

Rice Methane

Innovation Accelerator

Halving Methane Emissions from Rice

Research Strategy

2026-2040



Global
Methane
Hub

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Introduction

Decreasing methane (CH₄) emissions is the fastest way to decrease the negative impacts of greenhouse gas emissions on climate. Methane is responsible for nearly one third of the rise in global temperatures since the 19th century. Per unit of mass, methane is 84-86 times more potent than CO₂ over 20 years and 28-34 times over 100 years. Hence, methane emissions reduction is the emergency brake on global warming.

At COP26 in 2021, the Global Methane Pledge set the target to reduce anthropogenic methane emissions by at least 30% from 2020 levels by 2030, which could eliminate over 0.2°C warming by 2050. To limit global warming to below 2°C, the IPCC proposed a 45% reduction in methane emissions by 2050. The Global Methane Hub (GMH) was established in 2022 in response to the Global Methane Pledge. GMH is an effective regранter, influencer advisor and strategic convenor, addressing methane mitigation in three principal sectors: agriculture, waste, and energy.

GMH's Agriculture Program includes a significant focus on reducing methane emissions from rice cultivation because it accounts for about 8-12% of total anthropogenic methane emissions. Rice is also crucial for global food security, by some estimates supplying about 20% of global calorie consumption, and for the livelihoods of over 140M farmers globally, many of them smallholders.

Rice accounts for 8 to 12% of anthropogenic methane emissions, and provides around 20% of the world's calories.



Approach

Launched in November 2025 and guided by a Science Oversight Committee (SOC) of rice experts, GMH's Rice Methane Innovation Accelerator aims to halve rice methane emissions by 2040. This audacious but realistic goal builds on many years of work by the rice research community to reduce methane emissions through various interventions, such as water and fertilizer management, with varying degrees of success. This reflects the complex nature of rice growing systems and farming practices.

The Accelerator is pioneering a globally-coordinated public-good investment in a system-oriented, interdisciplinary research strategy aimed at catalyzing breakthrough research tackling rice methane. This initiative supports the development of holistic, integrated and practical solutions for rice methane mitigation that will be attractive for farmers to adopt, and that are viable within the diverse nature of rice production systems worldwide. This Research Strategy will evolve dynamically as science advances, taking an iterative approach to developing the best research projects. The Accelerator will add to the outputs of other research funders by being catalytic, comprehensive, and collaborative.

Catalytic in that the time from application to grant-making can be shorter than traditional funding routes due to streamlined governance chains, with the Science Oversight Committee providing the rigor of scientific review.

Comprehensive in that any discipline that complements the rice methane challenge will be explored. The Accelerator seeks to attract non-traditional disciplines to enhance research. The Accelerator has a global remit and proactively seeks to identify solutions for rice growing systems that are significant in terms of methane emissions, but have been underfunded to date.

Collaborative, through engaging philanthropic, private and public sector funding across the initial concept, through delivery of research outputs, to their practical application.

Priority

Irrigated Rice Systems

Rice is grown on about 130 million ha of land world-wide. Due to multi-cropping in tropical and sub-tropical regions (i.e. 2-3 rice harvests per year, primarily in Asia), the actual global harvested area is nearly 170 million ha per year. Asia accounts for 90% of the global rice production and about 65% of that comes from irrigated cropland.

Around the world, rice is grown in diverse environments, ranging from systems with water deficit to systems with water surplus (Fig. 1).

Annual global CH₄ emissions from rice production amount to nearly 40 million tonnes, or about 1.1 Gt CO₂ equivalent. Emissions are highest in Asia (Fig. 2; 87% of the global total), followed by Africa (about 6%), South America (3%), North America (3%) and Europe (1%). This strategy will take into account improvements continually being made in modeling that are refining emissions estimates. For now we will use the credible baseline estimate range of 0.8 - 1.1 Gt CO₂ equivalent (2020 and 2022 data respectively).

Just five Asian countries – China, India, Bangladesh, Vietnam, and Thailand – account for nearly 80% of the global CH₄ emissions from rice. In many South and Southeast Asian countries, rice also has the largest CH₄ mitigation potential compared to other sectors in the national greenhouse gas budgets. Achieving large emissions reductions while maintaining agricultural productivity growth would yield large net economic benefits, particularly in lower-income countries that are the primary producers and consumers of rice, but which also have greater vulnerability to the negative effects of climate change.



Global rice-based crop production systems can be divided into 9 types (Fig. 2). Since methane is only formed in the soil under anoxic conditions, irrigated rice systems with prolonged periods of flooding are the primary source of global rice CH₄ emissions.

Overall, the various irrigated rice systems account for about 80-85% of the global methane emissions from rice. Rainfed-lowland systems contribute another 15-20%, whereas upland rice has no significant direct contribution to methane.

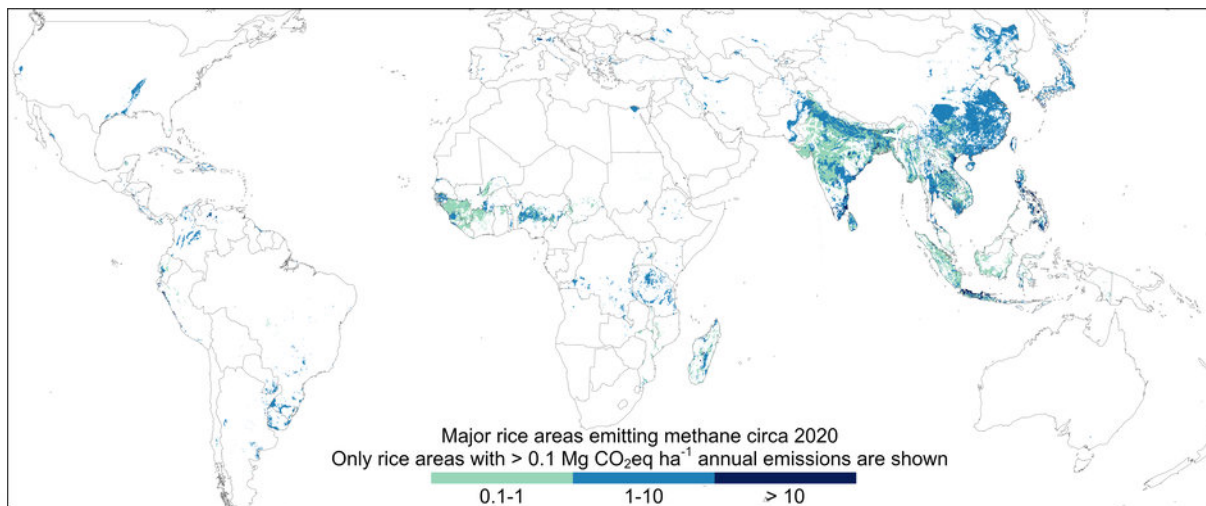


Figure 1. Annual methane emissions from rice in ca. 2020. Source: Cao et al., 2026.



