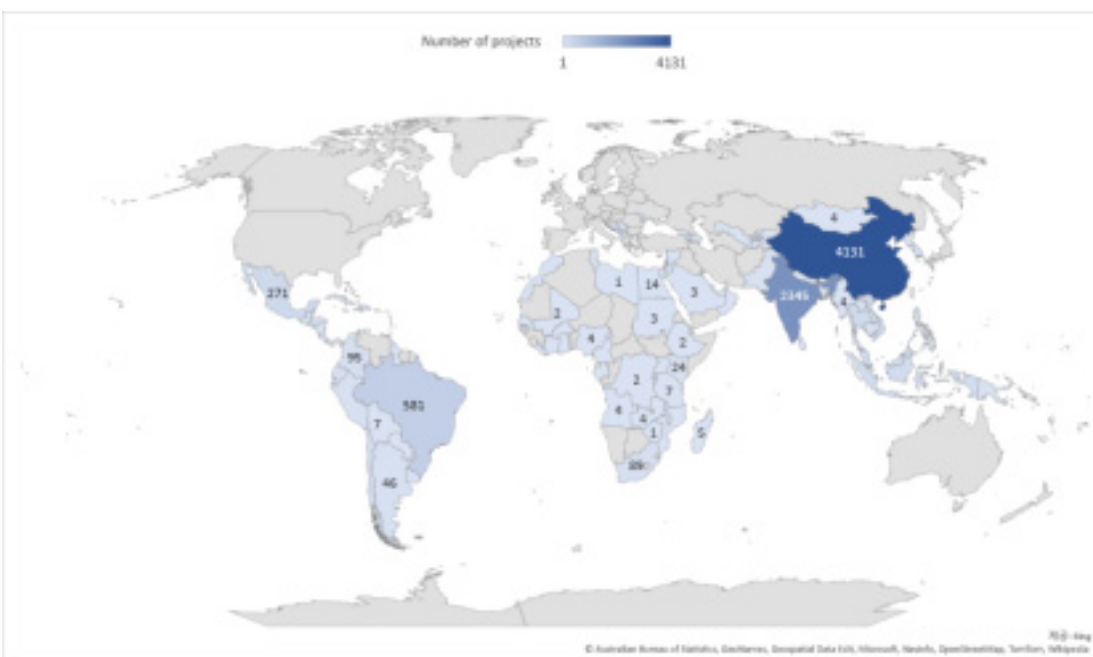
Chapter 5

Assessing the Progress and Challenges of Global Methane Reduction Projects in the Agricultural Sector

CDM projects are among the most important global methane reduction efforts.

- Of the 13,159 methane reduction projects registered in the CDM database (UNFCCC CDM Registry, 2022), approximately 9,901[2] include methane reduction and avoidance activities and approximately 378[3] include methane reduction activities as the main projects.
- Approximately 66% of the 9,901 projects including methane reduction activities are implemented in China (4,131; (approximately 42%) and India (2, 345; 24%). By continent, 81%, 16%, and 3% are in Asia, America, and Africa, respectively, with business investments concentrated in China and India.

[Figure 4-1] Geographical distribution of methane-reduction CDM products



2) CDM projects registered in the UNFCCC CDM Registry DB that apply 26 methodologies to reduce and avoid methane.

3) CDM projects registered in the UNFCCC CDM Registry DB that include methane projects in their title.

Although agriculture has the highest potential for anthropogenic methane emissions, the number of CDM projects implemented remains very low.

- Of the 9,901 projects including methane reduction activities, 7,701 (78%) were exclusively dedicated to the renewable energy sector, while 8,566 (87%) covered multiple sectors, including renewable energy. The waste sector followed with 814 (8%) projects conducted solely and 1,657 (17%) involving multiple sectors.
- Despite the agricultural sector being the largest contributor to anthropogenic methane emissions, only 57 (1%) projects were solely focused on the agricultural sector and 312 (3%) encompassed multiple sectors.

Implementing water management strategies in paddy fields, as opposed to maintaining continuous submergence, can lead to substantial reductions in methane emissions.

