India’s rice fields now rank among world’s top methane hotspots

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Irrigated paddy fields in India release around 3.9 million tonnes of methane every year, a little more than the entire annual methane emissions of Germany

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Flooded fields develop low-oxygen conditions where methane-producing microbes thrive. | Photo Credit: Prahlad Inala/Unsplash

Greenhouse gas (GHG) emissions from paddy fields worldwide have doubled since the 1960s, a new study in *NatureFood* has found. In the most recent decade, 2011-2020, paddy fields around the world produced around 1.1 billion tonnes of carbon dioxide-equivalent (CO_2-e) emissions every year — a 90.4% increase from the annual emissions between 1961 and 1980, the study reported.

Upon examining the sources contributing to the rise in emissions, the study found that about half the increase was driven by the loss of soil organic carbon. Between 1961 and 1980, paddy fields were soil organic carbon sinks, removing some 289 million tonnes of

CO_2-e emissions annually. However, the sink weakened over time. In the 2010s, over a third of paddy fields worldwide in fact began losing carbon from the soil.

Apart from soil organic carbon, methane from paddy fields was also a significant driver of emissions. Flooded fields develop low-oxygen conditions where methane-producing microbes thrive. And paddy fields in eastern India were among the global methane hotspots.

‘Comprehensive assessment’

“Most previous studies have focused on a single greenhouse gas, a specific management practice or a particular region,” Hanqin Tian, co-author of the study and director and institute professor, Department of Earth and Environmental Sciences, Boston College, the U.S., said.

“Our study provides a much more comprehensive assessment by integrating a global meta-analysis of more than 1,200 field experiments, process-based ecosystem modelling, and artificial intelligence approaches to quantify GHG emissions from rice cultivation worldwide.”

India tops the list of countries on rice production, delivering 154 million tonnes in 2025-26. The area under paddy cultivation has also increased by around 25% since the 1970s, and currently covers 55% of India’s rainfed harvested area. This expansion, together with continuous irrigation of fields, incorporating residues such as leftover stalks, leaves, and stubble, and increasing use of nitrogen fertilisers, also increased emissions.

Paddy fields v. Germany

Considering rice’s crucial role in India’s food security, the study underscored the need for urgent measures to reduce emissions while ensuring sustainable production.

“Our analysis indicates that a combination of improved irrigation, optimised fertiliser use, residue management, and reduced tillage could reduce global rice-related greenhouse gas emissions by about 10% by mid-century, even under a warming climate,” Dr. Tian said.

The study also projected that between 2031 and 2050, annual emissions will increase by around 26%, fuelled by global warming, erratic rainfall, and the continued intense use of agricultural inputs.

Irrigated paddy fields in India release around 3.9 million tonnes of methane every year. This is a little more than the entire annual methane emissions of Germany.

Potential and incentives

While India has not set up goals to reduce emissions from agriculture, several techniques and incentives are currently available to farmers.

The National Innovations in Climate Resilient Agriculture (NICRA) project, for example, suggests the ‘System for Rice Intensification’ technique to reduce emissions. Here, young seedlings are transplanted in a precise manner and fields are not continuously flooded during irrigation. Direct-seeded rice, where rice seeds are directly sown in fields as opposed to the traditional method of cultivation involving the transplantation of seedlings into a flooded field, is also encouraged. Drip Irrigation and the alternate wetting and drying technique — where the fields are only intermittently flooded — are also promoted.

However, they don’t address the fact that the emission reduction potentials vary widely between India’s States. Apart from large-scale demonstrations of these techniques across districts under NICRA, several country and state-level policies, like the National Mission for Sustainable Agriculture and financial incentives provided by states like Punjab and Haryana, aim to encourage the adoption of DSR and SRI. However, the reluctance to change from traditional practices, along with issues such as labour shortages, lack of technical knowledge, and changes in rainfall patterns, constrain farmers’ decisions.

Prakashan Chellattan Veettil, senior agricultural and behavioural economist at the International Rice Research Institute (IRRI), New Delhi, said a regional approach that considers the topography, soil, and irrigation conditions plus the farmers’ requirements is crucial.

Dr. Veettil is the IRRI lead in the KERA-AWD project, which is working to establish processes to cultivate low-emission rice systems in Kerala’s low-land (Thrissur kole lands) and mid-land (Palakkad Malampuzha canal) regions.

“Using a multi-pronged approach, which includes increasing soil organic carbon, understanding the hydrology and aligned irrigation systems, agricultural inputs, residue management protocols, soil microbes and farmer preferences, we are working on identifying low-emission packages, where a combination of these factors can help reduce emissions for various paddy varieties,” Dr. Veettil said.

He shared the example of lime that farmers use to neutralise the acidic soil that prevails in the State.

“We have observed that replacing a portion of the lime with [a material called] phosphogypsum has a positive impact on emissions in the subsoil surface,” he added. “We are also experimenting with different formulations and application methods for nitrogen fertilisers.”

Expansion of paddy

Ashwini Chhatre, associate professor of public policy and executive director at the Bharti Institute of Public Policy, Hyderabad, said that depending on a region’s suitability for paddy, farmers should have support to opt for low-emission techniques or grow alternative local

crop varieties. In his research, Dr. Chhatre found that despite facing climate-related losses and price variations, farmers still dedicate large areas of their farmlands to paddy.

“As a general strategy, there is no way forward without crop diversification,” he said. “Despite the agro-climatic diversity in the country, paddy has the largest area under cultivation at the cost of regional indigenous crops.”

Dr. Chhatre said several traditional millet varieties in Odisha have been replaced with high-yielding paddy. Reports indicate the State’s paddy fields have contributed the most to its greenhouse gas emissions.

Through initiatives like the Odisha Agriculture Drought Mitigation Programme with IRRI, and the Shree Anna Abhiyan-Odisha Millet Mission, the State government is taking steps to reduce paddy’s environmental footprint and encourage crop diversity.

“An integrated intervention for alternative grains is crucial,” Dr. Chhatre said, adding that it “must include” extension and training services, involve self-help groups, and provide procurement support. “While encouraging sustainable paddy cultivation, policies must also prevent further expansion of paddy fields to curb emissions.”

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