# A Study on Water Management Technique on Methane Emission Reduction in Rice Paddies in Japan

A Report on Experienced-Based Learning (EBL) Trip to Tsukuba City, Ibaraki Prefecture (Team 2)

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## I. Background

### Status and issues surrounding food system, agriculture, and greenhouse gas (GHG) emissions reduction goals in Japan

The challenge of strengthening the productivity of Japan's food, agriculture, forestry, and fisheries industries arises amidst a fragile production base and the decline of local communities, marked by a decreasing number of producers and an aging workforce (Fuhrmann-Aoyagi et al., 2024). Urgent measures are needed to address these issues and ensure a stable food supply. These involve enhancing labor productivity through efficiency measures, expanding the producer base, and mitigating environmental burdens by recycling resources, maximizing local resource use, reducing chemical inputs, and advancing towards carbon neutrality. As a matter of fact, Prime Minister Suga (2021) committed a 46% reduction in greenhouse gas emissions by 2030, with a potential increase to 50%, necessitating nationwide efforts and the development of technologies in the agricultural sector. The collaboration of all stakeholders, including producers, food companies, farmers, and consumers, is crucial and essential for a sustainable future.

The National Agriculture and Food Research Organization (NARO), operating under the supervision of Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF), comprises a central office, five (5) area specific agricultural study hubs, seven research units, and three specialized research facilities. NARO's mission, in a nutshell, is "*to advance fundamental and practical scientific investigations, emphasizing real-world applications of research findings to tackle challenges in food availability, farming efficiency, and rural community revitalization*." This includes but is not limited to improving crop yields and food safety to supporting rural economies and promoting sustainable farming practices. By focusing on both practical research and scientific breakthroughs, NARO bridges this gap in the agricultural sector. Because the scholars wanted to learn more about the different strategies to address issues relating to food self-sufficiency and because of the fact that many research projects related to techniques and practices to mitigate the adverse impacts of climate change had been conducted at NARO, they decided to pay a visit and conduct interviews. Particularly, the scholars were interested in water management practice in rice cultivation called mid-season drainage.

## II. Planning

The National Agriculture and Food Research Organization (NARO) is the biggest research institution focusing on agricultural research in Japan. Also, NARO, being a national research institute, possesses numerous fields for crop cultivation across Japan, enabling extensive field-based research. This is a distinctive feature of NARO's operations. Alternate Wetting and Drying (AWD) experiments, which are of particular interest to us, often require the use of actual paddy fields. From this perspective, NARO's research can be considered central to AWD studies in Japan.

During our literature review, we came across papers by Dr. Tokida, a NARO researcher specializing in methane emissions from paddy fields. This led us to initially arrange an appointment with Dr. Tokida for a laboratory visit and interview, to which he graciously agreed. Furthermore, Dr. Tokida went beyond our expectations by introducing us to Professor Nishida from Ibaraki University, with whom he collaborates on research projects. Professor Nishida also graciously agreed to an interview and extended an invitation to the 5th Anniversary Symposium of the Ibaraki University Institute for Global Change and Regional Environment. While we attempted to arrange interviews with several other researchers, some were unable to participate due to prior travel commitments. Online platforms such as Zoom could be utilized to interviews with these individuals and considered for continuation of the research activity.

To summarize our approach in planning this EBL project, we initially reached out to researchers whose work aligned with our interests. Subsequently, we expanded our network through referrals from these initial contacts. Moving forward, we are committed to maintaining the relationships established during this EBL project while actively seeking opportunities to broaden our research network.

This method of network expansion, starting with researchers in our field of interest and then leveraging their connections, proved to be an effective strategy for building our research network. We intend to continue nurturing these newly formed relationships and exploring avenues for further expansion in the future.