- The majority of methane emissions stem from biological factors, specifically from the activity of methanogenic bacteria. The anaerobic oxidation of methane (AOM) is mediated by the physical association between anaerobic methanotrophic archaea (ANME) and sulfate-reducing bacteria (SRB) (Malyan SK et al., 2016). In general, methanogens produce methane by decomposing organic matter in oxygen-poor environments (Ibid).
- Flooded paddy fields, commonly used for rice cultivation, represent a typical oxygen-poor environment from which approximately 8% (30 Tg) of anthropogenic methane emissions originate (Saunois M et al., 2020).
- Numerous management strategies are readily accessible for mitigating methane emissions in the context of rice cultivation. These approaches not only preserve or enhance crop yields but also bolster profitability and fortify resilience to climate challenges. For example, a highly effective approach to meet global methane reduction goals involves the amalgamation of locally adapted best management practices with water-conservation methods, such as the implementation of Alternate Wetting and Drying (AWD) techniques (Figure 4-2). AWD entails intermittently draining paddy fields or temporarily lowering water levels to a level that doesn't adversely affect rice yields. This method can curtail methane emissions by a significant margin, typically ranging from 30% to 70%. When paddy fields experience reduced water levels, oxygen from the atmosphere infiltrates the soil, thereby diminishing methane emissions. The longer the controlled reduction in water levels is maintained, the more substantial the reduction in emissions (Kwon H.,2022).
- This AWD approach not only delivers substantial environmental advantages but also boosts financial returns by increasing crop yields, reducing the need for chemical inputs, and conserving water resources. Recent assessments conducted by the International Rice Research Institute (IRRI) and the Consultative Group on International Agricultural Research (CGIAR) Climate Change, Agriculture, and Food Security Program (CCAFS) reveal that implementing AWD in suitable rice-growing regions of Vietnam's Mekong River Delta alone could annually reduce carbon dioxide

emissions by 5.6 million tons, which is roughly equivalent to removing 2.9 million passenger cars from the roads. Furthermore, the adoption of AWD techniques has been shown to increase profitability by up to 13%, translating to approximately $100 more per hectare in Vietnam.

As the methodology for managing paddy water is registered in the CDM, market mechanisms can be utilized to promote relevant actions.

- As a necessary condition for qualifying CDM projects, irrigation and drainage facilities in the targeted rice fields are essential, along with a robust monitoring, reporting, and verification system for monitoring the drainage of water removed from the rice fields.
- In the current methodology, the monitoring method of the project is applied through the farmer's farm diary and multiple governance measures of the rural field.

[Figure 4-2] Agricultural methane-reduction activities

Despite the numerous technological solutions proposed to reduce methane emissions in agriculture, achieving global methane reduction within the agricultural and rice water management sectors remains a formidable challenge.

- The proposed technological strategies for mitigating methane emissions typically involve the introduction of innovative technologies, often accompanied by regulatory policies addressing both the supply and demand aspects. Recent research underscores that discussions on the impact of currently available, technically and economically feasible methane mitigation measures tend to

overlook the potential for radical policy shifts (Ocko et al., 2021). These measures, while technically viable, have the capacity to reduce around one-third of livestock methane emissions. However, when viewed through the lens of current cost assessments, economically feasible strategies can mitigate only approximately 2% of these emissions (Ibid).

- Within the Agriculture, Forestry, and Other Land Use (AFOLU) sector, methane emissions are primarily driven by a handful of agricultural subsectors, such as enteric fermentation, manure, and rice, which are technically more challenging to mitigate than emissions in other sectors. As a result, achieving the objectives of the Paris Agreement necessitates a significant behavioral shift, including the widespread adoption of low-meat diets (CCAC and UNEP, 2021; Harmsen et al., 2019).
- The fragmented nature of rice value chains presents substantial challenges for large-scale transformations. Furthermore, as a challenging-to-mitigate methane source, the envisioned mitigation measures in rice are often costlier than those in most other sectors (Harmsen et al., 2019). Smallholder enterprises frequently lack the requisite knowledge and financial resources to adopt low-carbon technologies. Achieving substantial emission reductions through these technologies also demands long-term investments in irrigation infrastructure and post-harvest facilities, which are often challenging to secure in developing countries. In contrast, investment in methane abatement for rice paddies is currently limited, with only around USD 100 million allocated. The majority of these projects focus on pilot and research initiatives, with minimal capital expenditure targeting water management and rice varieties. This level of investment falls significantly short of the estimated USD 28 billion required for implementing mitigation measures in line with limiting global warming to +2°C. This shortfall is understandable, given the need for further innovation and research and development support to make scalable solutions market-ready.