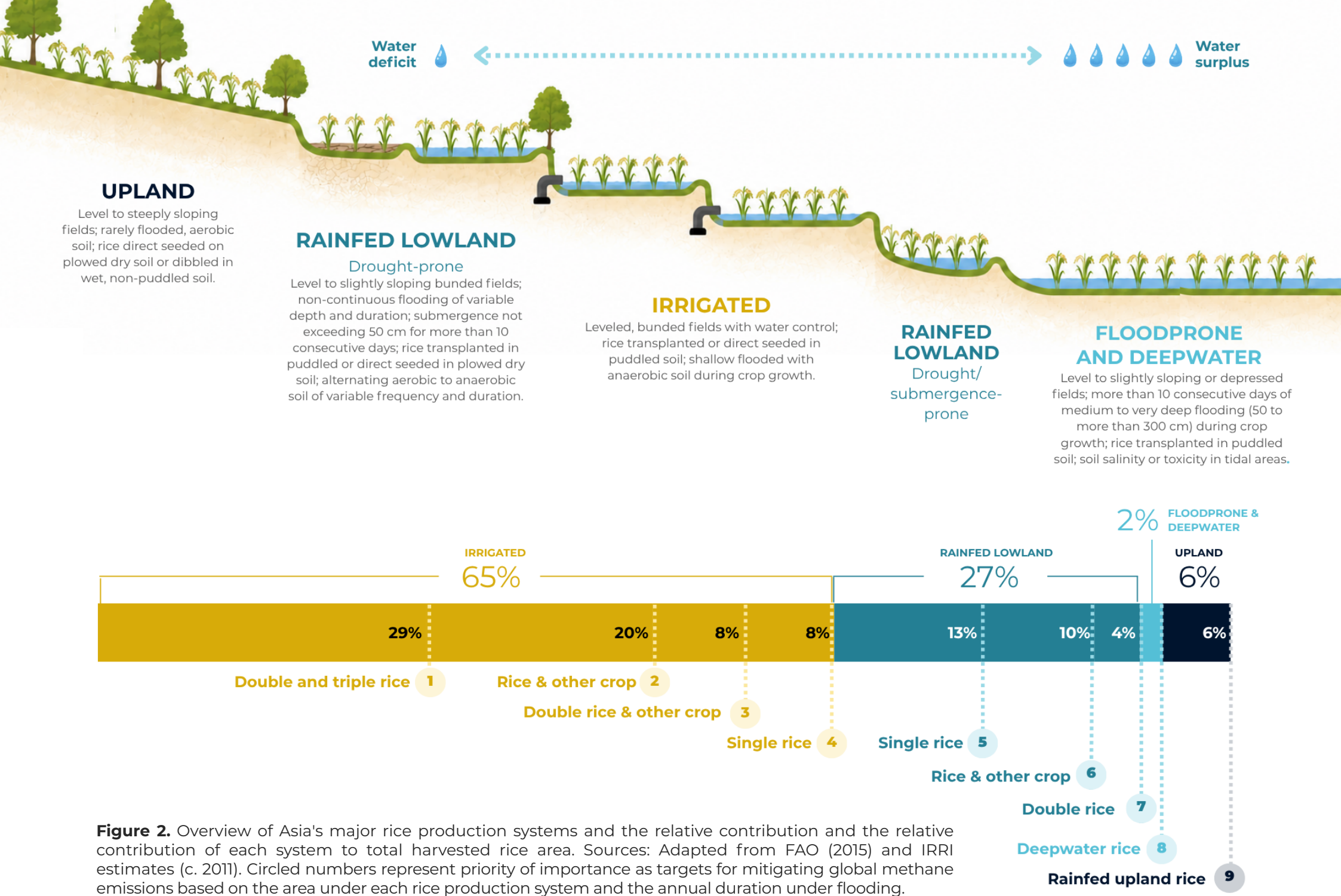


Figure 2. Overview of Asia's major rice production systems and the relative contribution and the relative contribution of each system to total harvested rice area. Sources: Adapted from FAO (2015) and IRRI estimates (c. 2011). Circled numbers represent priority of importance as targets for mitigating global methane emissions based on the area under each rice production system and the annual duration under flooding.

Methane Formation and Emission from Rice Fields

Unlike other crops, rice has the unique ability to grow and thrive in saturated, flooded soils, but this also results in emissions of CH_4 produced in the soil. This results from processes that follow basic soil thermodynamic principles but require microorganisms as catalysts. When soil is flooded, it becomes oxygen (O_2) depleted, changing the soil's redox potential. The latter is a simple measure of a soil's ability to oxidize or reduce substances chemically.

Oxygen diffusion through the soil is cut off when it is flooded, causing a shift from the microbial populations that decompose soil organic matter to those that can use electron acceptors other than O_2 . First, nitrate is microbially reduced, followed by manganese, iron, and sulfate compounds. Although there is some overlap in this, as a final step in this sequence, CH_4 is produced by methanogenic bacteria.