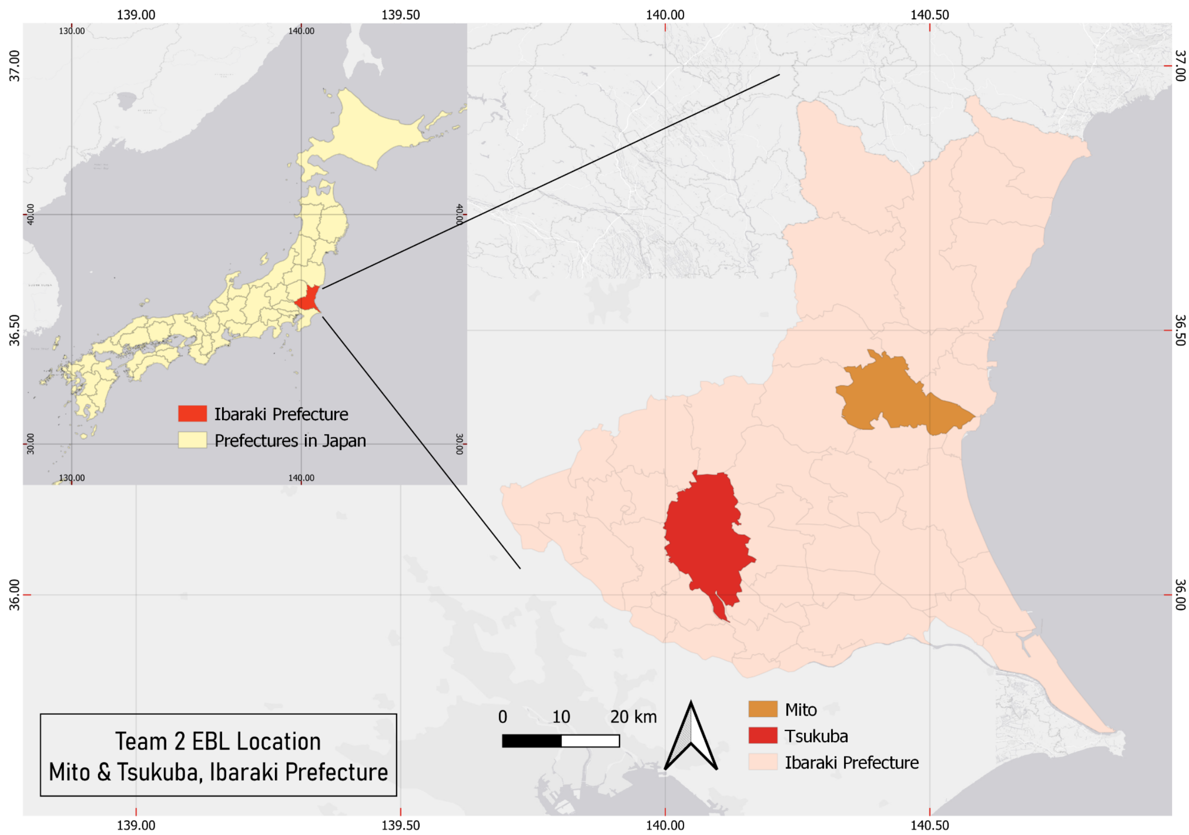


Figure 1. Research sites (Mito and Tsukuba areas, Ibaraki Prefecture).