Chapter 6

Accelerating Investments for the Methane Emission Reduction in the Agriculture Sector: Korean Case Study

Notable developments have been made to accelerate investments aimed at reducing methane emissions; however, addressing policy, measurement, data, and innovation challenges is crucial for mobilizing adequate funding.

- Notable developments include substantial commitments from the US and EU, along with support from esteemed institutions. For example, the US and the EU have made substantial commitments to provide financial and technical support to facilitate the implementation of pledges. Furthermore, esteemed institutions such as the European Bank for Reconstruction and Development, European Investment Bank, and Green Climate Fund have expressed their commitment to supporting the Global Methane Pledge through the provision of technical assistance and project financing. The International Energy Agency assumes a crucial role as an implementation partner.
- To mobilize investments on a scale commensurate with the urgency of methane abatement, it is imperative to address several critical barriers identified by the Climate Policy Initiative (CPI).
  - Policy and Regulatory Barriers: The current policies and regulatory landscapes often fail to adequately support methane mitigation activities. For instance, despite the potential for cost-effective methane emission reduction in the oil and gas sector, policies and regulatory frameworks for leak tracking and mandatory methane mitigation remain inconsistent.
  - Measurement Uncertainties: Measuring methane emissions is a complex task that has been chronically underestimated. The establishment of a reliable methane emission baseline is vital for tracking progress and identifying key areas for intervention. Additionally, monitoring reductions in methane emissions remains more of an art than science, necessitating significant advancements in methane tracking to facilitate targeted financial support for mitigation efforts. In addition, it is essential to establish a robust monitoring, reporting, and verification system with government support to create precise predictive emission models. This will enable targeted implementation of mitigation strategies and enhance the effectiveness of policymaking. The government can support this technological advancement by offering centralized fugitive emissions management services and financing innovative projects.
  - Challenges in Cost-Benefit Assessment: Limited data availability makes it challenging to comprehensively measure the costs and benefits of methane reduction. Standardized reporting of methane abatement activities by both public and private actors is lacking, leading to the risk

of over- or under-estimating the benefits of methane-related investments. This complexity hampers the assessment of investment gaps and needs. In particular, in the AFOLU sector, where some information is available to public actors, there is insufficient data on private sector flows.

- Lack of Support for Innovation: Certain methane mitigation solutions with high potential in the AFOLU sector, such as feed additives and chemical inhibitors, are in the early stages of development and require additional R&D support.