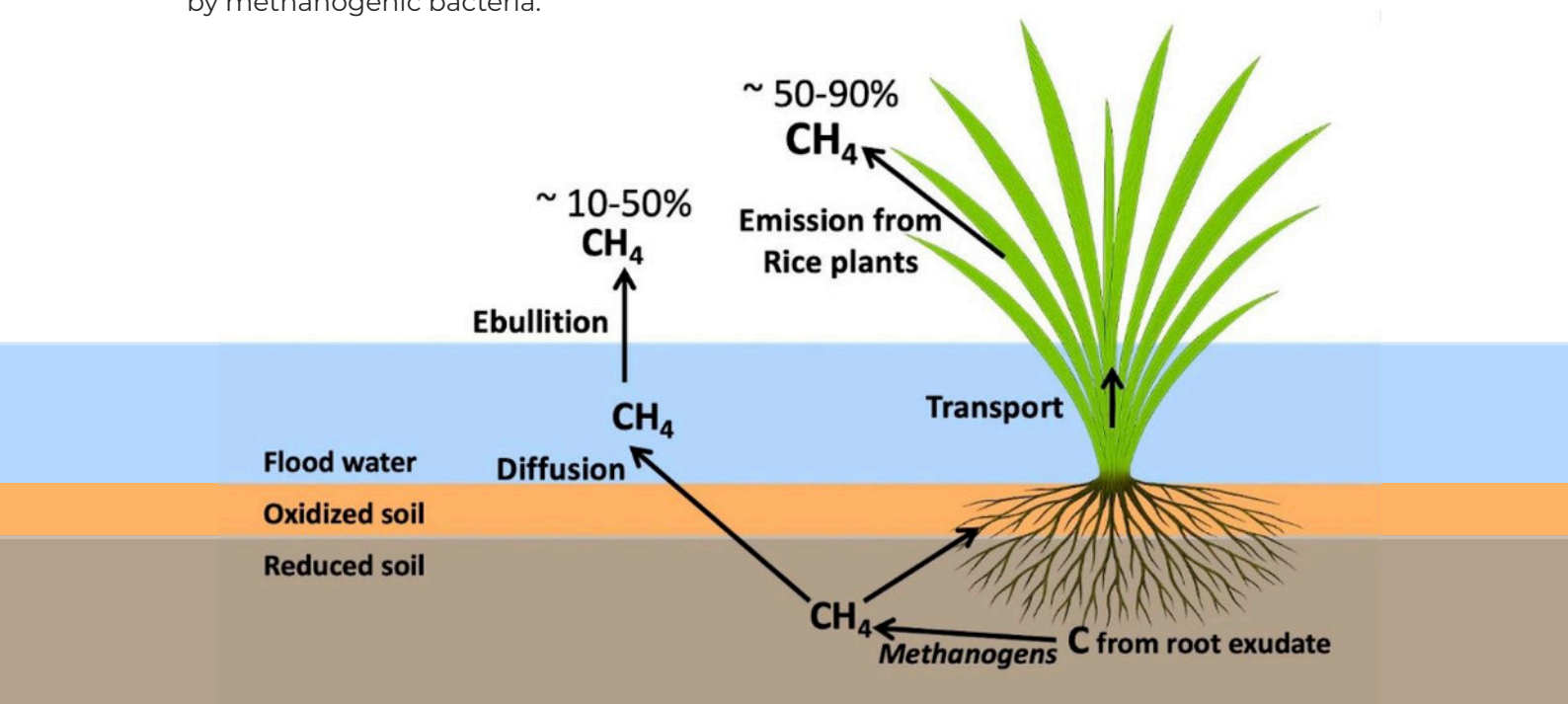


Figure 3. Methane from flooded rice fields is emitted primarily through the plant and by ebullition. The percentages shown are ranges from multiple studies, across different field conditions.

In drained (aerated) soil, the porous spaces are gas-filled and contain molecular O_2 , as well as carbon dioxide (CO_2) and nitrous oxide (N_2O) produced as by-products of respiration, nitrification and denitrification in the soil. These gases can easily diffuse from the soil to the atmosphere through gas-filled soil pores (Fig. 3). In flooded soils, however, the pores are filled with water, impeding molecular diffusion of gaseous compounds. CO_2 produced during respiration by roots or microorganism as well as CH_4 produced by methanogenic bacteria accumulate to high concentrations due to the slow diffusion. These gases are then primarily vented to the atmosphere through plant-mediated diffusion or, to a lesser extent, via ebullition (Fig. 3).

To grow in flooded soils, rice develops aerenchyma spaces in roots, internodes, and leaf blades. This forms a low-resistance pathway for the diffusion of O_2 from the atmosphere down to the flooded soil to maintain a thin, aerated layer around the roots, but in the same manner, CH_4 and CO_2 (also some N_2O) move in the opposite direction, from the rhizosphere to the atmosphere. In a fully developed plant canopy, the aerenchyma serves as the conduit through which up to 90% of the CH_4 formed in the soil escapes to the air. For a more detailed discussion, refer to the background brief on this topic.



Indicators of Success

Mitigating methane emissions from rice requires integrated solutions, i.e. a combination of technologies and practices that act synergistically and are optimized based on seasonal CH₄ emission patterns. Since irrigated rice cropping systems account for the bulk of global methane emissions from rice, they are the primary priority for mitigation action. Key indicators for a successful and sustainable change in irrigated rice systems may include a combination of the following:

Primary Accelerator Objectives:

Low CH₄ emissions per ha. Average rates of much less than 1 kg CH₄ per ha per day summed up over the growing season may provide a general target to aim for (e.g. a rice crop with <100-150 kg CH₄ per ha). More specific annual emission targets should be set for different rice cropping systems to account for differences in cropping intensity.

Low CH₄ emissions intensity per unit of rice produced. Methane intensity – CH₄ emissions per tonne of rice produced – is another measure for assessing methane-reduction options without compromising food security. Specific targets may vary, but an average emission intensity of <30 kg CH₄ per tonnes of rice produced may provide a good initial target, though this depends on the specific system and environment, including the attainable yield potential. CH₄ emissions intensity will be lower in high-yielding environments than in low-yielding environments.



Other Desirable Outcomes

Solutions for mitigating CH₄ emissions must be designed and implemented in a manner that avoids or minimizes potential negative trade-offs, particularly related to food security, soil and plant health, emissions of CO₂ and N₂O, natural resources management, and farm profitability. Hence, other critical outcomes to consider are:

No significant increase in N₂O emissions compared to the baseline before intervention, as N₂O has a global warming potential higher than that of CH₄ and a longer atmospheric lifetime. For example, changing water management to more aerated conditions or shifting from rice to other non-flooded crops may reduce CH₄ emissions, but may also increase N₂O emissions. Ideally, the N₂O increase would be minimal and the net global warming effect of such changes should still be negative.

No significant depletion of soil organic carbon compared to the baseline before intervention. Changing water management to more aerated conditions or shifting from rice to other, non-flooded crops may cause a loss of soil organic matter, which should be avoided or minimized through appropriate management practices, such as reduced tillage and application of organic matter.

A successful transition delivers both low methane emissions per hectare and low methane emissions per tonne of rice produced.



Maintain crop yield growth at average rates that ensure the necessary global supply of rice. On a global average basis, yield growth rates of >50 kg per ha per year need to be sustained to produce enough rice for a growing world population.