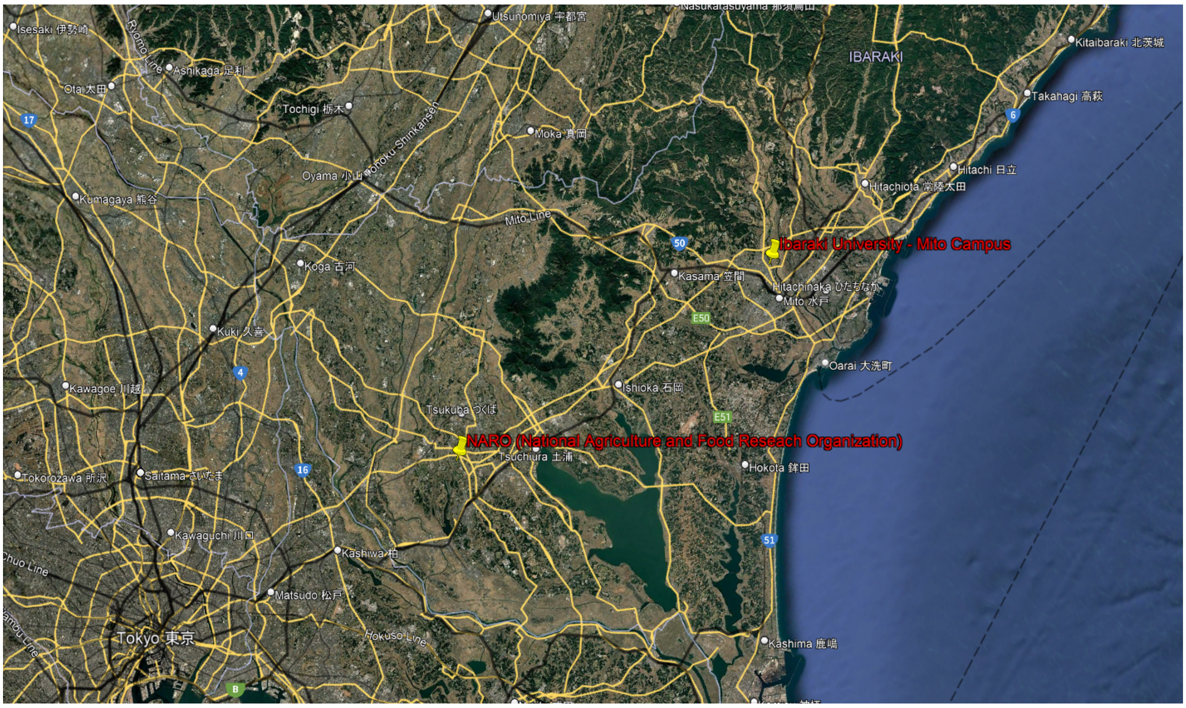

Figure 2. Research Sites (NARO and Ibaraki University).

## III. Aim

The activity aims to learn more about the current and development strategies for reducing methane emissions in rice cultivation, especially from the perspectives of academia and research institutions. The researchers who the team members intended to interview have previous and present research projects on methane emissions in rice paddies and are perfect as interviewees for the study of the team.

## IV. Detailed Activities

The activities that we did in Tsukuba City and Mito City were in the table below. On December 11, 2024 , the scholars traveled to Tsukuba City, where they stayed during this EBL, from Kyoto City by Shinkansen and local train. The team traveled to Mito City from Tsukuba City by bus and taxi on December 12, where the symposium was held. It took about more than 2 hours. Once we reached the venue, we participated in the symposium, which Prof. Nishizawa kindly invited us to. After the symposium, we conducted an interview with Prof. Nishizawa about his research and perspective as a university researcher. And then, they returned to Tsukuba City around 8  p.m. On Day 3, December 13, we visited the Tsukuba Agricultural Research Hall,, which is basically a kind of museum. There are lots of exhibits about food and agriculture and their history. After visiting the museum, we did an interview with Dr. Tokida, a researcher in NARO, about his research and history of mid-season drainage (MD) and alternate wetting and drying (AWD). Also, we got the perspective of an institute researcher. After the interview, we traveled to Kyoto from Tsukuba City.

Table 1. Experience-based Learning (EBL) Itinerary.

| Date | Time | Activities |
|---|---|---|
| Dec. 11, 2024 | 18:00 ~ 22:00 | Travel from Kyoto to Tsukuba |
| Dec. 12, 2024 | 10:00 ~ 13:30 | Travel from Tsukuba-city to Mito-city |
| | 13:30 ~ 15:30 | Participate in the symposium (5th anniversary of Global and Local Environment Co-creation Institute from Ibaraki University) |
| | 16:00 ~ 17:30 | Interview with Prof. Nishizawa |
| | 17:30 ~ 20:00 | Travel from Mito-city to Tsukuba-city |
| Dec. 13, 2024 | 11:00 ~ 11:30 | Travel from hotel to NARO Headquarter |
| | 11:30 ~ 13:30 | Tsukuba Agriculture Research Hall |
| | 14:00 ~ 17:00 | Interview with Dr. Tokida |
| | 17:00 ~ 21:00 | Travel from Tsukuba-city to Kyoto |

## V. What we learned

### *1. Mid-Season Drainage (MSD)*

One method advocated by the agricultural industry is mid-season drainage (MSD). Initially implemented by farmers in northeastern China in the 1960s to address water shortages (Ma *et al*., 2023), MSD has been found to offer additional benefits beyond water conservation. Research has shown that MSD can help eradicate straighthead disease in rice, which can reduce rice yield by up to 90% due to poor grain development (Yan *et al*., 2023), causing heads to remain upright.

Furthermore, in 2000, Wassmann *et al.* reported that MSD also significantly reduces methane emissions from rice paddies by 7% to 95%, depending on specific conditions, contributing to environmental sustainability. Given that rice cultivation accounts for approximately 10% of greenhouse gas emissions from agriculture, and this percentage is even higher in developing countries, reducing methane emissions from rice farming is a crucial step in mitigating global warming. This is particularly important for Japan in the context of ensuring food self-sufficiency while addressing climate change concerns. Implementing practices like mid-season drainage can significantly lower methane emissions, contributing to global and national environmental sustainability goals.

MSD involves temporarily withholding flood irrigation water to remove all surface water from the rice crop, allowing the soil to dry until it cracks and is reaerated. This re-aeration of the soil eradicates methanogenic archaea, microorganisms that thrive in anaerobic conditions and decompose organic matter to produce methane. By disrupting these anaerobic conditions, MSD significantly reduces methane emissions from rice paddies.