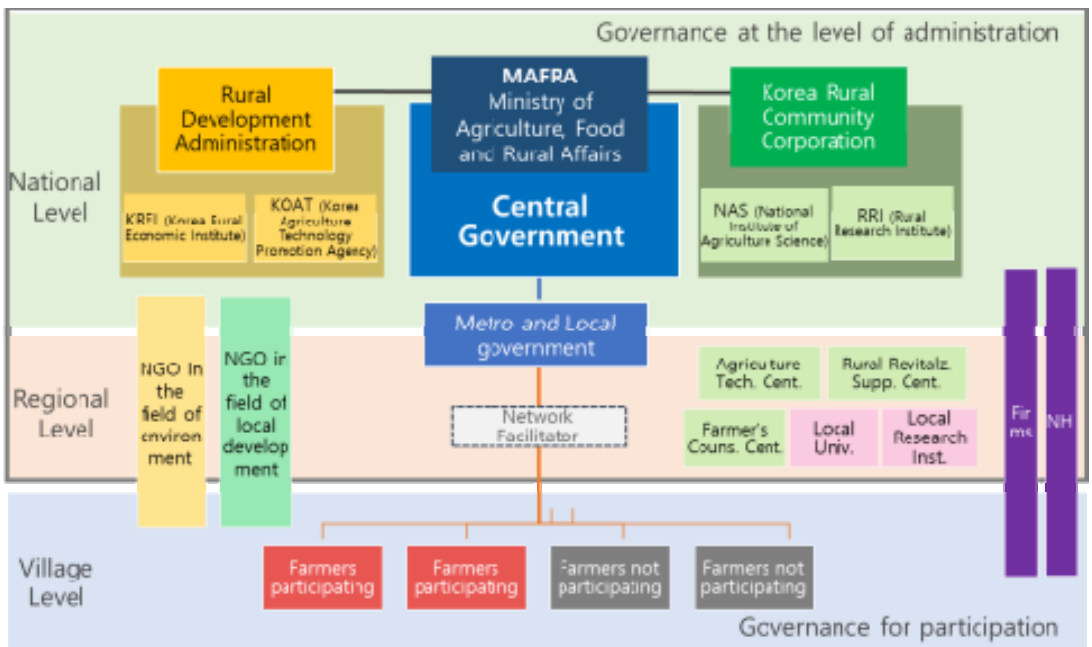
The significance of methane reduction resulting from agricultural cultivation in Korea cannot be overstated.

- As the proportion of rice cultivation in global anthropogenic methane emissions is significant, changing the rice cultivation process has enormous potential for reducing methane emissions in the agricultural sector (Gwon et al., 2022).
- The methane emissions in Korea are in the order of agriculture (12.21 Tg CO_2eq), waste (8.6 Tg CO_2eq), energy (6.3 Tg CO_2eq), industrial process (0.6 Tg CO_2eq), and LULUCF (0.3 Tg CO_2eq).
- In the agricultural sector, the methane generated from rice cultivation is the highest at about 6.4 Tg CO2eq (52%), followed by enteric fermentation (4.5 Tg CO2eq; 37%) and livestock manure (1.3 Tg CO2eq; 11%) (Kwon H.,2022). Thus, the methane generated from rice cultivation is at the same level as that generated by the entire energy sector. In Korea, 53% (865,000 ha) of the total agricultural land area comprises paddy fields, and approximately 22% (6.4 Tg CO2eq.) of total domestic methane emissions are generated during rice cultivation (GIR 2019).

Multilayered governance in Korea plays a critical role in overcoming technological and practical barriers in rural areas and promoting methane-reduction activities through paddy water management.

- Despite having the highest methane emission potential in the agricultural sector, the meager investment in the agricultural sector is due to difficulties in monitoring and methodologies for methane avoidance activities, as well as challenges in implementing the project in rural areas.
- Various stakeholders involved in rice cultivation and rural water management have been linked to AWD activities to reduce methane in rural areas. These stakeholders facilitate the development of rural methane-reduction projects and increase project implementation sustainability by establishing diverse governance in the value chain linked to the supply and demand of rice production.

[Figure 5-1] Governance structure of methane reduction projects in rural Korean areas