No greater difficulty in managing soil and plant health constraints compared to the baseline before intervention. This criterion often receives insufficient attention. Significant changes in rice systems management may lead to increased weed problems, micronutrient deficiencies, changes in soil microbes, or a greater incidence of diseases or insect pests.

High recovery efficiency of applied nitrogen fertilizer. Currently, the average recovery efficiency of N applied to rice is around 43%. Increasing it would allow for reductions in fertilizer application rates and environment losses, with direct and indirect benefits for profitability, greenhouse gas budgets, and environmental services.

Reduced total water footprint compared to the baseline before intervention. The total water footprint includes rainfall and irrigation. Although values of 3000-5000 L per kg rice are often cited, it has also been demonstrated that levels of just 1000 L per kg rice can be achieved. Specific targets for that may vary, depending on soil type, irrigation method, environment, and other factors. This criterion is particularly important in regions where water is becoming scarcer or less predictable.

*Long-term impact
depends on solutions
that work for farmers
as well as the climate.*



Although it is unlikely that these objectives can all be met in all systems, they provide general guidance on what to aim for. Specific emissions reduction targets need to be tailored to the different rice-based cropping systems and environments because they vary due to differences in climate (growth duration and yield potential), cropping intensity (number of flooded days), and management factors such as variety, organic matter inputs, water or fertilizer management. Critically, successful management changes must increase farmers' economic returns by reducing costs or increasing their income from production otherwise wider adoption cannot be achieved. For a more detailed discussion, refer to the background brief on this topic.



Research Areas

The available evidence suggests that individual agronomic practice changes such as intermittent irrigation, mid-season drainage, fertilizer management, biochar application, or straw removal may reduce CH₄ emissions by 15 to 50%, depending on the specific circumstances. More recently, research has expanded to explore crop genetic traits and to better understand the plant-soil-microbiome interactions that result in CH₄ emissions and which are affected by cultural management practices. Previous scaling efforts have mostly focused on a single or a few combined agronomic interventions, particularly water management, but few have taken a system-oriented, interdisciplinary approach to overcome the lack of coordination between different research disciplines.

The Accelerator will direct funding towards the five key research areas below in an integrated manner. The Science Oversight Committee selected these areas after a thorough assessment of the state of science in rice methane mitigation and meetings with experts in the field to identify critical knowledge gaps. The research areas represent a range of technology readiness levels (TRLs), different modes of deployment, and are applicable in different rice production systems. Mitigation mechanisms will be tailored for different systems, and so a range of solutions will be important to ensure widespread on-farm applicability. The research areas also require investments in four critical cross-cutting research capabilities, to ensure that synergies are built across the individual technologies developed, to facilitate effective and sustainable methane reduction.

The Accelerator seeks to fund research to advance potential methane mitigation solutions that are balanced across a range of development stages. The Accelerator will use TRLs to assess the current and evolving developmental stages, monitor progress and direct support. The TRL classification system is outlined in Figure 4.

For each research area, a brief synopsis of the state of science, current priority research questions, and outputs that the Accelerator aims to support in the short-term, by 2030, and medium-term, by 2040, are provided. Further information can be found under Additional Resources.