### *2. Perspective of a University researcher (Ibaraki University, Mito Campus)*

In order to reduce the influence of rice agriculture on climate change, research has been conducted to reduce the methane emission of paddy fields. Methane emissions from paddy fields are one of the most significant contributions to climate change. The global warming potential of global warming is approximately 25 times greater than carbon dioxide over a 100-year period.

One of the research areas of Prof. Nishizawa is reducing greenhouse gas emissions, specifically nitrogen oxide and methane, from agriculture. His works include exploring ways to reduce nitrous oxide emissions from upland rice, potentially by using bacteria called KH32C that can consume nitrogen and convert it into a less harmful form. This research has attracted attention from the Bill Gates Foundation and subsequently led to international collaboration and initial projects in India and Colombia, to name a few.

Prof. Nishizawa shared one of his research results in which the bacteria (KH32C) reduced methane emissions by 23%. This was achieved specifically by adding KH32C to the rice seeds. Rice paddies have organisms called methanogens that make methane and methanotrophs (usually found in flooded rice, swamps, etc.) that consume it. The effects of adding the said bacteria were investigated, and results indicated or revealed suppression of methane synthesis, increased methane consumption, and hence, decreased methane emissions (Sakoda et al., 2022).

### *3. Perspective of a researcher at an agricultural institute*

Dr. Tokida Takeshi, who belongs to the Agricultural Environment Research Division of NARO, provided a short lecture on the implementation of mid-season drainage in rice paddies in Japan. One of their division's research areas is climate change mitigation.

Mid-season drainage (MD) is a traditional water management practice in rice paddies cultivation common in East Asia (Japan, Korea, and China). It has a long history and started as early as the seventh century in China. It is a water-saving technique in which water is deliberately drained or discharged, usually at the end of the vegetative stage, for about one (1) week (5-7 days). One benefit of mid-season drainage is that it is good for rice growth. Recently, a longer period of drainage, about 12–14 days, is being advocated by the Japanese government, i.e. to reduce irrigation water consumption.

On average, the adoption rate in Japan is about 90% and this is ascribed to infrastructure development. In the Kanto region, for example, the adoption rate is 90%. Adoption in the Tokai-Kinki region is about 90% and 50% in the Hokkaido region. According to Dr. Tokida, the high adoption rate in Japan is not because of the fact that either the Japanese government or farmers wanted to reduce methane emissions but because of two (2) main reasons. First, the rice farming infrastructure in Japan has capabilities to control or drain water (mid-season drainage). Their canals for irrigation and drainage are separated.

Alternate Wetting and Drying (AWD), on the other hand, is also a water-saving method mainly developed by the International Rice Research Institute (IRRI) located in Los Baños, Laguna, Philippines, to help address the water shortage issues in the country. The main difference between AWD and MSD in these countries lies in their objectives. Before this method, the traditional rice cultivation in the Philippines was mainly in flooded conditions (*continuous flooding*). Percolation and evapotranspiration are important factors to consider when managing water resources for rice cultivation and with the AWD system, water losses via percolation and evapotranspiration are minimized. The adoption rate of AWD in the Philippines is less than 20%.

The second main reason for the adoption of MSD technique is “Yield Quality.” In particular, the technique is employed to avoid lodging, which, in rice farming, refers to the bending or falling over because of weak stems. Lodging results in lower rice yield and makes harvesting more difficult. This is a common issue of Koshihikari, a popular cultivar of Japonica rice in Japan, which is known for being delicious or having a good taste but easy to bend or fall over.

Dr. Tokida also talked briefly about the carbon credit scheme called J-Credit Scheme (shown on Figure 5 below) and described how the mechanisms of it are related to methane emissions reduction. Shown in a figure below the general outline of this scheme. Essentially, J-Credit promotes the reduction of greenhouse gas (GHG) emissions and removals in Japan. It enables mutual relationships between big businesses and small and midsized operators. As illustrated below, small and midsize enterprises (SMEs) earn credit when they implement activities that are friendly to the environment, which they could sell to big businesses who have excess funds and can finance other emission reduction activities, which in this case are SMEs and farmers’ groups. At present, businesses are not mandated to implement and align operations with J-Credit guidelines.