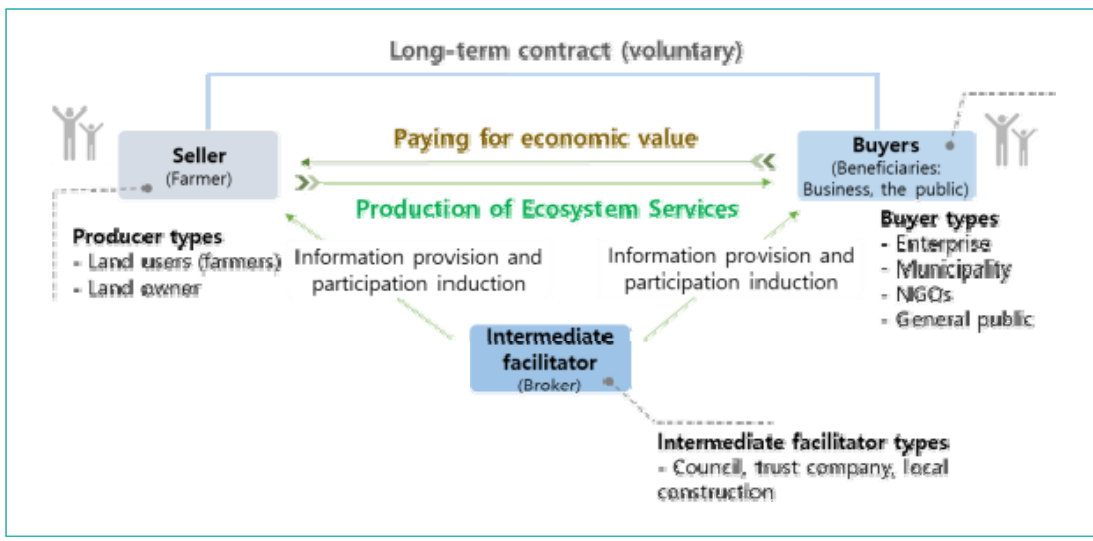
The Korean government has launched a pilot project aimed at mitigating methane emissions from rice cultivation across Korea and plans to complete it before 2024.

- This initiative successfully fosters voluntary participation among rice farmers and fosters their engagement in rice cultivation and water management activities through a well-structured governance framework, as illustrated in the diagram.
- In this pilot project, two distinct forms of governance are established. These two governance structures bring together diverse groups of stakeholders who collaborate harmoniously. Key participants in this endeavor include local government bodies, central administrative governance bodies, and various organizations such as the Rural Development Administration, Korea Agricultural Technology Promotion Agency and Korea Rural Community Corporation (both at the headquarters and branch levels), as well as local government agricultural technology centers, universities, agricultural cooperatives, village leaders, and, of course, farmers.
- This multifaceted governance model has proven instrumental in surmounting technological and practical challenges unique to rural areas. Furthermore, it has been the driving force behind the promotion of methane reduction activities, particularly through enhanced paddy water management practices. The collaborative efforts of these diverse stakeholders are pivotal in achieving the project objectives and ensuring the sustainable reduction of methane emissions in rice cultivation.

Currently, Korea is implementing provincial-level pilot projects aimed at disseminating methane-reduction technologies and enhancing capacity in rural areas.

- These initiatives have a dual focus, namely the establishment of measurement metrics for methane reduction in rice paddies and the identification and mitigation of various risks—ranging from technological and economic to social and environmental—inherent in the introduction of new climate technologies within rural settings. These initial steps are pivotal in laying the groundwork for the transition of projects from localized, site-specific efforts to broader regional scales.
- A critical aspect of the scaling-up process entails the implementation of coordinated water management projects within paddy fields to reduce methane emissions. This undertaking requires the establishment of governance structures responsible for the systematic management of water supply and drainage across extensive agricultural areas, going beyond the efforts of individual farmers. Effective execution also calls for a multi-layered institutional collaboration involving government agencies responsible for policy formulation and implementation. As these pilot projects progress from the demonstration phase to commercialization and expansion, they are poised to lay the foundation for robust public-private partnerships capable of attracting private investment. Therefore, securing initial funding from the public sector is imperative while actively seeking additional private capital.
- In Korea, the central government allocates financial resources to support these pilot projects, with provincial and municipal expenses covering local government costs, supplemented by a predetermined participation fee from project contributors. Although public financing primarily supports the initial stages, the growth of these projects requires additional financial resources. Incentives play a vital role in motivating farmer participation in rural areas. Furthermore, for effective monitoring of the project's impact, an initial investment in technology introduction is indispensable. To augment public financial resources, ongoing discussions revolve around connecting the payment for the ecosystem services system, which includes direct payments for agricultural and environmental services, to the project. This linkage could serve as a valuable mechanism for expanding funding opportunities and promoting sustainable methane reduction efforts.