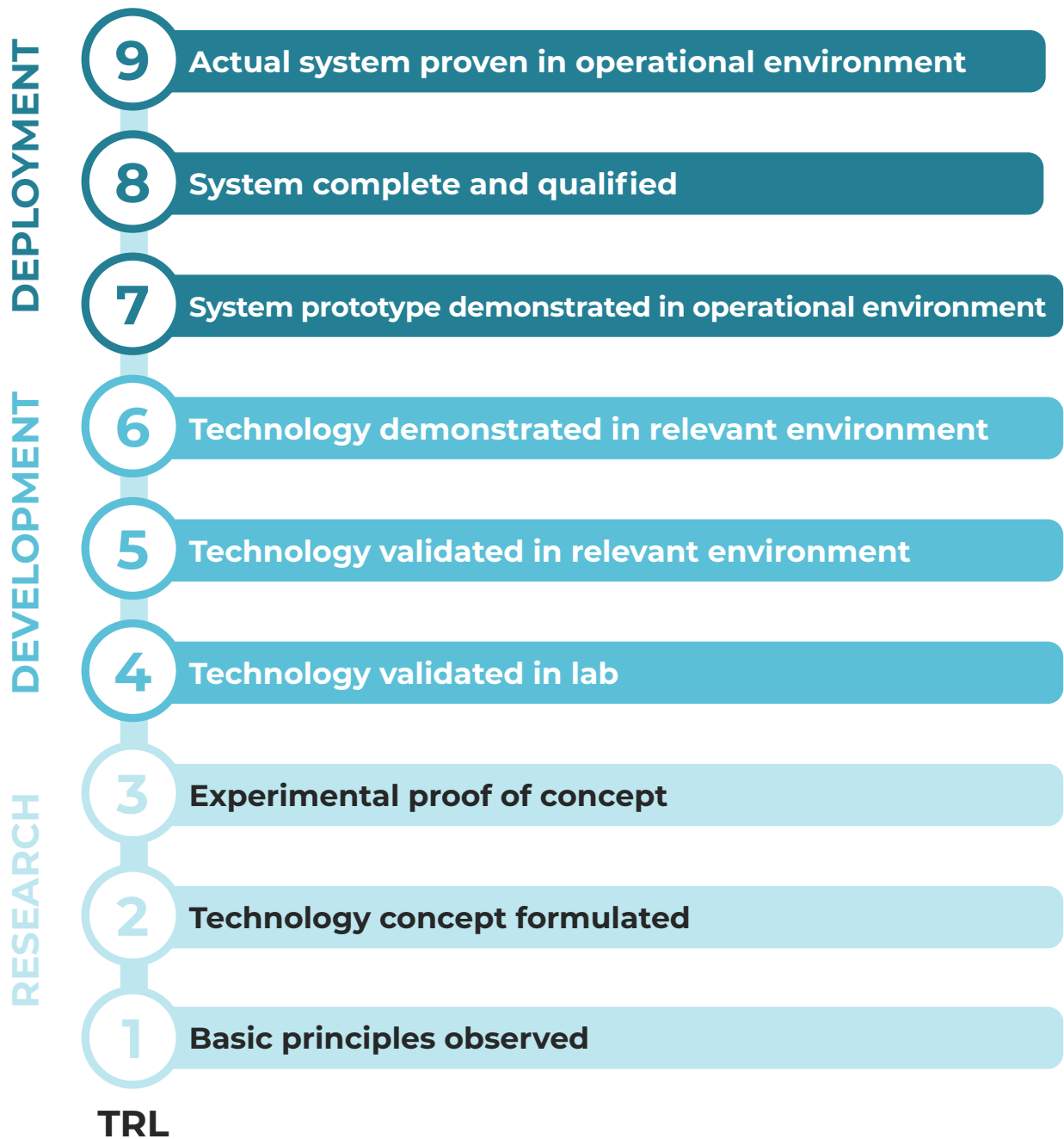
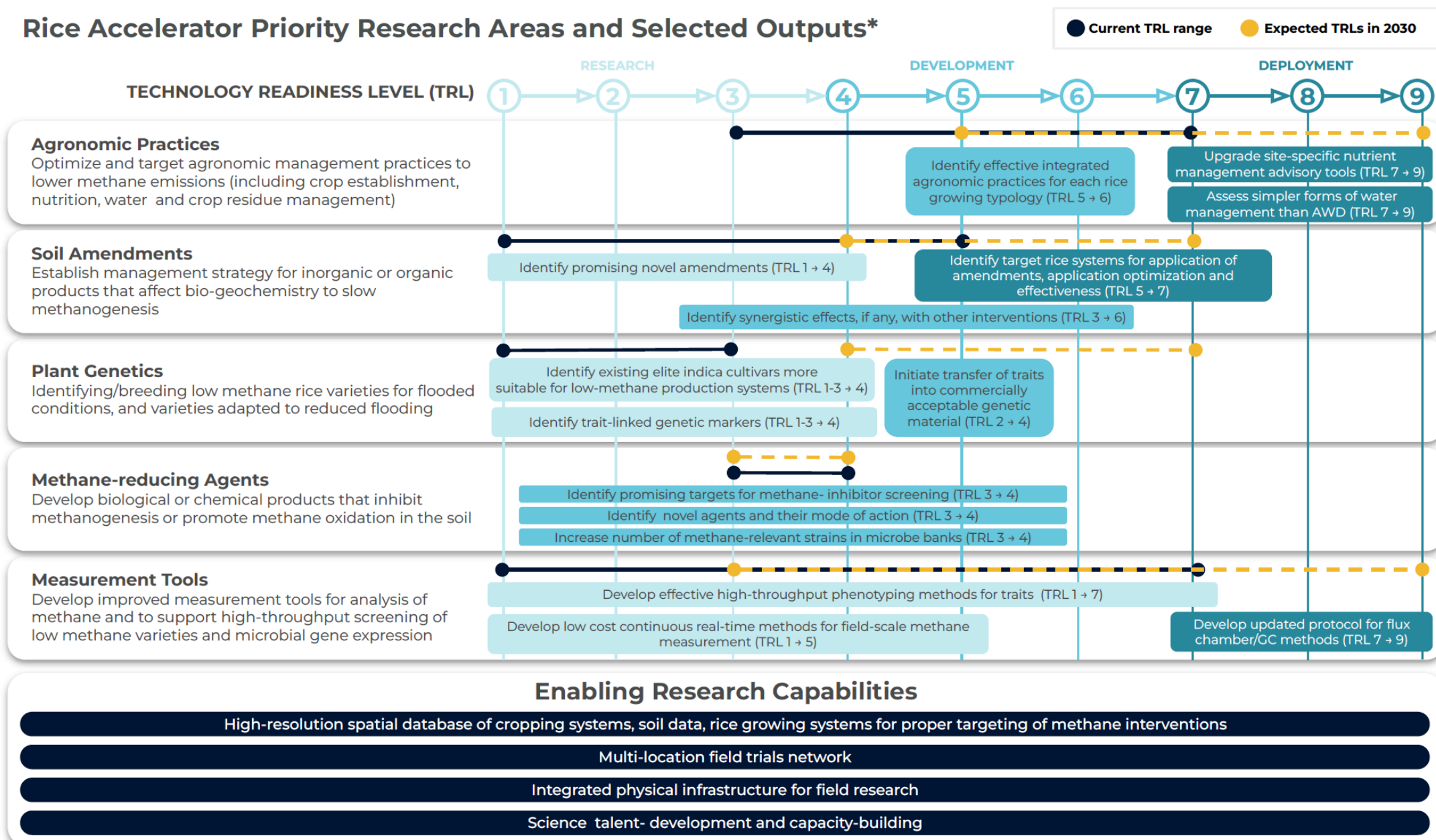


Figure 4. Technology readiness level (TRL) classification system (adapted from ISO 16290:2013)

Rice Accelerator Priority Research Areas and Selected Outputs*



* Selected outputs, comprehensive list in Research Strategy

Figure 5. Overview of priority research areas and their ranges of current TRLs (navy circles) and expected TRLs by 2030 (yellow circles), as a result of strategy implementation.

Agronomic Practices

A whole suite of agronomic practices need to be changed in an integrated manner to reduce methane emissions, while achieving high system productivity, resource efficiency, and sustaining or improving soil health, and other ecosystem services provided by rice. Ideally, such practices should act synergistically, which requires optimizing them to be location-specific.

The largest mitigation potential is generally achieved by changing continuous flooding to intermittent irrigation during key growth stages; a technique widely known as alternate wetting and drying (AWD). Proper applications of AWD have been reported to reduce 30-70% of methane emissions. Scaling farmer adoption, however, has proven challenging due to complex, interacting biophysical processes, how they affect agronomic management, as well as socioeconomic and/or cultural constraints.

Transforming an existing irrigated rice system to emit less methane, while remaining equally productive and resilient is not just a matter of changing water management, but also involves interconnected changes in land preparation, rice varieties, crop establishment, soil and nutrient management, crop protection and crop residue management. The research community needs to develop an understanding of these complex interactions in order to design, evaluate and disseminate effective, site-specific solutions that can be integrated into decision support tools (e.g. AI) for farmers and other value chain actors. Besides developing tools for better local targeting and decision-making capability, there is still a need to fine-tune the evaluation of the methane mitigation potential of specific practices, particularly fertilizer and crop residue management, in current cropping systems.



Priority Research Questions

What site-specific nutrient management strategies sustainably and effectively optimize methane mitigation?