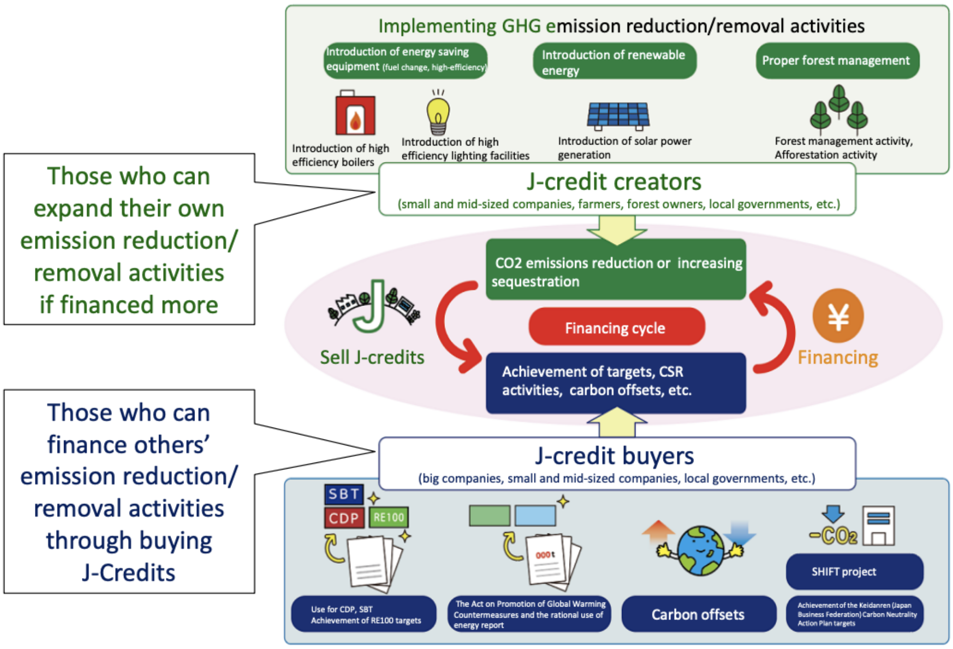


Figure 3. Mechanism of J-Credit Scheme (Source: japancredit.go.jp).

### *4. Tsukuba Agricultural Research Hall*

The agenda for visiting Tsukuba Agricultural Research Hall is part of the enrichment of the EBL team in terms of enhancing the knowledge of history and development of agriculture in Tsukuba and the whole of Japan. The Tsukuba Agricultural Research Hall is located near the NARO Headquarters in Tsukuba.

Figure 4. Agricultural Research Hall, Tsukuba.

There are several segments of the floor. First, the exhibition of the latest research focusing on the six agricultural research fields (Research of Stable Food Supply Systems, R&D to produce Added-Value Products, Useful Technologies to Stimulate New Industries, Adaptation & Mitigation to Climate Change, Various Researchers on Agriculture, Forestry and Fisheries, and Post Disaster Reconstruction). One of the research fields that the EBL team relates to is the adaptation and mitigation of climate change research. We found technology that resonates with the mid-season drainage technique, called remote-controlled water management. It uses sensors for water level and water temperature. The tools can also connect to the mobile devices for controlling the time and drainage level. The energy resource for using the tools is from the solar panel, which is renewable resources and easy to get in rice paddies area application.

Figure 5. Remote-controlled Water Management in Agricultural Research Hall.

Figure 6. NARO Technical Report Edition 5.

The exhibition segment also provides information and references about the development of precision farming or smart agriculture, especially drone monitoring by using NDVI (Normalized Difference Vegetation Index).

Furthermore, the Agricultural Research Hall provides screen information to know each segment deeply. Indirectly, we learned about the responsibility of NARO in developing agriculture in Japan through much information provided in the exhibition.