[Figure 5-2] Payment for ecosystem services structure to raise private funds for methane-reduction products in the agricultural sector



Chapter 7

Policy Implications to Promote Methane Reduction in the Agricultural Sector

7.1 Advancing Governance and Financing Strategies for Global Methane Reduction

International cooperation needs to be facilitated to promote methane reduction.

- International collaboration is essential for promoting methane reduction efforts. Facilitating dialogue and partnerships on a global scale is crucial for effectively addressing this transnational challenge.
- The Global Methane Pledge represents a significant opportunity to enhance ambition and international cooperation in reducing methane emissions (Manfredi C.,2021). Global governance, which is characterized by international organizations and agreements, plays a pivotal role in addressing climate change and other global challenges. This enables collective efforts beyond the capacity of individual states to tackle global problems (Kjaer, 2004; Weiss, 2009; Finkelstein L.S., 1995; Slaughter, A-M., 2004).
- International cooperation must lay the groundwork for governance structures promoting technology transfer and financing to support methane-reduction initiatives.
- Governance leadership is particularly needed in Asia, where participation in global methane reduction commitments is limited. The launch of the ASEAN-Korea Methane Initiative at the ASEAN summit has the potential to serve as a cornerstone for effective governance in reducing methane emissions in the Asian region.

Current investments in methane abatement fall far short, and investments need to increase 10-fold.

- Although methane emissions are responsible for almost half of global warming, targeted methane abatement financing represents approximately 2% of the total climate financing (CPI 2022). Current investment in targeted methane abatement is not enough to limit global warming to 1.5°C. It has been estimated that an average methane abatement funding of USD 119 billion will be needed annually through 2050 under the +2C warming scenario (Harmsen et al., 2019).
- Geographically, existing investment flows are not directed towards geographies or sectors with the highest abatement potential. Regionally, most methane emissions originate in the East Asian

and Pacific regions, primarily led by China (Hoesly et al., 2018). This region also concentrated most methane abatement finance in 2019/2020 (USD 6.0 billion, just over 50% of tracked abatement finance). However, significant abatement potential exists in other regions, particularly Latin America and the Caribbean, which is the second largest methane emitter, and Sub-Saharan Africa, which is the third, which combined attracted only 6% of methane abatement financing (CPI, 2022).

- In terms of sectors, almost two-thirds of methane abatement funding is concentrated in the waste and water sectors, whereas 82% of the emission sources come from the AFOLU (41%) and energy sectors (41%), which received only 33% of the total tracked funding (CPI 2022). AFOLU, at USD 43 billion per year, and fossil fuels, at USD 32 billion per year, are the two sectors in which the gap from current levels is the greatest.
- Although agriculture is a significant contributor to methane emissions, this sector attracted more than one-third of the targeted methane abatement financing in 2019/2020. The waste sector, responsible for less than one-fifth of human-made methane emissions, received more than half of the tracked targeted methane abatement financing in 2019/2020 (CPI 2022). However, the tracked financing levels are still significantly below the estimated needs of the agricultural and waste sectors.

Achieving methane reduction goals requires a multi-stakeholder financing approach, with collaboration between public and private sectors, along with non-governmental organizations.

- Addressing the urgent need to reduce methane emissions globally requires a multifaceted approach that includes international cooperation and diverse financing strategies. The Global Methane Pledge, in conjunction with international partnerships and non-governmental commitments, offers a promising path towards mitigating methane emissions and combating climate change on a global scale.
- In 2019/2020, development finance institutions contributed 13% of the methane abatement flows, and the private sector, especially in mature segments such as waste-to-energy technologies, played a significant role.
- Notably, 20 non-governmental organizations have committed over $233 million to reduce global methane emissions, partly supporting the Global Methane Pledge.[4] These commitments represent the largest private pledges for global methane reduction, offering critical financial resources, expertise, technical support, and monitoring and verification of data. For example, the foundations will coordinate their support for methane reduction solutions, providing expertise, financial resources, technical support, and best-in-class data to ensure progress in methane

4) The participating funders are Bloomberg Philanthropies, Breakthrough Energy, Sea Change Foundation International, Sequoia Climate Fund, Sobrato Philanthropies, the William and Flora Hewlett, Children's Investment Fund, Erol, Grantham, High Tide, IKEA, John D. and Catherine T. MacArthur, McCall MacBain, Montpelier and Hampshire, Oak, David and Lucile Packard, Pisces, Quadrature Climate, Skoll, and Zegar Family foundations

reduction and accurate monitoring, verification, and reporting, including in the resource extraction and agricultural sectors. Donors will continue to work together to increase non-governmental investments in methane reduction and engage international experts to determine how funding will be allocated.