Are there cropping practices not currently associated with methane mitigation that can lead to significant reductions in methane emissions?

Can non-flooded/aerobic rice be integrated into existing low-land irrigated systems, while still maintaining yields?

What practical, site-specific rice straw management practices that mitigate methane emissions can be developed for growers?

What are the criteria for water management to reduce methane emissions, that would result in a simpler form of AWD, for sites where AWD is not feasible?

Anticipated Research Outputs

By 2030

Quantify and map assessment of the reduction in methane associated with substituting dry-season lowland flooded rice with aerobic/non-flooded rice (TRL 3 → 5)

Quantify methane mitigation potential of alternative cropping practices (TRL 4 → 6)

Identify effective packages of integrated agronomic practices for each rice growing typology (TRL 5 → 6)

Develop locally adapted guidelines for crop residue management (TRL 5 → 7)

Upgrade site-specific nutrient management advisory tools for methane-reduction relevant practices (TRL 7 → 9)

Assess methane reduction resulting from simpler forms of water management than AWD (e.g. a single drainage event) in areas where AWD is not feasible (TRL 7 → 9)

By 2040

Demonstrate long-term impact of site-specific nutrient management practices on methane mitigation

Demonstrate feasible aerobic/non-flooded-flooded rice system at the field-level

Validate packages of agronomic practices that optimize yields for dry direct seeded rice and aerobic rice in target regions

Soil Amendments

Some specific bulk amendments for field soils have been found to have the side-benefit of methane mitigation, mostly by altering soil redox conditions. For example, gypsum (including phosphogypsum, a fertilizer byproduct), biochar, lime and basaltic rock dust have been reported to reduce methane emissions from rice paddies, whereas rice straw addition has the opposite effect of increasing methane emissions. The challenge is to combine application of these methane-reducing soil amendments with established cultivation practices, and to make them economical, practical and safe for farmers. Phosphogypsum, for example, has low but detectable radioactivity and may also contain other contaminants that may restrict its use. Biochar conductivity can vary widely depending on the source and manufacturing process, which can influence its effect on methane emissions. As with microbial inoculants (see below), it is important to ensure that the frequent use of such soil amendments does not result in long-term negative consequences to soil health, the ecology of cultivated fields, or humans. Focused research is needed to design science-based, location-specific strategies for integrating soil amendments in methane mitigation solutions that are feasible on a larger scale.



Priority Research Questions

Are there novel, cost-effective amendments that are effective at mitigating methane at scale?

What are the target rice systems and methods of application for soil amendments with demonstrated methane mitigation effects?

How can farmers incorporate soil amendments into integrated strategies for methane mitigation?

Anticipated Research Outputs

By 2030

Identify promising novel amendments (TRL 1 → 4)

Identify synergistic effects with other interventions, if any (TRL 3 → 6)

Identify target rice systems for application of amendments, application optimization and effectiveness (TRL 5 → 7)

By 2040

Optimal application protocols for existing and novel soil amendments are developed through field research

Proven soil amendments are being widely used by rice farmers as part of an integrated management strategy for methane mitigation

Plant Genetics

Crop genetics and breeding are important components of integrated strategies to reduce methane emissions from rice cultivation. Numerous studies have reported significant variation in methane fluxes among rice varieties. However, no systematic, large-scale evaluation of varieties and their associated methane emissions has been performed. Evaluation so far has been limited to a few genotypes and environments.

Furthermore, methane emissions are controlled by complex interactions of the plant with soil characteristics and soil microbial communities, making genetic selection particularly challenging. Breeding is considered a long-term project, developing a new variety takes 5-10 years even with newer approaches like speed breeding and genomic technologies. The development of high-throughput phenotyping methods and reliable genetic- and/or other bio-markers for methane-related traits would represent a major advance for rice breeding. Using transgenic technology to produce genetically modified organisms (GMOs) shows promise in reducing methane emissions, but there are market acceptance issues in many countries, which limit the use of GMOs beyond research purposes.

Plant genetics can help unlock lower methane emissions without compromising yield or grain quality.



Several crop traits that are known to affect the production and release of methane into the atmosphere have been shown to be promising breeding targets. Redirection of carbohydrates from roots to the developing grain has been shown to improve grain productivity while reducing root exudates that support the growth of methanogens. Genetic variation in regulatory genes associated with plant carbohydrate metabolism can dramatically alter allocation patterns and lower methanogen populations. Genes associated with the structure of the root system have also been found to decrease methane emissions through a reduction in exudates and by an increase in oxygenation of the rhizosphere through deep rooting. However, incorporating traits like these into varieties must be done in a way that does not impair other critical traits that would impact adoption by growers (i.e. grain yield) or consumer acceptance (i.e. grain quality).

Another breeding approach includes developing varieties that are better suited to cropping systems that have lower methane emissions. This may include systems that use direct seeded rice, shorter irrigation periods, changes in timing or types of nutrient amendments, a shorter cropping season, ratoon cropping, different rotation crops, or greater tolerance to fluctuations in soil moisture. All of these may require development of new varieties for optimization of production while minimizing methane emissions.



Priority Research Questions

Which genes have significant effects on lowering methane emissions in flooded rice varieties without negative effects on plant performance?

What traits are required for rice varieties to thrive in non-flooded conditions, including dry direct-seeded rice and aerobic rice?

What low methane traits can be transferred into local rice varieties without penalties in grain productivity and quality?

Are there existing elite indica cultivars that are well adapted to innovative cropping systems that reduce methane emissions?

What are the key physiological and phenotypic features of low methane, high-yielding rice ideotypes?

Anticipated Research Outputs

By 2030

Identify existing elite indica cultivars more suitable for low-methane production systems e.g. AWD, other forms of intermittent irrigation, direct seeding, ratoon cropping, or aerobic production (TRL 1-3 → 4)

"Identify trait-linked genetic markers that reduce methane emissions in flooded soils (TRL 1-3 → 4)

Initiate transfer of traits for low methane production or adaptation to low methane production systems, into commercially acceptable genetic material (TRL 2 → 4)

Establish global phenotypic and genotypic database associated with low methane production, for public good (TRL 2 → 7)

By 2040

Low methane traits mainstreamed into breeding pipelines in Asia and other regions

First generation of low methane, high-yielding rice varieties have been released for farmers' use

Plant-microbe mechanisms of action associated with low methane production have been identified for different cropping systems, leading to acceleration of genetic gain

Methane-reducing Agents

All methane emissions from rice cultivation are produced from methanogenic archaea, a type of soil microbe. Archaea produce methane from carbon compounds that are generated by fermentation of root exudates by a variety of soil bacteria. Methanotrophs are another type of soil bacteria that oxidize methane and thereby reduce emissions. Interventions that suppress the former, or promote the latter, or both, can be effective for reducing methane emissions. These interventions could involve the addition of inoculants that are microbial or chemical, or through soil amendments.