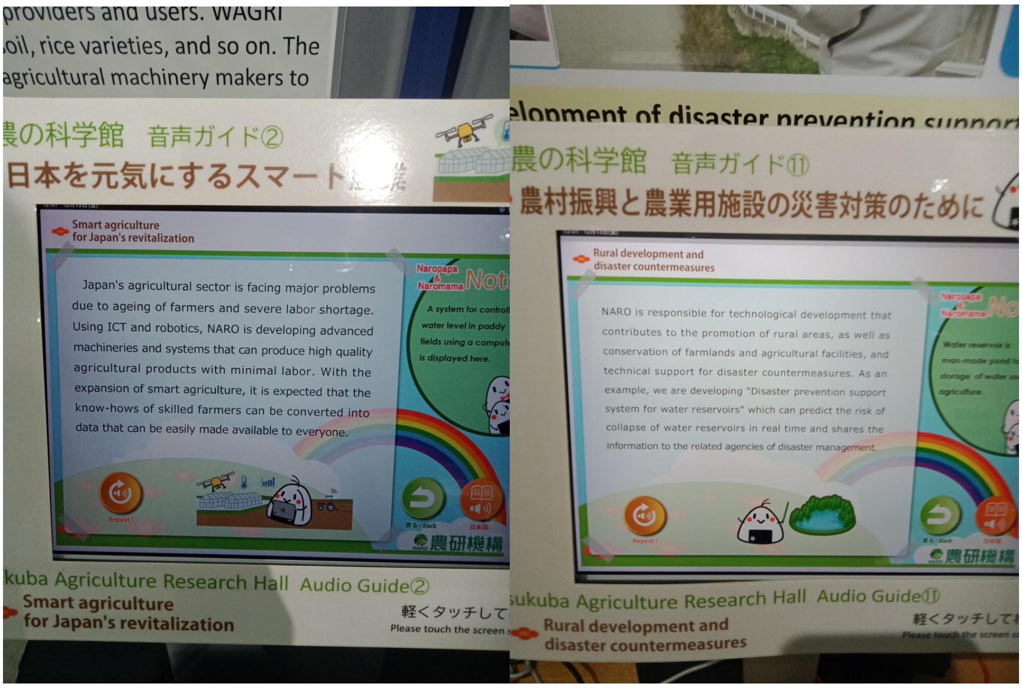

Figure 7. Information screen in Agricultural Research Hall.

### 5. *5th Anniversary Symposium of the Ibaraki University Institute for Global Change and Regional Environment*

This symposium was held at the Mito campus of Ibaraki University on 12th December. The symposium's primary objectives were to report on the research progress of various divisions within the Global and Local Environment Co-creation Institute (GLEC) and to clarify future prospects through panel discussions with representatives from different sectors.

Initially, the Climate Change Response Division of GLEC presented their research findings, including climate change analysis using satellite imagery and a virtual disaster prevention experience system utilizing downscaling techniques. Their emphasis on the importance of "social implementation" of scientific knowledge for future prospects was particularly noteworthy.

The Watershed Environment Division then introduced their research outcomes, primarily focusing on changes in fish ecosystems.

The Agriculture and Ecosystem Environment Adaptation Division reported on their five-year research under the goal of "Adaptation to Agricultural Ecosystem Changes × Leading

Environmental Conservation and Resource Recycling Technology Utilizing DX." A notable highlight was the development of technology to reduce methane emissions from paddy soil, which successfully promoted initial rice growth while reducing methane generation. The future field results of this research are eagerly anticipated. This division also outlined future prospects, including international collaborative research and partnerships with local Japanese governments, indicating promising developments ahead.

Lastly, the Human and Socioeconomic Division presented on the concept of "environmental co-creation," discussing how to adapt to changing environments and proposing initiatives to facilitate public acceptance of these adaptations.

The symposium showcased diverse approaches to global environmental research from various divisions, which was highly intriguing. While understanding some specialized topics posed challenges, the novel ideas presented were fascinating and underscored the significance of interdisciplinary research

## VI. Training Competence (*self-assessment*)

### 1. Cultural Exchange (*Communication*)

By interacting with different actors from various backgrounds, the group members were able to hear perspectives that are different from their own background. By conducting interviews, the group members were able to experience firsthand the nuances that come from having discussions with speakers of language that are different from them and therefore have different nuances in them.

### 2. Social Engagement

Through participation in interviews with researchers, government officials, and farmers, the project fosters meaningful interactions that enhance understanding of diverse perspectives on methane reduction in agriculture, especially through mid-season drainage. Engagement in symposiums and collaborative discussions further strengthens social connections and highlights the role of community-driven efforts in addressing climate crises.

### 3. Commitment to Excellence

This is one value in BXAI core values: commitment to excellence. By conducting literature reviews, arranging interviews with leading experts, and attending academic symposiums, the project demonstrates a dedication to achieving high standards in research and learning. This commitment is further reflected in the systematic approach to expanding the research network, ensuring that findings contribute meaningfully to the EBL project and future initiatives.

### 4. Research Skills

One of the competencies developed by the scholars is their research skills. Everyone was involved in the planning, questionnaire design, literature research, and other steps necessary for the field visits.

5. **Inter- and Multi-Disciplinary Practices**

It is apparent that the topic of this research activity is not within the research areas of the scholars. However, by engaging in an interdisciplinary study, the scholars were able to gain a broader and more comprehensive understanding of such as climate change and how mitigation practices such as mid-season drainage (MSD) contribute to solving global issues. The scholars developed a versatile skill that which is actually highly valued in today's complex world.