7.2 Introducing Innovation Solutions to Overcome Challenges in Agricultural Methane Reduction

Agricultural methane reduction projects require cooperative partnerships.

- The success of methane-reduction projects in the agricultural sector depends on governance measures involving diverse rural stakeholders. These initiatives not only reduce greenhouse gas emissions but also promote climate change adaptation and sustainable rural development. The effective implementation of methane reduction initiatives necessitates cooperative partnerships between governments and the private sector on a global scale, extending beyond individual project-level investments.

Innovative financing models for dairy and agriculture in methane mitigation are required.

- The cost of implementing enhanced manure management systems, coupled with unclear guidelines for carbon accounting for methane reduction, poses financial challenges for companies seeking to adopt these practices. Innovative financing models have emerged to help companies overcome these challenges. These models include:
  - Scope 3 Stacking: This collaborative approach involves dairy companies and other partners within the same value chain sharing carbon reductions achieved through their investments (Theresa E.,2022).
  - Value-Added Carbon Inserts: This approach involves allowing major dairy buyers to purchase value-added carbon credits directly from farmers or cooperatives within their supply chains, potentially increasing the value of carbon credits. Additionally, companies can collaborate with farms and dairy industry organizations to bundle and purchase carbon credits generated by dairy farms that source milk. By closely collaborating with the dairy industry to advance these initiatives, companies can make significant progress in reducing their Scope 3 emissions (Katherine D., 2021) and incentivize them to adopt net-zero practices. This can be achieved through long-term contracts, purchase agreements, or offtake agreements. Such agreements can provide stability and collateral, enabling dairies to consider investing in technologies, such as anaerobic digesters, or transitioning to climate-friendly practices that may take a few years to yield financial benefits.

– RNG and Methane Mitigation: This approach involves allowing companies within the same value chain to identify common geographic areas and invest in joint projects to reduce methane emissions. These projects claim carbon reductions through multiple green certification schemes.

Sustainable finance for methane mitigation in rice cultivation needs to be scaled up

- Financial resources for methane mitigation can be sourced from nationally targeted rural development programs, public investments, climate change responses and green growth initiatives, and policies supporting production linkages and large-field models. Encouraging private investments in agriculture and rural development is a domestic source of AWD. Additionally, international financial support can come from organizations such as the Global Environmental Fund, Special Climate Change Fund, Small Grants Program, Adaptation Fund, Clean Technology Fund, Pilot Auction Fund, International Climate Initiative, National NAMA(Nationally Appropriate Mitigation Actions) Facility, and Green Climate Fund.
- Large-scale investments across rice value chains are required to transform this sector. Governments can facilitate this by leveraging public financing to attract private investments. For instance, the Thai Rice NAMA project in central Thailand uses overseas development assistance grants to finance a revolving fund for AWD adoption combined with land laser leveling to encourage private sector involvement. Such initiatives are essential for bridging current financing gaps. Sustainable investors can incorporate rice into their portfolios and investment strategies.
- Investments are essential for improving existing canals and pumping facilities and enabling controlled water management. These efforts should be complemented by enhanced training and awareness campaigns to encourage responsible water-management practices.

Consumer-driven markets can be established through certification and labeling

- Rice is a staple food for four billion people worldwide and there is increasing evidence of consumer demand for food sustainability. Businesses and governments can collaborate to provide consumers with transparent information and green labels such as the SRP standard. Companies and governments can develop and promote carbon footprint labels for rice products.

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