The application of defined microbial strains for reducing methane emissions has been explored in many different studies over the past two decades. Promising results have been reported using different strains and species of methanotrophic bacteria, as well as other specialized bacteria e.g. cable bacteria. Microbial inoculants are relatively simple to implement, especially if delivered with the rice seeds or applied at the beginning of the season, making them an attractive option for lowering methane emissions. However, it is important that microbial taxa persist and can establish themselves in field soils of the specific rice growing regions, and exert their mitigating effects throughout the plant life cycle. More research is needed to determine the effectiveness and versatility of previously identified microbial inoculants, and to identify new ones. The vast diversity of microbial taxa in the soil is a rich resource for the identification of novel microbial inoculants, perhaps as microbial consortia that can be established as effective long-term solutions for methane mitigation.



As an alternative to microbial inoculants, recent studies have identified chemical agents that can reduce methane emissions, such as oxantel and ethanol. These chemical agents are thought to act by suppression of naturally occurring chemical processes that produce compounds used by methanogenic archaea, or by promoting the growth of methane oxidizing bacteria. Chemical agents have the advantage that they do not need to compete with existing soil bacteria, and would also be simpler to ship and store. However, chemical additives should not have unintended consequences on the root microbiome that are deleterious for plant performance. In addition, for simplicity and adaptability by farmers, the compounds or their effects should persist throughout the growing season under fluctuating environmental conditions without requiring multiple calibrated applications.

For translation to cultivation by rice growers, it will be important to demonstrate that field application of either microbial or chemical agents on a large scale does not result in long term negative effects on soil health, growth of pathogens, or biodiversity. Further research in this area can identify and characterize promising microbial and chemical agents that are safe and effective under field conditions, as well as practical to deploy and scale, leading to significant impacts on global emissions especially if integrated with other interventions.

The soil microbiome represents one of the greatest untapped opportunities for reducing methane emissions from rice.



Priority Research Questions

Are methanotrophs effective at mitigating methane emissions in rice fields over the growing season?

Can the soil microbiome be manipulated through a chemical or biological agent in a way that inhibits methanogenesis throughout the growing season?

Can combining such agents with other interventions result in synergistic effects on methane reduction?

What are the optimal application strategies for methane-inhibitors and methanotrophs in the targeted rice cropping systems?

Anticipated Research Outputs

By 2030

Identify promising targets for methane-inhibitor screening (TRL 3 → 4)

Identify novel agents that inhibit methane production and their mode of action (TRL 3 → 4)

Identify broader range of methanotrophs that reduce methane emissions (TRL 3 → 4)

Increase number of methane-relevant strains deposited in microbe banks (TRL 3 → 4)

By 2040

Prove effectiveness in field conditions of novel methane-reducing agents, without short-term or long-term detrimental effects

Establish effectiveness and persistence of methanotroph applications throughout the growing season under field conditions

Determine synergistic effects of applying both methanogenesis inhibitors and methanotrophs under field conditions

Determine optimal formulation and long-term management strategies in different rice cropping systems to ensure long-term beneficial effects



Measurement Tools

Methane emissions from rice paddies are most commonly measured using the closed chamber - gas chromatograph method. This method involves positioning a chamber over a secured base enclosing rice plants in the field. Air samples inside the chamber are collected at specific intervals to track changes in methane levels and are brought to the laboratory for methane analysis using a gas chromatograph (GC). These concentration measurements serve as the basis for calculating seasonal gas fluxes. The closed-chamber GC method, while providing accurate results when proper protocols are adhered to, is limited by its labor intensiveness and the challenges associated with deployment at scale.

An improvement to the closed-chamber method for on-site methane measurements uses portable laser or infrared devices, in addition to the GC. The analyzer records methane concentrations every second and calculates the methane flux, eliminating the need for periodic gas collection and laboratory analyses. In some cases however, data corrections for water vapor or temperature interferences are needed. These are expensive but provide continuous, real-time methane measurements.

The eddy covariance (EC) system is a standard micrometeorological tool for directly measuring CO₂, CH₄, water vapor, and heat fluxes over areas of at least 4 hectares (100 meter radius). It provides comprehensive flux measurements throughout the cropping cycle, capturing diurnal and seasonal variability influenced by agricultural practices. However, these complex systems have high maintenance costs and work best only in flat, uniform areas.

Remote sensing methods including satellites, drones, or cameras to observe field conditions linked to methane, like flooding and vegetation across wide areas, are also used in some cases. However, ground measurements are needed for calibration and verification. Overall, each method balances trade-offs between accuracy, cost, field coverage, and ease of use.

Progress depends on measuring methane faster, cheaper, and at a much greater scale.

To advance rice methane research, emissions reporting, and mitigation strategy development, measurement techniques must move beyond high-cost manual, periodic sampling, toward integrated, low-cost, high-throughput, and real-time methodologies.

Additionally, high-throughput screening systems for crop genetic analysis and soil microbial discovery can efficiently evaluate hundreds of genotypes and microbiomes to identify candidates for testing under field conditions.

High-throughput screening (HTS) of plant traits provides a practical strategy for identifying rice varieties with low methane emission potential that can be combined with low-cost methane sensors for field-based phenotyping. Affordable sensor systems can increase the frequency and spatial coverage of methane measurements across large breeding populations, reducing reliance on labor-intensive and costly conventional gas sampling methods. When paired with phenotyping for yield, plant growth, root traits, biomass, and stress tolerance, these methane measurements allow researchers to identify rice genotypes that produce lower emissions while maintaining strong agronomic performance. This integrated approach makes low-emission trait screening more accessible, scalable, and suitable for breeding programs aimed at developing climate-smart rice varieties that support greenhouse gas mitigation and food security.