6. **Language Issue**

Two of the four members are not fluent in Japanese and language barrier indeed became one of the challenges encountered during the field research activity. The other two members acted as interpreters and bridged the community gaps during the interview process. Active listening, quick thinking, and communication skills are the major skills enhanced because of this. Dialogue between the scholars and the interviewees and among the members achieved led to a common understanding and clarification of questions and statements.

7. **Shared Leadership**

The scholars were able to create a connection with each other and learned the importance of collaboration and doing their assigned tasks and responsibilities in the success of the study. The group did not rely on a single member (leader) and everyone was empowered to provide information, suggest ideas, and lead or take on leadership functions.

## VII. Documentation

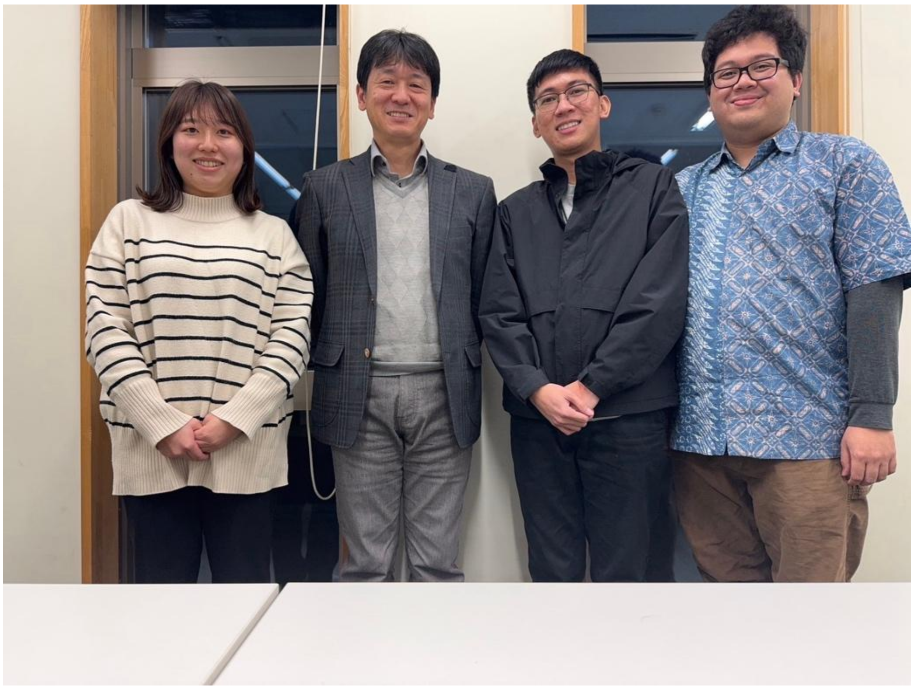

Figure 8. Team 2 members with Prof. Tomoyasu Nishizawa.

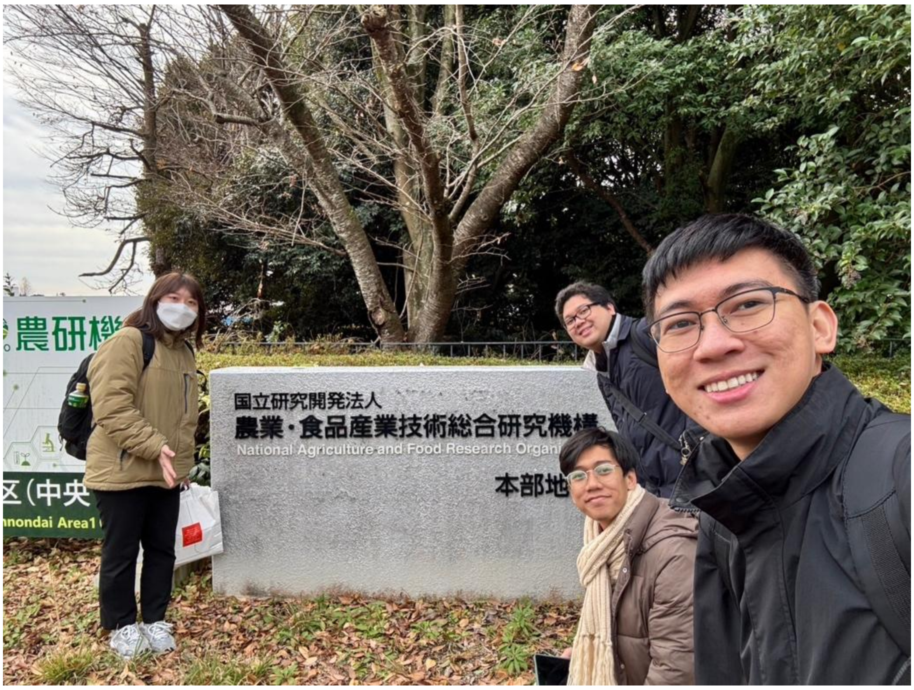


Figure 9. Team 2 members (Ayano, Hafizh, Sam, and Cezar) at NARO.