High-throughput microbial gene-expression screening is an emerging approach for studying functional microbial activity in rice soils by analyzing genes involved in key biogeochemical processes. Advances in metatranscriptomics, high-throughput qPCR, and sequencing now allow researchers to identify active methanogenic and methanotrophic microorganisms and assess their responses to water management, soil conditions, and crop growth stages. Although these tools have improved understanding of methane production and oxidation in flooded rice paddies, most studies remain small-scale or limited to single time points. Integrating gene-expression screening with continuous environmental monitoring and field-scale phenotyping could reveal microbial biomarkers linked to low methane emissions and guide effective methane mitigation strategies for climate-smart rice production.



Priority Research Questions

What standardized procedures are needed to ensure the correct use of existing methane measurement tools for different growing systems?

What new measurement devices can be developed and implemented for rapid, low-cost, real-time and continuous methane flux measurements at lab and field-scales?

What high throughput screening approaches can effectively be used to identify rice varieties and soil microbe variants that contribute to methane mitigation?

What does real-time monitoring reveal about key biophysical processes relevant to methane generation?

Anticipated Research Outputs

By 2030

Develop updated protocol for flux chamber/GC methods (TRL 7 → 9)

Develop new protocols for laser-based methods (TRL 4 → 6)

Develop effective high throughput phenotyping methods for traits that result in reduced methane emissions in rice production and can be used to reduce development time of new cultivars (TRL 1 → 7)

Develop high throughput screening systems for microbial gene expression (TRL 3 → 7)

Develop low cost continuous real-time methods for field-scale methane measurement (TRL 1 → 5)

Explore the potential of biosensors to monitor methane produced (TRL 1 → 3)

By 2040

Next generation of 2030 outputs as detailed previously

High throughput screening methods and tools developed

Enabling Research Capabilities

Implementing the proposed strategy requires support for several cross-cutting science capabilities that will enable better targeting of mitigation solutions, accelerate scientific discovery and solution development, and ensure longer-term impact. As building these capabilities could be highly capital-intensive, Accelerator funding will be used in a catalytic manner, leveraging partnerships and other sources of funding, including capital investments.

High-resolution spatial database of cropping systems, soil maps, and typologies for proper targeting of methane interventions

Currently available spatial information on soils, hydrology, rice systems and agronomic management practices is inconsistent, outdated, and often also not shared widely beyond institutional or national boundaries. This makes it difficult to properly target specific mitigation interventions and track their implementation and impact. Rapid improvements in remote sensing, spatial modeling and artificial intelligence now enable better characterization of rice-growing areas at unprecedented levels of spatial and temporal resolution.

The Accelerator will spearhead the development of a high-resolution spatial database of rice systems in Asia that integrates the available data and utilizes new information and methods to generate and regularly update thematic maps of key variables required for methane mitigation work and other purposes. Examples of that include a new high-resolution map of rice-based cropping systems, a high-resolution map (ca. 30 meter) of soil properties related to methane, and maps showing the suitability and impact potential for specific mitigation practices (e.g. potential for AWD, aerobic rice, etc.). This information will be made publicly available. The new data products and methodologies will also be applicable for monitoring and verification of methane mitigation measures.

Integrated physical infrastructure for field research

System change requires integrated solutions that are based on discovery, field testing and fine-tuning of existing and novel innovations. The Accelerator aims to help catalyze longer-term support (ca. 10 years) for developing 2-3 fit-for-purpose research ‘Super Sites’ in relevant rice growing areas of South, Southeast and East Asia, that complement existing infrastructure. These facilities will support research in all of the areas articulated above and they will also be used to generate high-quality emissions data that can be used to validate and improve specific technologies and models under near real-world farming conditions with state-of-the-art scientific instrumentation and data management.

The ‘Super Sites’ will operate as open access global methane research capabilities, accessible to any researchers who work on discovery, strategic or adaptive research solutions. They will follow FAIR open-access data principles and also allow for wide germplasm sharing following established international guidelines. They will attract scientists from universities, research institutes and the private sector, and will also serve as pioneering education and training facilities for next generation researchers using integrated agronomic systems.

Multi-location field trials network

Whereas the proposed ‘Super Sites’ primarily support early-stage research at a few locations, wider evaluation of promising innovations is needed under different soil, climatic and cropping systems. The Accelerator aims to catalyze support for that through partnerships with national programs and other organizations, taking advantage of existing networks, such as multi-location field trial networks of rice breeding programs or the CGIAR.

Researchers working on mitigation options for methane will thus have access to a larger number of sites and resources for conducting multi-location, single or multiple season field trials for agronomic and farmer-suitability evaluation. Common scientific protocols, peer-reviewed data and results for scientific rigor, and sharing of technologies through material transfer agreements will ensure high quality results, transparency, and scientific impact. Although the geographical focus is on Asia, the network may also include field trial locations in other regions.

Science talent development and capacity-building

Science and innovation rely on attracting and developing new talent. The Accelerator will support a dynamic, open-innovation model that turns scientific insight into climate impact. Research ideas need to be nurtured early, and innovation must be integrated throughout the research process. Promising concepts must be tested quickly in collaboration with partners, moving from lab work to field trials and commercial application. This does not happen without creating the right culture and enabling environment.

With support leveraged from other funders, we aim to create an environment that provides support for researchers to spot innovation early, incubate ideas, work with entrepreneurial mentors, and engage in translational work. The Accelerator will explore various approaches for that, ranging from 'ideas labs' to training and mentoring of young researchers in innovation thinking and entrepreneurship.



Next Steps

This strategy is not static, but a dynamic, living document. Regular, invitation-only, cross-disciplinary meetings of grantees and other relevant experts will be held to ensure that relevant research outputs are being factored into ongoing updates of the strategy. This will ensure that the Accelerator remains holistic, as developments in one research area can inform work in others, allowing priority research questions to evolve in real-time, while also helping to direct funding and fundraising.

The Accelerator has been designed to avoid many of the barriers of existing funding mechanisms. Research teams can be globally inclusive and engage multiple disciplines in solving the rice methane challenge. This will be a dynamic program evolving in response to scientific findings under the guidance of the Science Oversight Committee and through co-design with scientists and engagement with the public and private sectors. The Accelerator's Research Strategy will function as a compass to guide the research community in halving methane emissions from rice by 2040.



Additional Resources

The following resources have been prepared by the Rice Methane Innovation Accelerator's Science Oversight Committee:

1. State of Science: Agronomy & Case Study on Irrigated Rice
2. State of Science: Plant Genetics
3. State of Science: Methane-reducing Agents
4. State of the Science: Measurement Tools
5. Methane Formation and Emission from Rice Fields
6. Indicators of Success