Figure 10. Interview with Dr. Takeshi Tokida.

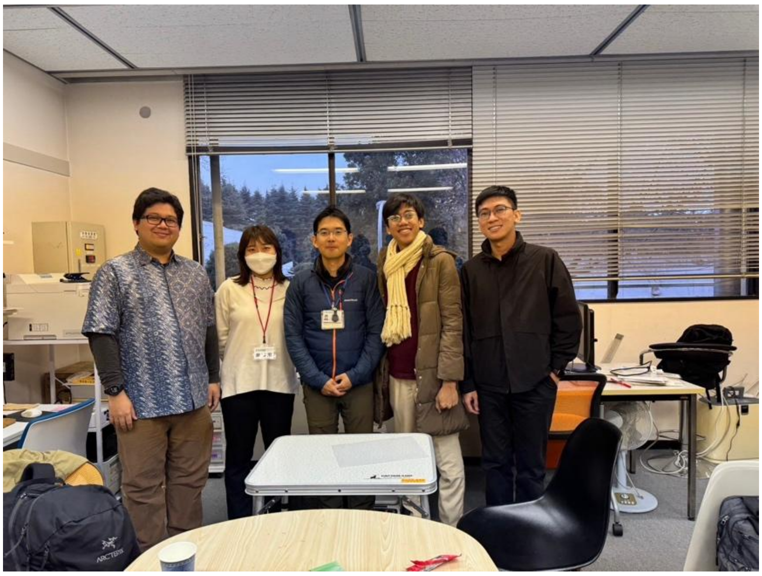

Figure 11. Team 2 members with Dr. Takeshi Tokida.

Figure 12. Dr. Tokida showing equipment and materials necessary for sample analysis.

## VIII. Conclusion

A. The research on utilizing bacteria to mitigate nitrous oxide and methane emissions while also promoting plant growth is very promising. However, scaling up the research and implementing these techniques in real-world agricultural practices requires significant resources and collaboration with various stakeholders. Moreover, concerns were raised about the potential risks of introducing new bacteria into the ecosystem, highlighting the need for thorough safety assessments.

B. The shift in participation in international conferences from scientists to businesses and finance professionals reflects the growing influence of private organizations in agricultural research funding. This trend is making international conferences more complex, as participants from diverse backgrounds bring different perspectives and priorities.

The implementation of mid-season drainage (MSD) in Japan and its adoption can be higher or more widespread when it is supported by robust infrastructure and aligned with benefits that are deemed practical by the Japanese farmers. Infrastructure, practical incentives, and the dual focus on productivity and sustainability are important in promoting and achieving widespread adoption of climate-friendly agricultural practices.

C. Overall, the team members came to realize the irreplaceable value of field research. Through face-to-face dialogue, we found that our intentions and enthusiasm were more easily conveyed, and simultaneously, we could better perceive the passion of our interviewees. Zoom interviews inevitably created a structured dynamic between the interviewer and respondent, making it challenging to achieve a genuine dialogue. In contrast, during in-person interviews, we encountered numerous instances where we could immediately pose questions during the interviewee's presentation, leading to a more profound and nuanced conversation. This advantage of immediate interaction is undoubtedly one of the significant benefits of conducting fieldwork.

D. Another substantial outcome was the opportunity to tour research laboratories. Visiting the laboratories at the National Agriculture and Food Research Organization (NARO) provided an excellent opportunity to have a deeper understanding of the research topic. This enabled the members to discover several pieces of equipment used for sample analysis and techniques we could apply to our own research. We were able to observe custom experimental equipment designed by Dr. Tokida, which was outside the scope/primary objectives of the EBL trip. Furthermore, engaging in fieldwork allowed team members to divide roles and collaborate closely, fostering deeper and stronger relationships. This field research proved to be invaluable experience for everyone.

E. Within the project, each team member played a vital role. Cezar provided coordination, ensuring the team remained focused on the broader objectives. Ayano acted as a liaison, connecting the team with expert resources and the field research schedule. With Samsul's real-world work experience, he contributed real-world insights. He was also given a chance to take on leadership functions (*i.e. overseeing the report's writing*). Hafizh addressed language barriers and provided interdisciplinary input because of his background.

## IX. References


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